Pharmacological interventions for pain relief during orthodontic treatment (Review)

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**ABSTRACT**

**Background**

Pain is a common side effect of orthodontic treatment. It increases in proportion to the amount of force applied to the teeth, and the type of orthodontic appliance used can affect the intensity of the pain. Pain during orthodontic treatment has been shown to be the most common reason for people wanting to discontinue treatment, and has been ranked as the worst aspect of treatment. Although pharmacological methods of pain relief have been investigated, there remains some uncertainty among orthodontists about which painkillers are most suitable and whether pre-emptive analgesia is beneficial. We conducted this Cochrane Review to assess and summarize the international evidence relating to the effectiveness of analgesics for preventing this unwanted side effect associated with orthodontic treatment.

**Objectives**

The objectives of this review are to determine:

- the effectiveness of drug interventions for pain relief during orthodontic treatment; and

- whether there is a difference in the analgesic effect provided by different types, forms and doses of analgesia taken during orthodontic treatment.

**Search methods**

Cochrane Oral Health's Information Specialist searched the following databases: the Cochrane Oral Health Trials Register (to 19 June 2017), the Cochrane Central Register of Controlled Trials (CENTRAL; the Cochrane Library 2016, Issue 7), MEDLINE Ovid (1946 to 19 June 2017), Embase Ovid (1980 to 19 June 2017) and CINAHL EBSCO (Cumulative Index to Nursing and Allied Health Literature; 1937 to 19 June 2017). The US National Institutes of Health Ongoing Trials Register (ClinicalTrials.gov) and the World Health Organization International Clinical Trials Registry Platform were searched on the 19 June 2017 for ongoing studies. We placed no restrictions on language or date of publication when searching the electronic databases.

**Selection criteria**

We included randomized controlled trials (RCTs) relating to pain control during orthodontic treatment. Pain could be measured on a visual analogue scale (VAS), numerical rating scale (NRS) or categorical scale.
Data collection and analysis

Two review authors independently screened the search results, agreed the studies to be included and extracted information from the included studies regarding methods, participants, interventions, outcomes, harms and results. We planned to resolve any discrepancies or disagreements through discussion. We used the Cochrane 'Risk of bias' tool to assess the risk of bias in the studies.

Main results

We identified 32 relevant RCTs, which included 3110 participants aged 9 to 34 years, 2348 of whom we were able to include in our analyses. Seventeen of the studies had more than two arms. We were able to use data from 12 trials in meta-analyses that compared analgesics versus control (no treatment or a placebo); nine that compared non-steroidal anti-inflammatory drugs (NSAIDs) versus paracetamol; and two that compared pre-emptive versus post-treatment ibuprofen for pain control following orthodontic treatment. One study provided data for the comparison of NSAIDs versus local anaesthetic.

We found moderate-quality evidence that analgesics effectively reduced pain following orthodontic treatment when compared to no treatment or a placebo at 2 hours (mean difference (MD) -11.66 mm on a 0 to 100 mm VAS, 95% confidence interval (CI) -16.15 to -7.17; 10 studies, 685 participants), 6 hours (MD -24.27 mm on a VAS, 95% CI -31.44 to -17.11; 9 studies, 535 participants) and 24 hours (MD -21.19 mm on a VAS, 95% CI -28.31 to -14.06; 12 studies, 1012 participants).

We did not find any evidence of a difference in efficacy between NSAID and paracetamol at 2, 6 or 24 hours (at 24 hours: MD -0.51, 95% CI -8.93 to 7.92; 9 studies, 734 participants; low-quality evidence).

Very low-quality evidence suggested pre-emptive ibuprofen gave better pain relief at 2 hours than ibuprofen taken post treatment (MD -11.30, 95% CI -16.27 to -6.33; one study, 41 participants), however, the difference was no longer significant at 6 or 24 hours.

A single study of 48 participants compared topical NSAIDs versus local anaesthetic and showed no evidence of a difference in the effectiveness of the interventions (very low-quality evidence).

Use of rescue analgesia was poorly reported. The very low-quality evidence did not show evidence of a difference between participants taking ibuprofen and participants taking paracetamol (relative risk (RR) 1.5, 95% CI 0.6 to 3.6). Nor did we find evidence of a difference between groups in likelihood of requiring rescue analgesia when ibuprofen was taken pre-emptively compared to after treatment (RR 0.8, 95% CI 0.3 to 1.9).

Adverse effects were identified in one study, with one participant developing a rash that required treatment with antihistamines. This was provisionally diagnosed as a hypersensitivity to paracetamol.

Authors' conclusions

Analgesics are more effective at reducing pain following orthodontic treatment than placebo or no treatment. Low-quality evidence did not show a difference in effectiveness between systemic NSAIDs compared with paracetamol, or topical NSAIDs compared with local anaesthetic. More high-quality research is needed to investigate these comparisons, and to evaluate pre-emptive versus post-treatment administration of analgesics.

PLAIN LANGUAGE SUMMARY

Painkillers for relieving pain caused by orthodontic treatment

Review question

Do painkillers, taken before or after orthodontic treatment, help relieve pain? If so, which painkillers work best?

Background

Pain is a common side effect of orthodontic treatment. The pain resulting from orthodontic treatment may differ depending on the amount of force applied and the type of braces used. It may also change over the first few days following treatment. Pain has been ranked as the worst aspect of treatment and is the most common reason for people wanting to discontinue orthodontic treatment. Painkillers, swallowed or applied directly to the sore areas of the mouth following treatment, are thought to relieve the pain, making brace treatment more comfortable and acceptable. These painkillers are often cheap, readily available, easy to use and do not cause serious side effects.
Study characteristics

Authors working with Cochrane Oral Health carried out a review of existing studies and the evidence is current up to 19 June 2017. This review includes 32 studies published from 1993 to 2016 in which 3110 participants aged 9 to 34 years (2348 of whom were included in the analyses) were randomly allocated to groups to receive:

1) painkillers versus no treatment,
2) painkillers versus a placebo (pretend or 'dummy' medicine),
3) one painkiller versus a different painkiller, or
4) a painkiller taken at different time intervals.

The severity of pain experienced by the study participants was compared. Nearly all the evidence was from adults who received oral painkillers versus no treatment, or one oral painkiller versus another oral painkiller. This evidence fell into two main groups:

1) adults receiving paracetamol; or
2) adults receiving non-steroidal anti-inflammatory drugs (NSAIDs).

A small amount of evidence also investigated the effect of local anaesthetic and opioids (tramadol).

Key results

Analgesic versus placebo or no treatment

We found evidence that paracetamol, NSAIDs and local anaesthetic were effective at reducing pain intensity at 2 hours, 6 hours and 24 hours following orthodontic treatment when compared with either a placebo or no treatment group.

NSAID versus paracetamol

We found no clear evidence of a difference between the effect of ibuprofen and paracetamol for reducing pain intensity at 2 hours, 6 hours or 24 hours following either the placement of separators (between teeth) or placement of an initial aligning archwire.

Pre-emptive NSAID versus post-treatment NSAID

We found some very low-quality evidence that ibuprofen taken 1 hour prior to separator placement significantly reduces pain intensity 2 hours afterwards when compared to ibuprofen taken post-treatment. However, at 6 hours and 24 hours, we detected no clear difference.

NSAID versus local anaesthetic

There was no evidence of a difference between the interventions.

Quality of the evidence

The evidence available for the main outcome of pain relief is of moderate to low quality, whilst the quality of the rest of the evidence was very low. We judged only one study to be at low risk of bias.
### Summary of Findings for the Main Comparison

**Analgesic compared to control (placebo or no treatment) for pain relief during orthodontic treatment**

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Anticipated absolute effects* (95% CI)</th>
<th>Relative effect (95% CI)</th>
<th>Number of participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk with control</td>
<td>Risk with analgesic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Pain assessed with VAS (0 to 100 mm where 0 = no pain) Follow-up: mean 2 hours | Mean pain ranged from 10 mm to 73 mm on a VAS | MD 11.66 mm lower (16.15 mm to 7.17 mm lower) | - | 685 (10 RCTs) | ⚫StringBuilder.m
| Rescue analgesia | Not reported | | | | |
| Adverse events | Not reported | | | | |

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)*

CI: confidence interval; MD: mean difference; VAS: visual analogue scale

**GRADE Working Group grades of evidence**

- **High quality**: we are very confident that the true effect lies close to that of the estimate of the effect
- **Moderate quality**: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
- **Low quality**: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect
- **Very low quality**: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect
1 Downgraded one level for risk of bias as four of the studies were at high risk of bias and the remaining six were at unclear risk of bias. Not downgraded for heterogeneity as effects were all in same direction.
**BACKGROUND**

Pain relief in dentistry has been fairly well studied in the literature, but the management of pain associated with orthodontic treatment is less well understood. As clinicians we are often asked whether it will be necessary for patients to take painkillers during orthodontic treatment, and, if so, which are likely to be the most effective. Some studies have shown that pretreatment doses of non-steroidal anti-inflammatory drugs (NSAIDs) may help to reduce the amount of pain experienced immediately after treatment (Steen-Law 2000). However, there is some uncertainty among orthodontists regarding which painkillers are most suitable and whether pre-emptive analgesia is beneficial.

We investigated relief of pain arising during and after the placement of orthodontic appliances (such as separators, fixed braces, removable braces and headgear) and during routine treatment to adjust appliances and replace archwires. We did not include pain relief following tooth extraction or surgical procedures associated with orthodontic treatment.

**Description of the condition**

Orthodontics is the area of dentistry concerned with the growth of the jaws and face, development of dentition and relationship between dentition, jaws and face. It also involves treatment of teeth and jaws when they are irregular in their alignment, morphology or function. Typically, orthodontic treatment is carried out to improve the functioning and appearance of the teeth. This may involve moving teeth by applying a force via:

- fixed appliances (braces that are attached to the teeth for the duration of the treatment);
- removable appliances (braces that are normally worn full-time during treatment but can be removed for cleaning); and/or
- functional appliances (removable or fixed braces that aim to move the teeth and modify the direction of growth of the jaws to induce an orthopaedic change) (British Orthodontic Society).

Orthodontic treatment may also involve: extraction of teeth in order to provide space for other teeth to be aligned; surgery to expose unerupted teeth in an attempt to guide them into alignment; and, occasionally, jaw surgery to correct the underlying position of the jaws. Most people undergoing orthodontic treatment are children or adolescents, although an increasing number of adults are seeking treatment. (Buttle 1999).

TREATMENT typically begins with construction and placement of an orthodontic appliance (whether fixed, removable or functional) over two visits of 30 to 45 minutes each. Routine adjustments are then carried out every four to six weeks over the course of treatment, which normally lasts approximately 12 to 24 months. Following treatment, removal of fixed appliances takes approximately 30 to 45 minutes and retainers are then provided to maintain teeth in their newly aligned position.

Pain resulting from orthodontic treatment increases in proportion to the amount of force applied to the teeth. Different types of orthodontic appliances affect the intensity of the pain. Fixed orthodontic appliances seem to cause more pain than removable braces, or functional appliances, which are used to help modify facial growth (Sergl 1998). Acute pain is experienced during or immediately after placement of separators. People may also experience pain for one to two days following each four- to six-weekly adjustment appointment. Pain may also be experienced acutely or continuously between adjustment visits. It is thought that the pain associated with orthodontic treatment is related to a reduction in the blood supply to the fibres that attach the tooth to the surrounding bone. This happens when a force is applied to the tooth via a brace. The reduction in blood supply causes inflammation and the release of several chemicals that greatly increase the transmission of painful stimuli (Proffit 2000).

Pain during orthodontic treatment has been shown to be the most common reason for patients wanting to discontinue treatment, and was ranked as the worst aspect of the treatment (Oliver 1985). Jones 1992 found that patients who underwent both premolar extractions and orthodontic tooth movement experienced more pain 24 hours after initial arch wire placement than 24 hours after tooth extraction. When separators (small rubber bands that make space for metal orthodontic band attachments around the back teeth) are placed between teeth, pain gradually increases, peaking the day after placement, and then decreases. By seven days, pain levels have decreased to the same level as at two hours following treatment (Bernhardt 2001). The amount of pain experienced depends upon the type of tooth movement occurring (tipping or bodily movement), and, in particular, the pain threshold of the individual. It is likely that patients only require drug-assisted pain relief for two to three days out of every four to six weeks, so the long-term implications of drug treatment are probably small.

**Description of the intervention**

Pharmacological management of pain involves the use of analgesics applied locally or systemically. These analgesics fall into four main categories:

- opioids;
- non-steroidal anti-inflammatory drugs (NSAIDs);
- paracetamol;
- local anaesthetic.

The first three of these analgesics are commonly taken, systemically, within two hours of the orthodontic visit and can then be re-administered over a period of time until pain resolves. Local, topical NSAIDs and anaesthetic are also commonly used for the relief of traumatic ulceration caused to the oral mucosa as a result of irritation by orthodontic appliances. As a result, these topical forms of analgesia are more commonly used to relieve the symptoms of pain, rather than as preventive measures.
Analgesics for the relief of orthodontic pain are readily available, have a low cost, are easily administered and are generally harmless (in terms of a lack of side effects).

**How the intervention might work**
The mechanism of action for pain relief differs according to the analgesic being used.

**Opioids**
Opioids, which are also referred to as narcotics, include codeine sulphate, tramadol and morphine sulphate. They may be classified as agonistic, agonist-antagonistic or partial agonist depending on their specific mode of action but they act on large A-δ fibres in the dorsal horn of the spinal cord. They bind to G-protein-coupled opiate receptors on inhibitory fibres, preventing stimulus of the gate and therefore prevent pain transmission to the brain (Pleuvry 1993). However, the specific mechanism of action differs slightly when considering tramadol. In addition to the mechanism described, tramadol can act to inhibit the reuptake of monoamines, causing an analgesic effect, but limiting the osteoporotic changes seen with other opioids at a histological level. By acting in this non-opioid way, it has been hypothesised that the effect on the rate of orthodontic tooth movement will be less with tramadol than that experienced with other, traditional opioids; however, under experimental situations this has not been the case (Rashidpour 2012).

**NSAIDs**
Non-steroidal anti-inflammatory drugs are the most popular method of pain control used during orthodontic treatment (Krishnan 2007). These include drugs like ibuprofen and aspirin, which function by inhibiting the activity of the enzyme cyclooxygenase (COX), which modulates the transformation of prostaglandins from arachidonic acid in the cellular plasma membrane (De Carlos 2006). Prostaglandins are responsible for causing pain; inhibition of COX suppresses prostaglandin production and so reduces pain. However, prostaglandins, including PGE1 and PGE2, are important mediators of bone resorption, and it has been suggested that suppression of their activity with NSAIDs may affect the rate of orthodontic tooth movement (Krishnan 2006). Kehoe 1996 found a significant difference in the rate of tooth movement achieved with elastic separators in guinea pigs when comparing treatment with misoprostol (a prostaglandin analogue) or ibuprofen to a control group. However, the significance of this on a clinical level is negligible: there was a 1 mm average difference between intervention and control groups, and the doses used experimentally differed from those routinely used in practice.

**Paracetamol**
Paracetamol, known as acetaminophen in the USA, has been available in the UK as an analgesic on prescription since 1956, and over-the-counter since 1963 (Shenoy 2013). The primary mechanism of action of paracetamol is similar to that of NSAIDs. It is believed to inhibit COX, with a predominant effect on COX-2; however, unlike NSAIDs, it is thought to act at a central nervous system level rather than acting across cell membranes (Karthi 2012). As a result, inhibition of prostaglandins is minimal and therefore it is thought that its use has no effect on the rate of tooth movement. However, although useful as an antipyretic and analgesic, it lacks an anti-inflammatory action and is therefore often used in combination with NSAIDs for management of pain.

**Local anaesthetic**
It has been suggested that local anaesthetics, in the form of topical gels, might be safer alternatives to systemic analgesics as a method of pain management before or during orthodontic procedures (Shenoy 2013). Gels provide localised delivery of the anaesthetic into the gingival crevice, and because of this, their use has been proposed for local orthodontic procedures such as band placement, archwire ligation and bracket removal (Keim 2005).

**Why it is important to do this review**
There is currently a lack of evidence regarding the best pharmacological intervention for pain relief during orthodontic pain. The recently published Cochrane Review exploring the evidence for non-pharmacological management of orthodontic pain found low-quality evidence suggesting that laser irradiation may help reduce pain during orthodontic treatment and for up to seven days following treatment; however, overall the results were inconclusive, suggesting further prospective research is required (Fleming 2016). We hope that this review will help produce evidence-based recommendations for managing orthodontic pain and can be used alongside the Fleming 2016 review.

**OBJECTIVES**
The objectives of this review are to determine:
- the effectiveness of drug interventions for pain relief during orthodontic treatment; and
- whether there is a difference in the analgesic effect provided by different types, forms and doses of analgesia taken during orthodontic treatment.
**METHODS**

**Criteria for considering studies for this review**

**Types of studies**
Randomized controlled clinical trials (RCTs) of orthodontic treatments where a pharmacological intervention for pain relief was compared to a placebo, or no intervention, or another pharmacological intervention. We excluded split-mouth studies, as we consider them to be an inappropriate study design. If an RCT compared pharmacological and non-pharmacological interventions to a placebo or no intervention, we included the study, but used only the data for the pharmacological intervention compared to placebo or no intervention.

**Types of participants**

**Inclusion criteria**
We included trials that recruited participants of any age who were receiving any type of orthodontic treatment.

**Exclusion criteria**
We excluded trials that recruited participants who had undergone surgical interventions, placement of temporary anchorage devices or dental extractions in combination with orthodontic treatment.

**Types of interventions**

**Active interventions**
We assessed the following active interventions to alleviate pain:
- opioid analgesics;
- any non-steroidal anti-inflammatory drug (NSAID);
- paracetamol;
- local anaesthetic.

We evaluated any intervention taken by any route, dose, form or combination, at any time during treatment. Interventions could be given at any time following treatment, or up to two hours before treatment.

**Controls**
Interventions could be compared to each other, a placebo or the same intervention at a different dose, intensity or time interval.

**Types of outcome measures**

**Primary outcomes**
- Participant-reported pain intensity, or relief, measured on a visual analogue scale (VAS), numerical rating scale (NRS) or any categorical scale

**Secondary outcomes**
- Rescue analgesia (alternative pain relief taken or prescribed, including dose and time, following last orthodontic treatment)
- Adverse effects (harms) of pain treatment, for example, total gastrointestinal side effects. We recorded and reported harms in descriptive terms.
- Quality of life or participant satisfaction
- Time off school or work
- Failure to complete orthodontic treatment due to the pain experienced

**Search methods for identification of studies**

**Electronic searches**
Cochrane Oral Health's Information Specialist conducted systematic searches in the following databases for randomized controlled trials and controlled clinical trials. There were no language, publication year or publication status restrictions:
- the Cochrane Oral Health Trials Register (searched 19 June 2017) ([Appendix 1](#));
- Cochrane Central Register of Controlled Trials in the Cochrane Library (CENTRAL; 2016, Issue 7; searched 19 June 2017) ([Appendix 2](#));
- MEDLINE Ovid (1946 to 19 June 2017) ([Appendix 3](#));
- Embase Ovid (1980 to 19 June 2017) ([Appendix 4](#));
- CINAHL EBSCO (Cumulative Index to Nursing and Allied Health Literature; 1937 to 19 June 2017) ([Appendix 5](#)).

Subject strategies were modelled on the search strategy designed for MEDLINE Ovid. Where appropriate, they were combined with subject strategy adaptations of the highly sensitive search strategy designed by Cochrane for identifying randomized controlled trials and controlled clinical trials as described in the *Cochrane Handbook for Systematic Reviews of Interventions* Chapter 6 ([Lefebvre 2011](#)).

**Searching other resources**
The following trial registries were searched for ongoing studies:
- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov ([clinicaltrials.gov]; searched 19 June 2017) ([Appendix 6](#));
We did not perform a separate search for adverse effects of interventions used, we considered adverse effects described in included studies only.

We checked the bibliographies of the clinical trials identified for references to trials.

Language
We searched databases to include papers and abstracts published in all languages and every effort was made to translate non-English papers.

Unpublished studies
We contacted the first named authors of all trial reports in an attempt to identify unpublished studies and to obtain any further information about the trials.

Data collection and analysis
Selection of studies
Two review authors (Aoife Monk (AM) and Jayne Harrison (JH) or Annabel Teague (AT)) assessed the titles and abstracts (when available) of all reports that were identified by the search strategy. This was carried out independently and in duplicate. The review authors were not blinded to trial author(s), institution or site of publication.

When we found insufficient information in the title and abstract to make a clear decision to exclude, or when there was disagreement between the review authors about eligibility, we obtained the full text of the paper. These full texts were then assessed independently and in duplicate by two review authors (AM and JH or AT) to establish whether or not the studies met the inclusion criteria.

We resolved disagreements through discussion between AM and JH. We consulted a third review author if we could not resolve disagreements. We kept a record of all decisions made about the potentially eligible studies. We obtained full texts for all studies that were ultimately included in this review.

Data extraction and management
Two review authors (AM and JH or AT) carried out data extraction independently and in duplicate, using a predesigned and piloted data collection form, which was stored electronically. We contacted study authors for clarification of missing data where necessary and feasible. We resolved any disagreements through discussion, consulting a third review author to achieve a consensus where necessary. We recorded the following key data for each included study in the Characteristics of included studies tables.

- Trial design, source of participants, method of recruitment, recruitment period and study duration
- Inclusion and exclusion criteria; age, gender and ethnicity of participants; number selected, excluded, randomized and analyzed
- Detailed description of the intervention and comparison including time, dose and route. We noted information relating to compliance, where available.
- Details of the outcomes reported, including method of assessment and time(s) assessed
- Details of sample size calculations, adverse effects, funding sources, declarations or conflicts of interest

The primary outcome was the relief of pain. We recorded adverse events or harms (e.g. total gastrointestinal side effects) narratively where these were reported.

We extracted all outcome data. We then grouped data into the time points that we felt were the most clinically relevant: that is, 2 hours, 6 hours and 24 hours following the orthodontic procedure (placement or adjustment of appliance). If outcome data were reported at other time points, we considered examining those as well.

Assessment of risk of bias in included studies
Independently and in duplicate, two review authors (AM and JH) undertook an assessment of the risk of bias in the studies as a part of the data extraction process. We used the Cochrane domain-based, two-part tool as described in Chapter 8 of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2008), which investigates seven domains:

- method of sequence generation;
- method of allocation concealment;
- blinding of participants and personnel;
- blinding of outcome assessment;
- incomplete outcome data;
- selective outcome reporting;
- other sources of bias.

We assessed sequence generation, allocation concealment and selective outcome reporting for the study as a whole. We assessed blinding and incomplete outcome data on the level of the study and for each outcome as appropriate. We assigned each domain a risk of bias judgement of high, low or unclear risk of bias. We also assessed the overall risk of bias as:

- low risk of bias (plausible bias that is unlikely to alter the results seriously), if all domains were at a low risk of bias;
- high risk of bias (plausible bias that seriously weakens confidence in the results), if one or more domains were at a high risk of bias; or
• unclear risk of bias (plausible bias that raises some doubt about the results), if one or more domains were at an unclear risk of bias.

We presented our 'Risk of bias' judgements in tables and in two summary diagrams (Figure 1; Figure 2).
Figure 1. Risk of bias summary: review authors' judgements about each risk of bias item for each included study
Measures of treatment effect

For continuous outcomes (e.g., pain measured on a VAS) where studies used the same scale, we used the mean values and standard deviations (SDs) reported in the studies in order to express the estimate of effect as mean difference (MD) with 95% confidence interval (CI). If different scales had been used to assess an outcome, we would have considered expressing the treatment effect as a standardised mean difference (SMD) with 95% CI. We calculated risk ratios (RR) and corresponding 95% CI for dichotomous data where possible.

For trials with multiple arms, the sample sizes of any shared groups were split for purposes of independent comparison.

Unit of analysis issues

The participant was the unit of analysis. The treatment effects from crossover trials were combined with those from parallel group trials where appropriate. We used data from the first round of the trial only and treated it as a parallel trial.

Dealing with missing data

We attempted to contact the author(s) of all included studies, where feasible, for clarification, missing data, and details of any outcomes that may have been measured but not reported. We were unable to use the methods described in Section 7.7.3 of the Cochrane Handbook for Systematic Reviews of Interventions to estimate missing SDs due to unclear or unavailable data (Higgins 2008). We did not use any other statistical methods, or perform any further imputation to account for missing data.

Assessment of heterogeneity

When a sufficient number of studies were included in any meta-analyses, we assessed clinical heterogeneity by examining the characteristics of the studies, the similarity between the types of participants, the interventions, and the outcomes. We also assessed heterogeneity statistically using a Chi² test, where a P value of less than 0.1 indicated statistically significant heterogeneity. We quantified heterogeneity using the I² statistic. A guide to interpretation of the I² statistic given in Section 9.5.2 of the Cochrane Handbook for Systematic Reviews of Interventions reads as follows (Higgins 2008):

- 0% to 40% might not be important;
- 30% to 60% may represent moderate heterogeneity;
- 50% to 90% may represent substantial heterogeneity;
- 75% to 100% represents considerable heterogeneity.

Assessment of reporting biases

Figure 2. Risk of bias graph: review authors’ judgements about each risk of bias item presented as percentages across all included studies
If we had included at least 10 studies in a meta-analysis, we would have assessed publication bias by testing for funnel plot asymmetry, as described in Section 10.4 of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2008). If asymmetry had been identified, we would have examined possible causes. It was not possible to assess publication bias in this way because, although we had a sufficient number of studies in our meta-analyses for the primary outcome, they were split into subgroups of less than 10 studies.

Data synthesis

We only carried out meta-analyses where there were studies of similar comparisons reporting the same outcomes. We combined MDs for continuous data, and would have combined RRs for dichotomous data, had any been reported. Our general approach was to use a random-effects model. With this approach, the CIs for the average intervention effect were wider than those that would have been obtained using a fixed-effect approach, leading to a more conservative interpretation. We used an additional table to report the results from studies that were not suitable for inclusion in a meta-analysis, including data analyzed by intervention.

Subgroup analysis and investigation of heterogeneity

We carried out subgroup analyses according to type of pharmacological intervention and timing of intervention. We carried our further subgroup analysis according to type of orthodontic intervention where possible.

Sensitivity analysis

As all studies except Bruno 2011 were at high risk of both performance and detection bias, it was not possible to test the robustness of our results by performing sensitivity analyses based on excluding studies judged to be at unclear or high risk of bias from the analyses. If any meta-analyses had included several small studies and a single very large study, we would have undertaken a sensitivity analysis to compare the effect estimates from both random-effects and fixed-effect models. If these had been different, we would have reported on both analyses as part of the results section, and we would have considered possible interpretations.

RESULTS

Description of studies

Results of the search

The electronic database search identified 721 references to studies and four additional articles were identified from additional sources (authors of this review); 360 of the records were duplicates, leaving 361 references. We discarded 315 of these as a result of screening the titles and abstracts. We obtained full-text articles of the remaining 46 articles, where possible, and excluded nine of the references at this stage. The remaining 37 references appeared to meet our inclusion criteria and we were able to include 33 references relating to 32 studies. We made attempts to contact the authors of the four remaining studies for further information. One of the studies is ongoing and the other three studies are awaiting classification. This selection process is presented as a flow chart in Figure 3.
Figure 3. Study flow diagram

721 records identified through database searching

4 additional records identified through other sources

725 records

364 duplicates removed

361 records screened

315 records rejected

9 articles excluded: 4 inappropriate study design, 2 potential confounding due to co-interventions, 3 abstracts with insufficient information to allow inclusion

46 full-text articles assessed for eligibility

32 studies (33 references) included in qualitative synthesis

3 studies awaiting classification

1 study ongoing

18 studies included in quantitative synthesis (meta-analysis)
Included studies

We included 32 studies, which randomized a total of 3110 participants and analyzed 2348 participants (see Characteristics of included studies tables).

Characteristics of the trial designs and settings

Design

Twenty-eight studies were of parallel design, and the remaining four studies used a cross-over design (Arantes 2009; Eslamian 2014; Eslamian 2016a; Eslamian 2016b). Studies had between two and six arms:

- five studies had two arms (Bird 2007; Bradley 2007; Kluemper 2002; Lauritano 2000; Ousehal 2009);
- 20 studies had three arms, but five of these studies had one arm excluded from this review because it involved a non-pharmacological intervention (Wang 2012), or non-comparable data (that is, mean and SD pain data were not available) (Bernhardt 2001; Minor 2009; Steen-Law 2000; Young 2006);
- two studies had four arms (Patel 2011; Sudhakar 2014);
- two studies had five arms; however, both had three arms excluded from this review because they involved data from non-pharmacological interventions (Bayani 2016; Farzanegan 2012);
- three studies had six arms (Pelisson 2008; Polat 2005a; Polat 2005b); however, one arm from Pelisson 2008 was excluded from this review because it involved non-comparable data.

Setting

Ten studies were conducted in the USA (Bernhardt 2001; Bird 2007; Kawamoto 2010; Kluemper 2002; Minor 2009; Ngan 1994; Patel 2011; Salmassian 2009; Steen-Law 2000; Young 2006); eight in Iran (Abtahi 2006; Bayani 2016; Eslamian 2014; Eslamian 2016b; Eslamian 2016a; Farzanegan 2012; Najafi 2015; Nik 2016); three in Turkey (Polat 2005a; Polat 2005b; Tuncer 2014); three in India (Gupta 2014; Kohli 2011; Sudhakar 2014); three in Brazil (Arantes 2009; Bruno 2011; Pelisson 2008); and one in each of China (Wang 2012), Italy (Paganelli 1993), Morocco (Ousehal 2009), Spain (Lauritano 2000), and the UK (Bradley 2007).

There were 25 single-centre studies, two studies with two centres (Eslamian 2014; Kawamoto 2010), and one study with three centres (Bradley 2007). Five studies were unclear about how many centres were involved (Kluemper 2002; Polat 2005a; Polat 2005b; Tuncer 2014; Young 2006).

Funding

Four studies reported their funding source (Arantes 2009; Bradley 2007; Najafi 2015; Wang 2012), all of which were in the form of independent funding from government, charities or universities. The remaining 28 studies did not report any funding source.

Conflict of interest

Six studies declared that there were no conflicts of interest (Bruno 2011; Gupta 2014; Najafi 2015; Salmassian 2009; Sudhakar 2014; Wang 2012), while the other 26 did not mention conflicts of interest.

Characteristics of the participants

There were 3110 participants randomized to interventions (in the intervention groups relevant to this review), of which 2348 were included in the studies’ analyses. Participant age ranged from 9 to 34 years. In general, there were comparable numbers of males and females in the studies, however, one study recruited only female participants (Farzanegan 2012), and nine studies reported large variation between male and female numbers at baseline (Abtahi 2006; Bradley 2007; Bruno 2011; Eslamian 2016b; Kawamoto 2010; Najafi 2015; Ousehal 2009; Tuncer 2014; Wang 2012).

Orthodontic intervention

In 14 studies, participants had separators placed (Abtahi 2006; Bernhardt 2001; Bird 2007; Bradley 2007; Bruno 2011; Kawamoto 2010; Kohli 2011; Minor 2009; Najafi 2015; Ngan 1994; Nik 2016; Patel 2011; Steen-Law 2000; Sudhakar 2014). In 12 studies, participants had placement of an initial aligning archwire (Bayani 2016; Farzanegan 2012; Gupta 2014; Lauritano 2000; Ousehal 2009; Pelisson 2008; Polat 2005a; Polat 2005b; Salmassian 2009; Tuncer 2014; Wang 2012; Young 2006). Five studies included participants who were in the middle of treatment (Arantes 2009; Eslamian 2014; Eslamian 2016b; Eslamian 2016a; Paganelli 1993). One study included participants who had only brackets placed, without placement of an archwire (Kluemper 2002).

Characteristics of the interventions and comparisons

Opioid

One study compared tramadol with a control group that received a placebo (Abtahi 2006). This study also compared ibuprofen with tramadol (Abtahi 2006).
Paracetamol

Eight studies compared paracetamol with a control group that received a placebo (Gupta 2014; Kawamoto 2010; Nik 2016; Patel 2011; Polat 2005a; Salmassian 2009; Sudhakar 2014; Tuncer 2014). Twelve studies compared NSAIDs with paracetamol (Bird 2007; Bradley 2007; Gupta 2014; Kawamoto 2010; Najafi 2015; Nik 2016; Ousehal 2009; Patel 2011; Polat 2005a; Salmassian 2009; Sudhakar 2014; Tuncer 2014). Eleven of these studies compared ibuprofen with paracetamol, either independently or in addition to other classes of NSAID (Bird 2007; Bradley 2007; Kawamoto 2010; Najafi 2015; Nik 2016; Ousehal 2009; Patel 2011; Polat 2005a; Salmassian 2009; Sudhakar 2014; Tuncer 2014). One study compared etoricoxib with paracetamol (Gupta 2014).

NSAIDs

Twenty-one studies compared NSAIDs with a control group (Abtahi 2006; Bayani 2016; Bruno 2011; Eslamian 2014; Eslamian 2016a; Farzaneag 2012; Gupta 2014; Kawamoto 2010; Kohli 2011; Minor 2009; Ngan 1994; Nik 2016; Paganelli 1993; Patel 2011; Pelosi 2008; Polat 2005a; Polat 2005b; Salmassian 2009; Sudhakar 2014; Tuncer 2014; Wang 2012). Sixteen of these studies compared ibuprofen to a control group, either independently or in addition to other classes of NSAID (Abtahi 2006; Bayani 2016; Farzaneag 2012; Kawamoto 2010; Kohli 2011; Minor 2009; Ngan 1994; Nik 2016; Patel 2011; Pelosi 2008; Polat 2005a; Polat 2005b; Salmassian 2009; Sudhakar 2014; Tuncer 2014; Wang 2012). Eight studies compared ibuprofen with another form of NSAID (Kohli 2011; Najafi 2015; Ngan 1994; Patel 2011; Pelosi 2008; Polat 2005a; Polat 2005b; Salmassian 2009; Sudhakar 2014; Tuncer 2014). Two studies compared ibuprofen taken pre-emptively with ibuprofen taken postoperatively (Berkhard 2001; Steen-Law 2000). One study compared valdecoxb taken pre-emptively with valdecoxb taken postoperatively (Young 2006). One study compared tenoxicam taken pre-emptively with tenoxicam taken postoperatively (Arantes 2009). One study compared a topical NSAID (benzocaine hydrochloride) with another topical NSAID (ketoprofen lysinate) (Lauritano 2000).

Local anaesthetic

Four studies compared benzocaine local anaesthetic with a control. Of these studies had the benzocaine intervention in chewing gum form (Eslamian 2014), two had the benzocaine intervention in gel form (Eslamian 2016a; Eslamian 2016b), and one had the benzocaine intervention in wax form for the management of orthodontic related ulceration (Kluemper 2002). Two studies compared NSAIDs with local anaesthetic (Eslamian 2014; Eslamian 2016a).

Duration

The duration of treatment varied between studies, from one dose one hour before treatment to seven days of treatment.

Characteristics of the outcomes

Primary outcome

For the primary outcome of pain, we were interested in either pain relief or pain intensity, and also different levels of severity. All included studies measured pain intensity using a 100 mm visual analogue scale (VAS), reported in either centimetres or millimetres. For the purposes of this review, we analyzed VAS data relating to the primary outcome in millimetres. Therefore, for studies that recorded results in centimetres, we converted the data to millimetres. Most studies recorded this value on the basis of an overall summary of the participant’s pain experience, however, some studies reported pain intensity for additional specified activities. Ten studies recorded pain intensity during chewing, biting, fitting front teeth together, and fitting posterior teeth together (Bayani 2016; Bernhardt 2001; Farzaneag 2012; Kohli 2011; Minor 2009; Ngan 1994; Pelosi 2008; Polat 2005a; Polat 2005b; Steen-Law 2000). Four studies recorded pain intensity during chewing, rest, and fitting posterior teeth together (Bird 2007; Kawamoto 2010; Najafi 2015; Sudhakar 2014), and one study recorded pain intensity during chewing, fitting front teeth together, and fitting back teeth together (Tuncer 2014). For the purposes of this review, we included only data for chewing in our analyses of these studies. One study also measured pain using a verbal descriptive scale (VDS) consisting of a group of words that described pain intensity. The participants were asked to mark the word that best described what they were feeling. The studies recorded a total of 23 time points. These ranged from one hour pre-treatment to 30 days post-treatment. We analyzed data from 2 hours, 6 hours, and 24 hours, as we felt these were the most important time points from a clinical perspective, in addition to being some of the time points reported most commonly across the studies. It was also evident from the data that the peak in pain intensity occurred at 24 hours, after which it rapidly reduced regardless of intervention and, therefore, we felt that analysing data beyond this point would provide little valuable information. As a result, data from Kluemper 2002; Lauritano 2000 and Paganelli 1993 did not contribute to the overall analyses due to variations in time points used to measure their primary outcome. Although all studies reported mean VAS measurements for pain intensity in addition to standard deviation, a number of studies did not contribute data to the analyses because the data relating to the primary outcome were not presented clearly, lacked a standard deviation, or were presented in median and interquartile format, and attempts to contact the authors produced no response or no answers (Abtahi 2006; Arantes 2009; Bayani 2016; Bird 2007;
Secondary outcomes

Rescue analgesia
Use of rescue analgesia was reported in seven studies (Arantes 2009; Bernhardt 2001; Bradley 2007; Bruno 2011; Najafi 2015; Steen-Law 2000; Tuncer 2014). However, data relating to class and dose were not reported in any study, and timing was reported in only one study (Bradley 2007), although all studies stated that participants were asked to record this information on the VAS questionnaires.

Adverse events
Adverse events were reported in two studies (Abrahi 2006; Bradley 2007). We decided to report this outcome in narrative form.

Quality of life or participant satisfaction
Patient satisfaction was not reported for any study. The authors of one study reported quality of life assessed by the Short Form-36 Health Survey (SF-36) at baseline and 30 days, and the Self-Rating Anxiety Scale (SAS) at baseline and 30 days (Wang 2012). One study reported affective states assessed with the State and Trait Anxiety Inventory (STAI) and the Positive Affect Negative Affect Schedule (PANAS) (Minor 2009).

Time off school or work
No studies reported this outcome.

Failure to complete orthodontic treatment due to the pain experienced
No studies reported this outcome.

Excluded studies
We excluded nine studies from this review for the following reasons:

- inappropriate study design (Al-Melh 2017; Eslamian 2013; Eslamian 2017a; Soheilifar 2016);
- abstract with insufficient information (Cherubini 2003; Ogata 1999; Parks 2001).

In addition, three studies had insufficient information in the trial registration record to allow inclusion and are therefore awaiting classification (Eslamian 2017b; Moradinejad 2014; Rooke 2012). One study is ongoing (Mohammed 2016). See Characteristics of excluded studies, Characteristics of studies awaiting classification and Characteristics of ongoing studies.

Risk of bias in included studies

Allocation

Random sequence generation
Seventeen studies described an adequate method of random sequence generation in the papers or in further information received via correspondence with the authors (Arantes 2009; Bayani 2016; Bernhardt 2001; Bird 2007; Bradley 2007, Bruno 2011; Eslamian 2016b; Eslamian 2016a; Farzanegan 2012; Gupta 2014; Kawamoto 2010; Najafi 2015; Ousehal 2009; Paganelli 1993; Patel 2011; Wang 2012; Young 2006). We assessed these 17 trials as being at low risk of bias for this domain. The remaining 15 studies simply stated that participants were randomized. Since their methods were not described, or remained unclear, we assessed them as being at unclear risk of bias for this domain.

Allocation concealment
Fourteen studies described an adequate method of allocation concealment in the papers or through further information received via correspondence with the authors (Bernhardt 2001; Bird 2007; Bradley 2007; Eslamian 2014; Eslamian 2016b; Gupta 2014; Kawamoto 2010; Kluemper 2002; Najafi 2015; Nik 2016; Ousehal 2009; Paganelli 1993; Wang 2012). Therefore, we assessed these 14 trials as being at low risk of bias for this domain. Seventeen of the remaining studies did not mention any methods used to conceal the random sequence, so we assessed them as being at unclear risk of bias. One trial author, in correspondence, stated that the allocation was not concealed in his study, so we assessed it as being at high risk of bias for this domain (Bruno 2011).

We assessed 11 studies as being at low risk of bias for both random sequence generation and allocation concealment, and, therefore, at overall low risk of selection bias (Bernhardt 2001; Bird 2007; Bradley 2007; Eslamian 2016b; Eslamian 2016a; Gupta 2014; Kawamoto 2010; Najafi 2015; Ousehal 2009; Paganelli 1993; Wang 2012).
Blinding

Blinding of participants and personnel (performance bias)
Twenty studies described adequate methods of blinding of participants and personnel, and, therefore, were assessed as being at low risk of bias for this domain (Abtahi 2006; Bayani 2016; Bernhardt 2001; Bird 2007; Bradley 2007; Eslamian 2014; Eslamian 2016b; Eslamian 2016a; Farzanegan 2012; Kawamoto 2010; Kluemper 2002; Najafi 2015; Ngal 1994; Nik 2016; Polat 2005a; Polat 2005b; Salmassian 2009; Steen-Law 2000; Sudhakar 2014; Tuner 2014). It was not possible to blind participants to the type of intervention in four studies (Bruno 2011; Ousehal 2009; Paganelli 1993; Wang 2012). Therefore, we assessed these four studies as being at a high risk of performance bias. The remaining eight studies stated that blinding was achieved, but did not describe their methods, and so we assessed them as being at unclear risk of performance bias.

Blinding of outcome assessment (detection bias)
Seventeen studies described an adequate method of blinding of outcome assessment (Bayani 2016; Bernhardt 2001; Bird 2007; Bradley 2007; Bruno 2011; Eslamian 2014; Kawamoto 2010; Kohli 2011; Najafi 2015; Ngal 1994; Nik 2016; Ousehal 2009; Paganelli 1993; Salmassian 2009; Steen-Law 2000; Sudhakar 2014; Wang 2012). Therefore, we assessed them as being at low risk of detection bias. The remaining 15 studies stated that blinding was achieved, but did not describe their methods, so we assessed them as being at unclear risk of detection bias.

Incomplete outcome data
We assessed eight studies as being at high risk of attrition bias due to high numbers of dropouts (Bayani 2016; Bernhardt 2001; Bruno 2011; Eslamian 2016b; Eslamian 2016a; Kawamoto 2010; Najafi 2015; Steen-Law 2000). The remaining 24 studies had negligible, or no attrition, and, therefore, we assessed them as being at low risk of attrition bias.

Selective reporting
We assessed 13 studies as being at a high risk of selective reporting bias. Eleven of these studies did not report the outcomes appropriately and we were unable to use the data for pooling (Abtahi 2006; Arantes 2009; Bayani 2016; Bird 2007; Eslamian 2014; Eslamian 2016b; Eslamian 2016a; Ngal 1994; Patel 2011; Sudhakar 2014; Young 2006). One study did not report outcomes for all time points investigated (Lauritano 2000). Another did not report on the outcome of bite efficiency as measured with a modified mastication performance index (Minor 2009). The remaining 19 studies reported appropriately on all outcomes, and, therefore, we assessed them as being at low risk of reporting bias.

Other potential sources of bias
We assessed six studies as being at high risk of other sources of bias. Four of these studies provided no baseline characteristics of groups, or sample sizes for the final numbers included in the analysis (Arantes 2009; Bayani 2016; Bird 2007; Lauritano 2000). There was an imbalance between numbers of males and females at baseline in two studies (Abtahi 2006; Tuner 2014). Two further studies failed to report gender or age at baseline by study group, and we assessed these as being at unclear risk of bias (Ousehal 2009; Pelisson 2008; Young 2006). We did not consider the remaining 23 studies to have any other potential sources of bias, and, therefore, we assessed them as being at low risk of bias for this domain.

Overall risk of bias
We assessed only one study as being at low risk of bias overall (Bradley 2007). We assessed 10 studies as being at unclear risk of bias overall (Farzanegan 2012; Gupta 2014; Kluemper 2002; Kohli 2011; Nik 2016; Patel 2011; Pelisson 2008; Polat 2005a; Polat 2005b; Salmassian 2009). We assessed the remaining 21 studies as being at high risk of bias overall. This is summarised in Figure 1 and Figure 2.

Effects of interventions
See: Summary of findings for the main comparison Analgesic compared to control (placebo or no treatment) for pain relief during orthodontic treatment; Summary of findings 2 NSAID compared to paracetamol for pain relief during orthodontic treatment; Summary of findings 3 Pre-emptive ibuprofen compared to ibuprofen post-treatment for pain relief during orthodontic treatment; Summary of findings 4 NSAID compared to local anaesthetic for pain relief during orthodontic treatment

Comparison 1: Analgesic versus control (placebo or no treatment)

Pain
We combined data from 10 studies (685 participants) that measured pain at two hours. Four of these studies were at a high risk of bias (Bruno 2011; Farzanegan 2012; Kawamoto 2010; Minor 2009); whilst the remaining six were at unclear risk of bias (Gupta 2014; Kohli 2011; Nik 2016; Pelisson 2008; Polat 2005a; Polat 2005b). All except Pelisson 2008 also provided data at six hours (535 participants). These 10 studies measured pain at 24 hours, but Minor 2009 did not provide data. Three additional studies measured pain at 24 hours: one study had an unknown risk of bias (Salmassian 2009), and the other two studies were at a high risk of bias (Tunercorrection).
This resulted in a total of 12 studies (1012 participants) being combined in a meta-analysis for pain at 24 hours. The meta-analyses showed that analgesics reduced mean pain intensity during orthodontic treatment at:

- 2 hours (mean difference (MD) -11.66 mm, 95% confidence interval (CI) -16.15 to -7.17, P < 0.00001; 10 studies; Analysis 1.1);
- 6 hours (MD -24.27 mm, 95% CI -31.44 to -17.11, P < 0.001; 9 studies; Analysis 1.2); and
- 24 hours (MD -21.19 mm, 95% CI -28.31 to -14.06, P < 0.001; 12 studies; Analysis 1.3), when compared to a placebo or no-treatment control.

However, there was substantial heterogeneity at all three time points ($I^2$ statistic between 70% and 85%), which may be related in part to variations in orthodontic treatment method, or to different interventions at different doses. Data for all time points was deemed to provide evidence of moderate quality.

We were unable to use the data from 11 studies that compared analgesics with control. The reported results for 10 of these studies (Abtahi 2006; Arantes 2009; Bayani 2016; Eslamian 2014; Eslamian 2016b; Eslamian 2016a; Ngan 1994; Patel 2011; Sudhakar 2014; Young 2006), plus extra narrative is given in Analysis 1.4. In general, these findings agreed with the meta-analyses presented above. Paganelli 1993 compared an NSAID mouthwash with placebo, but only reported data at baseline, three and seven days after separator placement, so did not report pain at the time points of interest to this review.

**Subgroup analysis and heterogeneity**

We included two subgroups for paracetamol and NSAID in the pooled estimate for any analgesic versus control (placebo or no treatment) at each time point. There was no evidence of a difference between the subgroups. Although no difference was found between the subgroups, the effect estimates for ibuprofen are given below as this is the most common analgesic:

- 2 hours (MD -16.10, 95% CI -17.63 to -10.99, P < 0.001; 8 studies, 265 participants)
- 6 hours (MD -22.96, 95% CI -35.42 to -10.49, P < 0.001; 7 studies, 227 participants)
- 24 hours (MD -17.95, 95% CI -28.64 to -7.27, P < 0.001; 10 studies, 588 participants)

There were insufficient trials comparing the same NSAID to make subgroup comparisons between them. For each meta-analysis, there was substantial heterogeneity. This may have been due in part to the type of orthodontic intervention, which we explored in a subgroup analysis of pain following separator placement and pain following placement of an initial archwire.

For separator placement, paracetamol was more effective than a control at reducing pain at 2 and 6 hours, however, there was no difference at 24 hours. There was no heterogeneity at 2 or 6 hours ($I^2 = 0$%), however, there was considerable heterogeneity at 24 hours ($I^2 = 65$%) (Table 1). For archwire placement, paracetamol was more effective than a control at reducing pain at 2, 6 and 24 hours. There was no heterogeneity at 2 hours ($I^2 = 0$%), and low heterogeneity - which may not be important - at 6 hours ($I^2 = 6$%), but there was considerable heterogeneity at 24 hours ($I^2 = 85$%) (Table 2).

For separator placement, NSAIDs were more effective than a control at reducing pain at 2, 6 and 24 hours. The results for heterogeneity improved, with low heterogeneity - which may not be important - at 2 hours ($I^2 = 23$%), no heterogeneity at 6 hours ($I^2 = 0$%), and moderate heterogeneity at 24 hours ($I^2 = 42$%) (Table 3).

For archwire placement, NSAIDs were more effective than a control at reducing pain at 2, 6 and 24 hours. However, there was moderate heterogeneity at 2 hours ($I^2 = 47$%), low heterogeneity at 6 hours ($I^2 = 10$%), and considerable heterogeneity at 24 hours ($I^2 = 85$%) (Table 4).

For participants who were mid-treatment, NSAIDs, in the form of ketoprofen chewing gum, were more effective than a control at reducing pain at 2, 6 and 24 hours (Table 5).

**Rescue analgesia**

Use of rescue analgesia was recorded in seven studies (Arantes 2009; Bernhardt 2001; Bradley 2007; Bruno 2011; Najafi 2015; Steen-Law 2000; Tuncer 2014). Only two of these studies reported data on the number of participants who required rescue medication during the study (Bruno 2011; Tuncer 2014). Tuncer 2014 reported that two participants required rescue medication, whilst Bruno 2011 reported that six participants required the use of analgesic medication during the study. No further information was available relating to class, dose or timing of this medication.

**Adverse events**

No studies in this comparison reported any adverse events.

**Quality of life or participant satisfaction**

One study reported quality of life assessed using SF-36 and found that, at 30 days, there was a significant reduction in the scale of bodily pain compared to baseline results, however, there were no significant differences in other variables of the SF-36 among the three treatment groups (Wang 2012). The study also recorded SAS scores and found that these were not significantly different between the three treatment groups.

One study reported quality of life assessed using STAI and PANAS, and found that there were no significant differences between the treatment groups (Minor 2009).
Time off school or work
No studies in this comparison reported this outcome.

Failure to complete orthodontic treatment due to the pain experienced
No studies reported this outcome.

Comparison 2: NSAID versus paracetamol

Pain
We combined seven studies in a meta-analysis for pain at 2 hours and at 6 hours. Three of these studies were at a high risk of bias (Kawamoto 2010; Najafi 2015; Ousehal 2009); three studies were at an unclear risk of bias (Gupta 2014; Nik 2016; Polat 2005a); and one study was assessed as being at a low risk of bias (Bradley 2007). In total, 664 participants were analyzed at these time points (Analysis 2.1; Analysis 2.2).

For the outcome at 24 hours, we combined nine studies in a meta-analysis (Analysis 2.3). Four of these studies were at a high risk of bias (Kawamoto 2010; Najafi 2015; Ousehal 2009; Tuncer 2014); four studies were at an unclear risk of bias (Gupta 2014; Nik 2016; Polat 2005a; Salmassian 2009); and one study was assessed as being at a low risk of bias (Bradley 2007). In total, 734 participants were analyzed for pain at 24 hours.

Six different classes of NSAIDs were investigated across the nine studies. Eight studies investigated ibuprofen (Bradley 2007; Kawamoto 2010; Najafi 2015; Nik 2016; Ousehal 2009; Polat 2005a; Salmassian 2009; Tuncer 2014). One study also investigated each of the following: aspirin (Polat 2005a), etoricoxib (Gupta 2014), flurbiprofen (Polat 2005a), meloxicam (Najafi 2015), and naproxen sodium (Polat 2005a).

The meta-analysis showed no evidence of a difference in mean pain intensity during orthodontic treatment between NSAID and paracetamol at 2, 6 or 24 hours.

- 2 hours (MD -2.92, 95% CI -8.48 to 2.65, P = 0.30; 7 studies, 664 participants; Analysis 2.1)
- 6 hours (MD -5.17, 95% CI -11.71 to 1.37, P = 0.12; 7 studies, 664 participants; Analysis 2.2)
- 24 hours (MD -0.51, 95% CI -8.93 to 7.92, P = 0.91; 9 studies, 734 participants; Analysis 2.3), when compared to paracetamol.

A further study compared NSAID versus paracetamol and the findings support those presented above (Sudhakar 2014) (Analysis 2.4).

For separator placement, NSAIDs were no more effective than paracetamol for reducing pain at 2, 6 and 24 hours. The results for heterogeneity improved, with low heterogeneity - which may not be important - at 2 hours ($I^2 = 6%$), moderate heterogeneity at 6 hours ($I^2 = 40%$), and no heterogeneity at 24 hours ($I^2 = 0%$) (Table 6). We considered the data for all time points to be of low quality.

Again, for archwire placement, NSAIDs were no more effective than paracetamol for reducing pain at 2, 6 and 24 hours. Heterogeneity in these results remained, with substantial heterogeneity at 2 hours ($I^2 = 73%$) and 6 hours ($I^2 = 63%$), and considerable heterogeneity at 24 hours ($I^2 = 82%$) (Table 7).

Rescue analgesia
Two studies in this comparison reported that participants required rescue medication during the study (Bradley 2007; Najafi 2015). Bradley 2007 reported that 18 participants required rescue medication. The percentages of participants who took additional analgesics were 9% (7 participants) in the paracetamol group and 14% (11 participants) in the ibuprofen group (relative risk (RR) 1.5, 95% CI 0.60 to 3.60). The study stated that “the additional analgesics were most often taken at bedtime or on day one after separator placement”; however, no additional information was available regarding class, dose or specific timing of medication. Najafi 2015 reported 18 participants used other analgesics during the study, again, no further information was available relating to class, dose or timing.

Adverse events
One study reported that one participant (< 1%) experienced a suspected adverse reaction (Bradley 2007). Further information was provided in an additional paper that detailed an incident involving a 12-year-old boy with no relevant medical history and no history of drug allergy (McAlinden 2005): “Following 2 doses of the intervention analgesia, the patient was still experiencing discomfort and self-medicated with 1000 mg of paracetamol. Several hours later he suddenly developed a rash on all parts of his body described as ‘red, blotchy and itchy’. There were no other symptoms. The patient attended his GMP [general medical practitioner] the following day and was prescribed a course of anti-histamines. He did not report the adverse reaction to the trial coordinators until 1 week after the trial drugs were given, at which time the rash had completely resolved and the patient was symptom-free. A provisional diagnosis of drug hypersensitivity to either the trial drug or to the paracetamol was made. Since one of the trial drugs was also paracetamol we decided to break the randomisation code for this patient to determine which drug the patient had received. The trial drug given was found to be paracetamol, suggesting a drug hypersensitivity reaction to paracetamol. Before a controlled Drug Provocation Test (DPT) could be organized, the patient took another dose of paracetamol on the advice of his GMP. On this occasion there was no reaction to the drug, suggesting a previous false positive result. Since the patient had already taken paracetamol without event, the DPT was deemed unnecessary.”
Quality of life or participant satisfaction
No studies in this comparison reported this outcome.

Time off school or work
No studies in this comparison reported this outcome.

Failure to complete orthodontic treatment due to the pain experienced
No studies in this comparison reported this outcome.

Comparison 3: one type of NSAID versus another type of NSAID

Pre-emptive NSAID versus NSAID post-treatment

Pain
One study at a high risk of bias showed that pre-emptive ibuprofen reduced mean pain intensity following separator placement at 2 hours (MD -11.30, 95% CI -16.27 to -6.33, P < 0.001; 41 participants) when compared with ibuprofen taken post-treatment (Steen-Law 2000) (Analysis 3.1). Data from a second paper did not contribute to data at this time point, as participants in the comparison group did not receive the active intervention until 6 hours post-treatment (Bernhardt 2001).

For pain at 6 hours and 24 hours, two studies at high risk of bias compared ibuprofen taken pre-emptively with ibuprofen taken post-treatment for the placement of separators, analysing 69 participants (Bernhardt 2001; Steen-Law 2000). This showed that there was no difference at 6 hours (MD -8.43, 95% CI -30.37 to 13.50, P = 0.45; Analysis 3.2); or 24 hours (MD -9.74, 95% CI -47.88 to 28.40, P = 0.62; Analysis 3.3). Additionally, although there was no heterogeneity at 2 hours (I² = 0%), there was substantial heterogeneity at 6 hours (I² = 72%), and considerable heterogeneity at 24 hours (I² = 87%). We considered data for all time points to be of very low quality.

Rescue analgesia
Two studies in this comparison reported on the need for rescue medication during the study. One study reported that 22 participants required additional analgesics during the study (Bernhardt 2001). These 22 participants were evenly distributed among the three groups in the study, but no further information was available relating to class, dose or timing of the medication, and participants from one group who received pre-emptive and post-treatment ibuprofen did not contribute to the analysis in this review. One study reported that 17 participants required additional analgesics during the study, four in the pre-emptive ibuprofen group; six in the post-treatment ibuprofen group and seven in the control group, who did not contribute to the analysis in this review (Steen-Law 2000). No further information was available relating to class, dose or timing of medication. When these results were combined, we did not find evidence of a difference in risk of requiring rescue analgesia when ibuprofen was taken pre-emptively compared to after treatment (RR 0.8, 95% CI 0.30 to 1.90).

Adverse events
No studies in this comparison reported any adverse events.

Quality of life and/or participant satisfaction
No studies in this comparison reported this outcome.

Time off school/work
No studies in this comparison reported this outcome.

Failure to complete orthodontic treatment due to the pain experienced
No studies in this comparison reported this outcome.

One NSAID versus another NSAID: ketoprofen (160 mg) versus benzidamine chloride (22.5 mg)

Pain
One further study compared ketoprofen versus benzidamine chloride mouthwashes (Lauritano 2000). It presented data at four days only so we were unable to include the data in this review.

Adverse events
The study did not report any adverse events.

Quality of life and/or participant satisfaction
The study did not report this outcome.

Time off school or work
The study did not report this outcome.

Failure to complete orthodontic treatment due to the pain experienced
The study did not report this outcome.
**Comparison 4: NSAID versus local anaesthetic**

**Pain**
One study at unclear risk of bias, compared ketoprofen chewing gum with benzocaine chewing gum, for the relief of pain mid-treatment, and analyzed 48 participants (Eslamian 2014). We were unable to use the data from this cross-over study as the mean and standard deviation results were unclearly reported; however, the results showed no evidence of a difference between the interventions. We judged the data for this comparison to be of very low quality.

**Adverse events**
The study did not report any adverse events.

**Quality of life or participant satisfaction**
The study did not report this outcome.

**Time off school or work**
The study did not report this outcome.

**Failure to complete orthodontic treatment due to the pain experienced**
The study did not report this outcome.

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**Comparison 5: one type of NSAID versus another type of NSAID**

**Pain**
One study at high risk of bias, compared ketoprofen chewing gum with benzocaine chewing gum, for the relief of pain mid-treatment, and analyzed 48 participants (Eslamian 2014). We were unable to use the data from this cross-over study as the mean and standard deviation results were unclearly reported; however, the results failed to show a benefit for either intervention.

**Adverse events**
The study did not report any adverse events.

**Quality of life or participant satisfaction**
The study did not report these outcomes.

**Time off school or work**
The study did not report this outcome.

**Failure to complete orthodontic treatment due to the pain experienced**
The study did not report this outcome.
### ADDITIONAL SUMMARY OF FINDINGS

**NSAID compared to paracetamol for pain relief during orthodontic treatment**

Population: people undergoing orthodontic treatment  
Setting: any dental setting  
Intervention: NSAID  
Comparison: paracetamol

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Anticipated absolute effects* (95% CI)</th>
<th>Relative effect (95% CI)</th>
<th>Number of participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk with paracetamol</td>
<td>Risk with ibuprofen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain assessed with VAS (0 to 100 mm where 0 = no pain) Follow-up: mean 2 hours</td>
<td>Mean pain ranged from 8.8 mm to 32.4 mm on a VAS MD 2.92 mm lower on the VAS (8.48 mm lower to 2.65 mm higher)</td>
<td>-</td>
<td>664 (7 RCTs)</td>
<td>⊕⊕⊕⊕ low1,2</td>
<td>Findings at 6 and 24 hours were similar and not statistically significant</td>
</tr>
<tr>
<td>Rescue analgesia</td>
<td>91 per 1000</td>
<td>136 per 1000 (55 to 327)</td>
<td>RR 1.5 (0.6 to 3.6)</td>
<td>159 (1 RCT)</td>
<td>⊕⊕⊕⊕ very low3</td>
</tr>
<tr>
<td>Adverse events</td>
<td>In one study, one participant (&lt; 1%) in the paracetamol group experienced drug hypersensitivity involving a “red, blotchy and itchy rash”, which resolved without treatment within 1 week</td>
<td>-</td>
<td>(1 RCT)</td>
<td>⊕⊕⊕⊕ very low3</td>
<td></td>
</tr>
</tbody>
</table>

* The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).  
CI: confidence interval; MD: mean difference; NSAID: non-steroidal anti-inflammatory; RR: risk ratio; VAS: visual analogue scale
GRADE Working Group grades of evidence

High quality: we are very confident that the true effect lies close to that of the estimate of the effect

Moderate quality: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low quality: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect

Very low quality: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of the effect

1 Downgraded one level for risk of bias: three studies at high risk of bias and two at unknown risk of bias; only one study of low risk of bias.

2 Downgraded one level for imprecision of estimate.

3 Downgraded as only one trial reported on this.
Pre-emptive ibuprofen compared to ibuprofen post-treatment for pain relief during orthodontic treatment

**Population:** pain relief during orthodontic treatment  
**Setting:** dental hospital  
**Intervention:** ibuprofen pre-emptively  
**Comparison:** ibuprofen post-treatment

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Anticipated absolute effects* (95% CI)</th>
<th>Relative effect (95% CI)</th>
<th>Number of participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Risk with ibuprofen post-treatment</strong></td>
<td><strong>Risk with ibuprofen pre-emptively</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain assessed with VAS (0 to 100 mm where 0 = no pain) Follow-up: mean 2 hours</td>
<td>Mean pain ranged from 19.1 mm to 20.5 mm MD 11.30 mm lower (16.27 mm lower to 6.33 mm lower)</td>
<td>-</td>
<td>41 (1 RCT)</td>
<td>⬤⬤⬤⬤ very low 1,2,3</td>
<td>Effect no longer seen at 6 or 24 hours (2 studies with 69 participants)</td>
</tr>
<tr>
<td>Rescue analgesia</td>
<td>316 per 1000 (95 to 600)</td>
<td>253 per 1000 (95 to 600)</td>
<td>RR 0.8 (0.3 to 1.9)</td>
<td>41 (1 RCT)</td>
<td></td>
</tr>
<tr>
<td>Adverse events</td>
<td>Not reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI: confidence interval; MD: mean difference; RR: risk ratio; VAS: visual analogue scale

**GRADE Working Group grades of evidence**

- **High quality:** we are very confident that the true effect lies close to that of the estimate of the effect
- **Moderate quality:** we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
- **Low quality:** our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect
- **Very low quality:** we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect

1 Downgraded one level for risk of bias: high risk of attrition bias.
2 Downgraded one level as single small study.
3 Downgraded one level for imprecision: the confidence interval is wide and crosses no difference.
4 Downgraded one level for inconsistency: significant heterogeneity.
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Anticipated absolute effects* (95% CI)</th>
<th>Relative effect (95% CI)</th>
<th>Number of participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk with local anaesthetic</td>
<td>Risk with NSAID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain assessed with VAS</td>
<td>Mean pain was 51 mm</td>
<td>MD 13 mm higher (3.45 mm lower to 29.45 mm higher)</td>
<td>-</td>
<td>48 (1 RCT)</td>
<td>☩������ very low¹,²</td>
</tr>
<tr>
<td>Rescue analgesia</td>
<td>Not measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adverse events</td>
<td>Not measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI: confidence interval; MD: mean difference; NSAID: non-steroidal anti-inflammatory; VAS: visual analogue scale.

GRADE Working Group grades of evidence
- **High quality**: we are very confident that the true effect lies close to that of the estimate of the effect
- **Moderate quality**: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
- **Low quality**: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect
- **Very low quality**: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect

¹ Downgraded two levels as single, small study at unclear risk of bias
² Downgraded one level for imprecision: the confidence interval crosses the line of no difference.
DISCUSSION

Summary of main results
Thirty-two randomized controlled trials (RCTs) met our eligibility criteria and were included in this review. We performed a meta-analysis where appropriate for the main outcome of pain intensity at 2 hours, 6 hours and 24 hours after orthodontic treatment. All data were measured using a visual analogue scale (VAS), with most studies comparing the effectiveness of drug interventions following either placement of separators or placement of an initial aligning archwire. We assessed the quality of the body of evidence for each comparison and outcome.

Analgesic versus control
We found moderate-quality evidence that analgesics were effective at reducing pain intensity at 2 hours, 6 hours and 24 hours following orthodontic treatment. Subgroup analysis by drug type found that both paracetamol and NSAIDs were effective at reducing pain intensity at 2 hours, 6 hours and 24 hours after treatment compared with a placebo or no treatment group, and there was no evidence of a difference between the subgroups. We performed further subgroup analyses, grouping data according to the orthodontic intervention carried out, and found the following.

- Non-steroidal anti-inflammatory (NSAIDs) were significantly more effective at reducing pain intensity than a control intervention at all time points, regardless of the orthodontic intervention.
- Paracetamol was significantly more effective at reducing pain intensity than a control intervention at all time points when an initial archwire was placed, however, it was effective only at 2 hours and 6 hours following placement of separators. By 24 hours, there was no significant difference between the effectiveness of paracetamol or a control intervention on pain intensity.

NSAID versus paracetamol
There was insufficient evidence to claim that either NSAIDs or paracetamol were better at reducing pain intensity at 2 hours, 6 hours or 24 hours following either the placement of separators or placement of an initial aligning archwire (low-quality evidence).

Pre-emptive NSAID versus post-treatment NSAID
We found some very low-quality evidence that ibuprofen taken one hour prior to separator placement significantly reduced pain intensity at 2 hours after treatment when compared to ibuprofen taken post-treatment. However, it is worth noting that this effect was seen at 2 hours, even when ibuprofen was taken immediately after treatment. However, at 6 hours and 24 hours, there was no significant difference detected.

NSAID versus local anaesthetic
One study compared the use of topical ketoprofen chewing gum (NSAID) with benzocaine chewing gum (local anaesthetic). This small study did not show evidence of a difference between ketoprofen or benzocaine in terms of pain intensity following treatment, and, therefore, no recommendation can be made to support one intervention over the other (very low-quality evidence).

Overall completeness and applicability of evidence
Overall, we found 32 studies that investigated interventions to treat pain associated with orthodontic treatment. The studies measured multiple outcomes. Six studies compared paracetamol with a control group receiving either no treatment or a placebo; 14 studies compared NSAIDs with a control group receiving either no treatment or a placebo; nine studies compared NSAIDs with paracetamol and five studies compared different classes of NSAIDs with one another. Two studies compared ibuprofen taken pre-emptively with ibuprofen taken postoperatively. Two studies compared benzocaine local anaesthetic with a control group receiving a placebo, and one study compared NSAIDs with a local anaesthetic. The current evidence allowed us to assess if any of the interventions succeed in providing pain relief during the first 24 hours of orthodontic treatment.

Most studies carried out an a priori sample size calculation; however, due to high levels of attrition, it is likely that five studies were underpowered to find a difference between their analgesic and control groups (Bernhardt 2001; Bruno 2011; Kawamoto 2010; Najafi 2015; Steen-Law 2000). There was a lack of clear reporting, especially with respect to methodology, as well as some cases of inappropriate or missing statistical data. In particular, presentation of the results for cross-over studies was problematic. Some of the evidence was moderate quality, but much of it was of low or very low quality and the results must be interpreted with caution.

Quality of the evidence
We describe the overall quality of the evidence in the 'Summary of findings' tables (Summary of findings for the main comparison; Summary of findings 2; Summary of findings 3; Summary of findings 4). We graded the evidence for all comparisons and outcomes as moderate, low, or very low quality. The reasons for our gradings included the small number of studies and participants, the high or unclear risk of bias in these studies, and the high level of heterogeneity in the meta-analyses.
Potential biases in the review process

We minimised bias in this review by using a broad, sensitive search of multiple databases with no restrictions on language. We also searched for unpublished studies and data, and included studies reported in all languages. However, numerous potential biases have been detected, both within and between, individual studies included in this review.

We were unable to pool data from 10 studies in the meta-analyses due to inconsistencies or inappropriate presentation of the data (Abtahi 2006; Arantes 2009; Bayani 2016; Eslamian 2014; Eslamian 2016b; Eslamian 2016a; Ngan 1994; Patel 2011; Sudhakar 2014; Young 2006).

Data were not presented in any study according to the class, dose or specific timing of rescue analgesia taken, despite six studies recording these medications. This presents a potential bias and limitation, as it may be that one intervention required more additional analgesics than another, ultimately influencing the pain intensity experienced, and this effect may have been attributed to the trial intervention.

A number of included studies had small sample sizes, which in some cases did not reach the minimum number required to detect a difference based on the studies’ sample size calculations. Additionally, multiple studies with three or more arms required the sample sizes to be split for the purpose of comparison. The control arm sample size was split for the comparison of analgesics versus control in 10 studies (Bruno 2011; Eslamian 2014; Gupta 2014; Kawamoto 2010; Kohli 2011; Nik 2016; Polat 2005a; Polat 2005b; Salmassian 2009; Tuner 2014). The paracetamol arm sample size was split for the head-to-head comparison of NSAIDs versus paracetamol in two studies (Najafi 2015; Polat 2005a). This resulted in small numbers of participants and wide confidence intervals in the final analysis, which may have had an impact on the overall outcome.

Another limitation of the studies was heterogeneity, which was identified to varying degrees across all comparisons. We considered this to be caused by clinical heterogeneity, such as individual variations in participant responses to pain, differences in orthodontic treatments, and different doses, classes and timings of the analgesics. We carried out further subgroup analyses, by orthodontic intervention, to determine if this was the cause of the heterogeneity. Our results showed that, although it did account for some heterogeneity, and reduced the I² statistic to some extent in most cases, heterogeneity still remained. We did not feel that further subgroup analysis to try to account for this remaining element of heterogeneity, for example by reanalyzing according to timing of intervention, was appropriate due to the small number of studies. Therefore, we allowed for the heterogeneity by using a random-effects model.

Agreements and disagreements with other studies or reviews

We found three other reviews that reported on comparisons and outcomes similar to those in this review (Angelopoulou 2012; Ashley 2016; Xiaoting 2010). Angelopoulou 2012 and Xiaoting 2010 reported the efficacy of ibuprofen with lower confidence than we have reported. Although each of these reviews found a significant difference between ibuprofen and a control group receiving a placebo or no treatment, Angelopoulou 2012 found there was only a significant difference at two hours and six hours following placement of separators or an initial aligning archwire, whilst Xiaoting 2010 reported the difference as significant only at six hours and 24 hours following placement an initial aligning archwire. We are able to be more confident in the findings than previous reviews, because we have included several additional studies that were published subsequent to the other reviews.

Additionally, Xiaoting 2010 reported that there was no difference in pain control between ibuprofen and paracetamol, which supports the findings of this review.

The Ashley 2016 Cochrane Review reported the efficacy of pre-emptive ibuprofen at two hours, which supports our conclusion that pre-emptive ibuprofen is effective at reducing pain following treatment. However, unlike this review, they did not investigate the effectiveness at any time points beyond two hours.

Authors’ Conclusions

Implications for practice

There is moderate-quality evidence that the use of analgesics reduces the pain associated with orthodontic treatment.

Due to a lack of evidence, we remain uncertain whether the systemic non steroidal anti-inflammatories (NSAIDs) are more effective than paracetamol, and whether topical NSAIDs are more effective than local anaesthetic, at reducing pain associated with orthodontic treatment.

There is very low-quality evidence that the use of pre-emptive ibuprofen, taken one hour before orthodontic treatment, significantly reduces pain up to two hours after treatment; however, the effect appears to reduce over time, with no evidence of a difference at six hours and beyond.

Implications for research

In view of the quality of the available evidence, it is difficult to draw definitive conclusions regarding the relative effectiveness of different drugs, and whether taking an analgesic before treatment is effective.

The results of this review imply that there is a need for more long-term, well designed and reported randomized controlled clinical
studies to assess the efficacy of drug interventions with relation to NSAIDs and paracetamol.

The design of future studies should consider the following.

- Clear inclusion and exclusion criteria should be set, taking into consideration factors that can effect participant perception of pain, particularly gender.
- An a priori sample size calculation should be carried out.
- Presentation and analysis of data should be appropriate, especially for cross-over studies.
- There should be adequate reporting of rescue analgesics taken by participants in each arm of the trial. We recommend that the following be reported:
  - type of drug taken;
  - dose of drug taken;
  - time at which drug was taken
  - intervention group of person taking the drug.
- Adverse effects should be reported; and if none were encountered, this should be recorded.
- Reports of clinical trials would be improved by following the guidelines produced by the CONSORT group to ensure that all relevant information is provided.

ACKNOWLEDGEMENTS

We would like to thank James E. Cooper for his work on the protocol. We would like to thank Anne Littlewood (Information Specialist, Cochrane Oral Health) for developing the search strategy; Laura MacDonald for editorial management of the review; Jo Weldon for entering study characteristics to tables; Scott Deacon, Tanya Walsh and Ruth Floate for editorial comments; Soodabeh Behboodi and Greg Herbert for external referee feedback; and Elizabeth Royle for final copy editing.

We are grateful to Dr Sepideh Banava for translating Abtahi 2006 from Farsi, and to Janet Lear for arranging this.

We would also express our sincere thanks to the following study authors who provided extra information on their studies.

- Marcella Bruno: provided mean and standard deviation data relating to VAS measurements of pain intensity, as well as details of random sequence generation and allocation concealment (Bruno 2011).
- Melissa Bernhardt: provided details of random sequence generation and allocation concealment (Bernhardt 2001).
- Sarvraj Kohli: provided details of random sequence generation, allocation concealment and blinding (Kohli 2011).
- Sara Yousefinia: provided details of random sequence generation, allocation concealment and orthodontic intervention (Eslamian 2014).

REFERENCES

References to studies included in this review

Abtahi 2006 {published and unpublished data}

Arantes 2009 {published data only (unpublished sought but not used)}

Bayani 2016 {published data only}

Bernhardt 2001 {published data only (unpublished sought but not used)}

Bird 2007 {published data only (unpublished sought but not used)}

Bradley 2007 {published data only (unpublished sought but not used)}


Bruno 2011 {published and unpublished data}
Bruno MB, Bruno MA, Krymchantowski AV, da Motta AF, Mucha JN. A double-blind, randomized clinical trial...
Pharmacological interventions for pain relief during orthodontic treatment (Review)

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in controlling pain after orthodontic tooth movement. 


**Steen-Law 2000 [published data only (unpublished sought but not used)]**


**Sudhakar 2012 [published data only (unpublished sought but not used)]**


**Tuncer 2014 [published data only]**


**Wang 2012 [published data only]**


**Young 2006 [published data only (unpublished sought but not used)]**


**References to studies excluded from this review**

**Al-Melh 2017 [published data only]**


**Cherubini 2003 [published data only]**


**Eslamian 2010 [published data only]**


**Eslamian 2017a [published data only]**


**Ireland 2016 [published data only]**


**Murdock 2010 [published data only]**


**Ogata 1999 [unpublished data only]**


**Parks 2001 [unpublished data only]**


**Soheilifar 2016 [unpublished data only]**

Soheilifar S. Comparison of pain perception from two type of elastomeric and brass wire separators and utilizing menthol patch and benzocaine patch in orthodontic patients: a randomized clinical trial. Iranian Registry of Clinical Trials 2016.

**References to studies awaiting assessment**

**Eslamian 2017b [published data only]**


**Moradinejad 2014 [published data only]**


**Rooke 2012 [published data only]**

Rooke J. A randomised prospective study of analgesic protocols involving ibuprofen and acetaminophen (paracetamol) for the management of orthodontic pain and discomfort in relation to fitting of fixed appliances in patients aged 14-19. Australian New Zealand Clinical Trials Registry 2012.
References to ongoing studies

Mohammed 2016  [unpublished data only]

Additional references

Angelopoulou 2012
Angelopoulou M, Vlachou V, Halazonetis DJ.

Ashley 2016
Ashley PF, Parekh S, Moles DR, Anand P, MacDonald LC.

British Orthodontic Society
British Orthodontic Society. Treatment and Brace Types. Available at URL: http://www.bos.org.uk/public-patients-home/orthodontics-for-children-and-teens/treatment-types..

Buttke 1999

De Carlos 2006

Fleming 2016

Higgins 2008

Johnson 1997

Jones 1992

Karthi 2012

Kehoe 1996

Keim 2005

Krishnan 2006

Krishnan 2007

Lefebvre 2011

Little 1975

McAlinden 2005

Oliver 1985

Pleuvry 1993

Proffit 2000

Rashidpour 2012

Sergl 1998
Shek 1993

Shenoy 2013

Xiaoting 2010

* Indicates the major publication for the study
### Characteristics of included studies  
*ordered by study ID*

#### Abtahi 2006

| Methods | Setting: orthodontics private offices (in Hamedan, Iran)  
Design: parallel (3 arms)  
Number of centres: 1  
Study duration: not reported |
|---|---|
| Participants | Inclusion criteria: people who were not experiencing any kind of pain before treatment, or using any kind of analgesic; and who did not have any kidney or liver disease or other contraindication for using the medications being tested in the study  
Exclusion criteria: people who had not completed the questionnaires in different times [sic]; people who consumed other analgesics during the study  
Orthodontic intervention: separator placement  
Participant sampling:  
n = 60 recruited and randomized  
n = 0 lost to follow-up  
n = 60 data analyzed (18 male:42, female, mean age 15.43 years ± 3.7)  
Group 1 (n = 20): 10 male:3 female, mean age 15.75 ± 3.95 years  
Group 2 (n = 20): 4 male:10 female, mean age 15.05 ± 3.49 years  
Group 3 (n = 20): 6 male:8 female, mean age 15.5 ± 3.98 years |
| Interventions | Comparison: NSAID vs placebo, opioid vs placebo, NSAID vs opioid  
Ibuprofen (800 mg) vs tramadol (100 mg) vs placebo (500 mg starch) provided pre-emptively and postoperatively following insertion of separators  
Group 1: 400 mg ibuprofen 1 h before and 5 h after insertion of separators  
Group 2: 50 mg tramadol 1 h before and 5 h after insertion of separators  
Group 3: placebo 1 h before and 5 h after insertion of separators |
| Outcomes | Pain score (VAS) recorded at 2 h, 6 h, 24 h, 2 days, 3 days and 7 days after separator placement |
| Notes | Conflict of interests/funding: no source of funding or conflict of interest reported  
Adverse events/harm: participants in the tramadol group reported dizziness, drowsiness, nausea and headache  
Data handling by review authors: study reported Group 2 as placebo arm and Group 3 as tramadol; for the purposes of the review, Groups 2 and 3 have been inverted to present tramadol as an intervention and placebo as its control  
Other information: the paper has been translated from Farsi |

#### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Unclear risk</td>
<td>Quote: “The patients who met the inclusion criteria randomly allocated in one of the three groups and received the medica-</td>
</tr>
</tbody>
</table>
**Abtahi 2006** *(Continued)*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Risk</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocation concealment</td>
<td>Unclear risk</td>
<td>inadequate information regarding allocation concealment was carried out therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of participants and personnel</td>
<td>Low risk</td>
<td>Participants were not aware of the medication to which they or others had been allocated, as they received similar sealed pockets with A, B or C stickers on them Comment: blinding appears to have been adequate</td>
</tr>
<tr>
<td>Blinding of outcome assessment</td>
<td>Unclear risk</td>
<td>inadequate information regarding method of blinding of assessors, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Incomplete outcome data</td>
<td>Low risk</td>
<td>0/60 dropouts = 0% attrition (100% completed)</td>
</tr>
<tr>
<td>Selective reporting</td>
<td>High risk</td>
<td>The data for outcomes in this study were not reported appropriately. We were unable to extract data for use in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>High risk</td>
<td>There was large variation in the gender balance of the groups at baseline, which could indicate selection bias</td>
</tr>
</tbody>
</table>

**Arantes 2009**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Setting: private clinic, Brazil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design: cross-over (3 arms)</td>
</tr>
<tr>
<td></td>
<td>Number of centres: 1</td>
</tr>
<tr>
<td></td>
<td>Study duration: not reported</td>
</tr>
<tr>
<td></td>
<td>Inclusion criteria: people of both sexes; aged 16 to 25 years; orthodontic indication for bilateral retraction of the canine teeth</td>
</tr>
<tr>
<td></td>
<td>Exclusion criteria: not reported</td>
</tr>
<tr>
<td></td>
<td>Orthodontic intervention: activation of canine retraction using NiTi springs</td>
</tr>
<tr>
<td></td>
<td>Participant sampling: n = 36 recruited, randomized and analyzed (Group A = 36, Group B = 36, Group C = 36)</td>
</tr>
</tbody>
</table>
### Interventions

**Comparisons:** NSAID vs placebo, and pre-emptive vs post-treatment analgesia  
Tenoxicam (20 mg) pre-emptive vs placebo (lactose placebo) vs tenoxicam post-treatment; provided to combat pain from canine activation  
**Group A:** tenoxicam 45 minutes before treatment, placebo just after, tenoxicam 24 h and 48 h after activation  
**Group B:** placebo 45 minutes before treatment, tenoxicam just after, tenoxicam 24 h and 48 h after activation  
**Group C:** placebo 45 minutes before treatment, just after treatment, 24 h and 48 h after activation

### Outcomes

- Pain score (VAS) recorded at 12 h, 24 h, 48 h and 72 h after each activation  
- Pain score (VDS) recorded at 12 h, 24 h, 48 h and 72 h after each activation  
- Amount of tooth movement (mm) recorded at 4 weeks after each activation (not an outcome of this review)  
- Rescue medication paracetamol up to 750 mg 3 times per day

### Notes

**Conflict of interests/funding:** “This study was supported by a grant-in-aid for scientific research from FAPESP - Fundacao de Amparo a Pesquisa de Estado de Sao Paulo.”  
**Adverse events/harm:** no rescue analgesia taken. Harm/adverse effects not reported  
**Data handling by review authors:** we were unable to extract any usable data from the study.  
**Other information:** each retraction procedure consisted of 3 activations, alternating between right and left with a 14-day wash-out interval between activations. Participants were randomised to two of the three groups for the left and right side retractions

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Low risk | *Quote:* “The patients were initially randomised into three groups (A, B, and C) using the program for randomisation available at http://www.random.org.”  
*Comment:* randomisation appears to be adequate |
| Allocation concealment (selection bias) | Unclear risk | *Quote:* “The drugs and administration methods had been concealed before the procedures.”  
*Comment:* inadequate information regarding method of allocation concealment, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias)  
All outcomes | Unclear risk | *Comment:* inadequate information regarding method of blinding, therefore unable to make a judgement on appropriateness |
### Arantes 2009  (Continued)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Risk</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding of outcome assessment (detection bias) All outcomes</td>
<td>Unclear risk</td>
<td>inadequate information regarding method of blinding, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes</td>
<td>Low risk</td>
<td>0/36 dropouts = 0% attrition (100% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this cross-over trial were not reported appropriately. We were unable to extract data for use in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>High risk</td>
<td>There were no data presented in the paper about baseline characteristics of the groups</td>
</tr>
</tbody>
</table>

### Bayani 2016

**Methods**

- **Setting:** Department of Orthodontics, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran
- **Design:** parallel RCT (5 arms)
- **Number of centres:** 1
- **Study duration:** not reported

**Participants**

- **Inclusion criteria:** moderate (4 mm to 8 mm) crowding according to Little's irregularity index (Little 1975); requiring extraction of 4 first or second premolars for orthodontic reasons
- **Exclusion criteria:** systemic or periodontal diseases; previous orthodontic therapy; using analgesics, or medication interrupting tooth movement
- **Orthodontic intervention:** initial archwire placement
- **Participant sampling:**
  - n = 100 recruited and randomized (34 male:66 female, aged 14 to 21 years, mean age 17.6 years); n = 90 returned their completed questionnaire; n = 90 had their data analyzed
  - Number in each arm not reported
  - Participant age and gender data not reported for any arm of the trial

**Interventions**

- **Comparison:** NSAID versus placebo
- **Ibuprofen (400 mg) vs placebo**
  - **Group 1:** placebo vitamin B6 40 mg tablet immediately after appliance placement and at 8-h intervals for 1 week, if pain persisted
  - **Group 2:** ibuprofen 400 mg tablet immediately after appliance placement and at 8-h intervals for 1 week, if pain persisted
  - **Group 3:** bite wafer to chew on immediately after appliance placement and at 8-h intervals for 1 week, if pain persisted
  - **Group 4:** low-level red laser received as a single session irradiation from a low power indium-gallium-aluminium-phosphide diode laser immediately after appliance placement
  - **Group 5:** low-level infrared laser received as a single session irradiation from a low-level gallium-aluminium-arsenide diode laser immediately after appliance placement
Only Groups 1 and 2 are included in the comparisons for this review

Outcomes

- Pain score (VAS) recorded at 2 h, 6 h, 10 h (or bedtime), 24 h, 2 days, 3 days and 7 days after archwire placement
- Pain was recorded during chewing, biting, fitting back teeth together and fitting front teeth together (the latter 3 not being used in this review)

Notes

- **Conflict of interests/funding:** no source of funding or conflict of interest reported
- **Adverse events/harm:** not reported
- **Data handling by review authors:** data for Groups 1 and 2 have been inverted to reflect ibuprofen as an intervention and placebo as its control. Data from Groups 3, 4 and 5 did not contribute to the analyses
- **Other information:** “The study protocol was reviewed and approved by the Ethics Committee of Kerman University of Medical Sciences.”

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Low risk           | **Quote:** “The subjects were randomly assigned to 5 groups of 20 each according to a computer-generated random assignment program.”  
**Comment:** randomisation appears to be adequate |
| Allocation concealment (selection bias)   | Unclear risk       | **Comment:** inadequate information regarding method of allocation concealment, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) | Low risk           | **Quote:** “The subjects assigned to the ibuprofen and placebo medication groups were blinded to their allocation. Furthermore, the investigator who assessed the outcomes and the data analyst were kept blinded to the assignments.”  
**Comment:** blinding appears to be adequate |
| Blinding of outcome assessment (detection bias) | Low risk           | **Quote:** “The investigator who assessed the outcomes and the data analyst were kept blinded to the assignments.”  
**Comment:** blinding appears to be adequate |
| Incomplete outcome data (attrition bias)   | High risk          | 59/100 dropouts = 59% attrition (41% completion)                     |
Bayani 2016  (Continued)

<table>
<thead>
<tr>
<th>Bias</th>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this study were not reported appropriately. We were unable to extract data for use in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>High risk</td>
<td>No baseline characteristics of groups provided; no sample sizes for the final numbers included in the analysis</td>
</tr>
</tbody>
</table>

Bernhardt 2001

**Methods**
- **Setting:** University of Iowa, College of Dentistry, Department of Orthodontics
- **Design:** parallel RCT (3 arms)
- **Number of centres:** 1
- **Study duration:** not reported

**Participants**
- **Inclusion criteria:** scheduled to begin comprehensive orthodontic treatment; no prophylactic antibiotic coverage required; no debilitating systemic diseases; currently not using antibiotics or analgesics; no contraindication to the use of ibuprofen; a maximum age of 16 years and a minimum weight requirement of 88 pounds (weight requirement based on Food and Drug Administration-approved over-the-counter paediatric dosage labelling guidelines)
- **Exclusion criteria:** none outlined in the Methods, but trialists later excluded participants who did not agree to participate or did not return a completed questionnaire, and those who took additional ‘rescue’ medication
- **Orthodontic intervention:** separator placement
- **Participant sampling:**
  - n = 114 recruited and randomized
  - n = 63 returned their completed questionnaire
  - n = 22 excluded from analysis for taking additional medication (evenly distributed between the 3 groups)
  - n = 41 data analyzed for (aged 9 years 3 months to 16 years 11 months)
  - **Group 1** (n = 13) 10 male:3 female, mean age 12.1 + 1.6 years
  - **Group 2** (n = 14) 4 male:10 female, mean age 13.5 + 1.9 years
  - **Group 3** (n = 14) 6 male:8 female, mean age 12.8 + 1.5 years

**Interventions**
- **Comparisons:** NSAID vs placebo, and pre-emptive vs post-treatment
  - Ibuprofen (400 mg) vs control (lactose placebo)
  - **Group 1:** ibuprofen 1 h before placement, followed by ibuprofen 6 h after initial dose
  - **Group 2:** ibuprofen 1 h before placement, followed by placebo 6 h after initial dose
  - **Group 3:** placebo 1 h before placement, followed by ibuprofen 6 h after initial dose

**Outcomes**
- **Pain score (VAS) recorded at 2 h, 6 h, 10 h (bedtime), 17 h (awakening) and 24 h, and 2, 3 and 7 days after separator placement**
- Pain was recorded during chewing (other measures reported in the study but not included in this review included pain during biting, when fitting back teeth together, and when fitting front teeth together)
**Notes**

**Conflict of interests/funding:** no source of funding or conflict of interest reported

**Adverse events/harm:** 22 participants excluded from analysis for taking additional medication. No harms reported

**Data handling by review authors:** data presented for analysis is based on Figure 1 in the paper, which showed mean pain scores (mean + SEM) for chewing. The SEM was used to calculate SD. Data from Group 1 did not contribute to the analyses, Groups 2 and 3 data were used for the comparison of pre-emptive versus post-treatment analgesia

**Other information of note:** wide variation in gender at baseline for Group 1: "a wide range of individual variation was noted in the pain levels reported, which resulted in large standard deviations. Another possible explanation is the uneven distribution of male and female patients among the groups"

<table>
<thead>
<tr>
<th>Risk of bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Low risk | Quotes: "Patients were randomly assigned to 1 of 3 experimental groups.”
"The randomization of which of the three experimental conditions the patients were assigned to was computer generated.”
Comment: randomisation appears to be adequate |
| Allocation concealment (selection bias) | Low risk | Quotes: “Patients were randomly assigned to 1 of 3 experimental groups.”
“The randomization of which of the three experimental conditions the patients were assigned to was computer generated.”
Comment: allocation concealment appears to be adequate |
| Blinding of participants and personnel (performance bias) | Low risk | Quote: “The ibuprofen and placebo capsules were identical in appearance. The patient, research assistant, and investigator were blinded to each subject’s experimental group.”
Comment: adequate method of blinding |
| Blinding of outcome assessment (detection bias) | Low risk | Quote: “The ibuprofen and placebo capsules were identical in appearance. The patient, research assistant, and investigator were blinded to each subject’s experimental group.”
Comment: adequate method of blinding |
### Bernhardt 2001  (Continued)

| Incomplete outcome data (attrition bias) | High risk | 73/114 dropouts = 64% attrition (36% completion). High number of dropouts, but equally distributed across the groups |
| Selective reporting (reporting bias) | Low risk | Data for outcomes of this review reported appropriately |
| Other bias | Low risk | No other sources of bias detected. |

### Bird 2007

**Methods**

**Setting:** Postgraduate Orthodontic Clinic, Kansas City School of Dentistry, University of Missouri  
**Design:** parallel (2 arms)  
**Number of centres:** 1  
**Study duration:** not reported

**Participants**

**Inclusion criteria:** starting orthodontic treatment that required separators; no orthodontic appliances in the mouth; no debilitating systemic diseases or GI problems; not currently taking analgesics or antibiotics; 9 to 19 years of age; minimum weight of 88 pounds; no prophylactic antibiotic coverage required; literate; English-speaking; able to swallow pills; and no contraindication to the use of acetaminophen or ibuprofen  
**Exclusion criteria:** not specified  
**Orthodontic intervention:** separator placement  
**Participant sampling:**  
\( n = 40 \) selected and randomized  
\( n = 7 \) dropouts/excluded from analysis (sought treatment elsewhere \( n = 1 \); did not complete questionnaire \( n = 1 \); excluded from analysis for not taking medication before the appointment \( n = 5 \))  
\( n = 33 \) data analyzed  
No numbers per group were provided and no sex or age data

**Interventions**

**Comparison:** NSAID vs paracetamol  
**Ibuprofen (400 mg) vs paracetamol (650 mg):** provided pre-emptively to separator placement  
**Group 1:** paracetamol 1 h before placement  
**Group 2:** ibuprofen 1 h before placement

**Outcomes**

Pain score (VAS) recorded immediately after separator placement, at 2 to 3 hours, at bedtime and on rising the next day  
Pain was recorded during the following activities:  
- chewing  
- teeth not touching (not an outcome of this review)  
- biting back teeth together (not an outcome of this review)

**Notes**

**Conflict of interests/funding:** no source of funding or conflict of interest reported.  
**Adverse events/harm:** none reported  
**Data handling by review authors:** only pain during chewing data are reflected in this
Bird 2007 (Continued)

systematic review

**Other information of note:** no SD, baseline or group size data presented in the paper; no reply from authors when emailed and asked to provide further information

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “A computer-generated stratified random assignment strategy was used to balance the groups with respect to sex.” <strong>Comment:</strong> method of randomisation appears to be adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The tablets were given to the patients in sealed, coded envelopes.” <strong>Comment:</strong> adequate method of allocation concealment</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The investigator (C.B.), the patient, and the parent were blinded to the experimental group.” <strong>Comment:</strong> adequate method of blinding</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The investigator (C.B.), the patient, and the parent were blinded to the experimental group.” <strong>Comment:</strong> adequate method of blinding</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low risk</td>
<td>7/40 dropouts = 17.5% attrition (82.5% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this study were not reported appropriately. We were unable to extract data for use in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>High risk</td>
<td>No baseline characteristics of groups provided; no sample sizes for the final numbers included in the analysis</td>
</tr>
</tbody>
</table>
### Bradley 2007

| Methods | Setting: Dorset County Hospital Dorchester; Royal United Hospitals, Bath, and, Southmead Hospital, Bristol  
Design: parallel (2 arms)  
Number of centres: 3  
Study duration: February 2004 to December 2005 (23 months) |
|----------|---------------------------------------------------|
| Participants | Inclusion criteria: age between 12 and 16 years; no history of peptic ulceration, or renal, hepatic, or cardiac impairment; no history of asthma requiring steroid inhalers or unstable asthma in the last year; no history of adverse reactions to ibuprofen or paracetamol; and currently not using analgesics or antibiotics  
Exclusion criteria: not specified  
Orthodontic intervention: separator placement  
Participant sampling:  
n = 208 selected  
n = 21 excluded  
n = 21 refused to participate  
n = 187 randomized (Group 1 n = 92; Group 2 n = 95)  
n = 28 dropouts/excluded from analysis (lost to follow-up (not returning questionnaire): Group 1 n = 6, Group 2 n = 3; did not fulfil inclusion criteria: Group 1 n = 9, Group 2 n = 10)  
n = 159 data analyzed  
Group 1 (n = 77): 28 male:49 female, mean age 13.7 ± 1.0 years  
Group 2 (n = 82): 29 male:53 female, mean age 13.8 ± 1.2 years  
Age: P = 0.38 (independent-samples t test)  
Sex: P = 1.00 (Chi² test for association) male 35.8%, female 64.2% |
| Interventions | Comparison: NSAID vs paracetamol  
Ibuprofen (400 mg; 2 x 200 mg caplet) vs paracetamol (1 g; 2 x 500 mg caplet); provided pre-emptively to separator placement, and again post-treatment  
Group 1: ibuprofen 1 h before placement, followed by ibuprofen 6 h after initial dose  
Group 2: paracetamol 1 h before placement, followed by paracetamol 6 h after initial dose |
| Outcomes | Pain score (VAS) - recorded at 2 h, 6 h, 10 h/bedtime (primary outcome), 24 h and 2, 3 and 7 days (secondary outcome) after separator placement |
| Notes | Conflict of interests/funding: “We thank the Clinical Trials team in the Pharmacy Production Unit at the Royal Hallamshire Hospital, Sheffield, for supplying the drugs and performing the randomization, and the patients who participated in this trial.” Both ibuprofen and paracetamol supplies were cited as being produced by Boots Company, Nottingham, United Kingdom  
Adverse events/harm: 18 participants required additional medication.  
Quote: “During this trial 1 patient experienced a suspected adverse reaction to paracetamol.”  
This was reported in more detail in the secondary paper by McAlinden et al (Bradley 2007): “since one of the trial drugs was also paracetamol we decided to break the randomization code for this patient to determine which drug the patient had received. The trial drug given was found to be paracetamol, suggesting a drug hypersensitivity reaction to paracetamol” |
**Data handling by review authors:** study reported Group 1 as the paracetamol arm of trial, and Group 2 as the ibuprofen arm. In order to align with the protocol for this systematic review, the figures for Groups 1 and 2 have been inverted to reflect ibuprofen as an intervention and paracetamol as its control.

**Other information of note:** intention-to-treat analysis noted in methods, but only completing participants were analyzed. Trial authors carried out an intention-to-treat analysis on the 18 participants who required additional analgesia.

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random sequence generation (selection bias)</strong></td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The drugs were supplied according to a restricted randomization method in blocks of 8 to ensure that equal numbers of patients were allocated to each group.” <strong>Comment:</strong> block randomisation carried out therefore it can be assumed that this was adequate</td>
</tr>
<tr>
<td><strong>Allocation concealment (selection bias)</strong></td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The analgesics were in the form of identical capsules and were stored in sealed, numbered containers. The random allocation sequence was concealed in an envelope and held centrally.” <strong>Comment:</strong> adequate method of allocation concealment</td>
</tr>
<tr>
<td><strong>Blinding of participants and personnel (performance bias)</strong></td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The investigator, the clinicians, the subjects, and the statistician were all blinded to each subject’s treatment group.” <strong>Comment:</strong> adequate method of blinding</td>
</tr>
<tr>
<td><strong>Blinding of outcome assessment (detection bias)</strong></td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The investigator, the clinicians, the subjects, and the statistician were all blinded to each subject’s treatment group.” <strong>Comment:</strong> adequate method of blinding</td>
</tr>
<tr>
<td><strong>Incomplete outcome data (attrition bias)</strong></td>
<td>Low risk</td>
<td>28/187 dropouts = 15% attrition (85% completion)</td>
</tr>
<tr>
<td><strong>Selective reporting (reporting bias)</strong></td>
<td>Low risk</td>
<td>Data for outcomes of this review reported appropriately</td>
</tr>
<tr>
<td><strong>Other bias</strong></td>
<td>Low risk</td>
<td>No other sources of bias detected</td>
</tr>
</tbody>
</table>
### Methods

**Setting:** Dentistry School of Universidade Federal Fluminense, (Niterói, RJ, Brazil)

**Design:** parallel (3 arms)

**Number of centres:** 1

**Study duration:** not reported

### Participants

**Inclusion criteria:** at least 18 years of age; presence of second molars and second bicuspids, since separating elastics had to be fixed on the first molars; no clinical signs of gingival inflammation

**Exclusion criteria:** use of any medication that could interfere with results > 2 weeks before the procedure; any of the following conditions, screened through a questionnaire: cardiopathies, nephropathies, hepatopathies or GI disorders, diabetes, high cholesterol, blood vessel obstructions, allergy to anti-inflammatory drugs, intolerance to lactose, pregnancy

**Orthodontic intervention:** separator placement

**Participant sampling:**

- **n = 87** recruited and randomized
- **n = 38** dropouts or excluded from analysis (n = 18 missing or incomplete information; n = 10 discomfort due to elastic, sought treatment elsewhere; n = 6 used analgesic medication during the study; n = 2 lost their diaries and were unwilling to be resubmitted to the intervention)
- **n = 51** data analyzed

- **Group A** (n = 17) 4 male:13 female, mean age 24.64 years
- **Group B** (n = 17) 4 male:13 female, mean age 22.64 years
- **Group C** (n = 17) 5 male:12 female, mean age 22.47 years

### Interventions

**Comparison:** NSAID vs placebo

**Lumiracoxib (400 mg) vs placebo vs no treatment:** provided pre-emptively to separator placement

- **Group A:** lumiracoxib 1 h before separator placement
- **Group B:** placebo 1 h before separator placement
- **Group C:** no intervention

### Outcomes

Pain score (VAS) recorded at 2 h, 6 h and 24 hours and at 2 and 4 days after separator placement

### Notes

**Conflict of interests/funding:** quote: “The authors have reported no conflicts of interest.”

**Adverse events/harm:** not reported

**Data handling by review authors:** study reports Group A as placebo, Group B as lumiracoxib and Group C as control

For the purposes of aligning with the protocol for this systematic review, the figures for Groups A and B have been inverted to reflect ibuprofen as an intervention and placebo and no treatment as its controls

**Other information of note:** we received data for means and standard deviations via correspondence with the author

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>

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**Pharmacological interventions for pain relief during orthodontic treatment (Review)**

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<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Risk Level</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> &quot;Patients were randomly assigned into one of three groups by drawing lots. To ensure similarity in size of the groups, randomisation was stratified in blocks of ten (permuted-block randomisation).&quot; <strong>Comment:</strong> block randomisation carried out, therefore it can be assumed that this was adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>High risk</td>
<td><strong>Quote:</strong> &quot;Patients were randomly assigned into one of three groups by drawing lots&quot;; &quot;As each volunteer attended the Department of Orthodontics, in Universidade Federal Fluminense (the University), he was allocated to the group following the last participant had entered. The search was not started with the sample enclosed.&quot; <strong>Comment:</strong> allocation concealment not achieved</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias)</td>
<td>High risk</td>
<td><strong>Quote:</strong> &quot;The placebo and lumiracoxib capsules were perfectly identical and neither the researchers nor the subjects knew the group of each subject. Patients of the non-medication group knew about the use of capsules by the other two groups.&quot; <strong>Comment:</strong> adequate method of blinding where appropriate. Not possible to blind participants and personnel to allocated control group</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> &quot;The VAS was given to a statistician blinded to the study group.&quot; <strong>Comment:</strong> adequate method of blinding.</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>High risk</td>
<td>36/87 dropouts = 41.4% attrition (58.6% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Raw data not presented in paper, only statistical analysis and significance. Further information regarding data was received via correspondence with the author</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other source of bias detected</td>
</tr>
</tbody>
</table>
### Methods

**Setting:** Orthodontics Department of Shahid Beheshti University, School of Dentistry and a private clinic in Tehran  
**Design:** cross-over (3 arms)  
**Number of centres:** 2  
**Study duration:** not reported

### Participants

**Inclusion criteria:** no pain at the onset of study; in previous sessions complained of pain > 50 based on the VAS; 6 mm to 8 mm crowding; no use of analgesics during the study period; no history of renal or liver disease or any other contraindication for the use of understudy medications (Comment: we have assumed a typographical error was made in the paper and that the trial authors meant ‘liver’ disease when they wrote ‘river’ disease.)  
**Exclusion criteria:** did not sign the consent form; used analgesics and anti-inflammatory drugs during the study; did not complete the questionnaire; did not use or used benzocaine or ketoprofen chewing gums improperly  
**Orthodontic intervention:** mid-treatment adjustments  
**Participant sampling:**  
- n = 30 recruited and randomized  
- n = 4 dropouts/excluded from analysis  
- n = 26 data analyzed  
  - **Group A** (n = 26) 12 male:14 female, mean age 18.07 ± 3.19 years  
  - **Group B** (n = 26) 12 male:14 female, mean age 18.07 ± 3.19 years  
  - **Group C** (n = 26) 12 male:14 female, mean age 18.07 ± 3.19 years

### Interventions

**Comparisons:** NSAID vs placebo, local anaesthetic vs placebo, and NSAID vs local anaesthetic  
**Ketoprofen chewing gum vs benzocaine chewing gum vs placebo chewing gum** provided postoperatively following appliance adjustments  
- **Group A:** ketoprofen chewing gum every 8 h for 3 days after treatment  
- **Group B:** benzocaine chewing gum every 8 h for 3 days after treatment  
- **Group C:** placebo chewing gum every 8 h for 3 days after treatment

### Outcomes

Pain score (VAS) - recorded at 2 h, 6 h, 24 hours, 10 am and 6 pm on day 2; 10 am and 6 pm on day 3, and 7 days after appliance adjustment

### Notes

**Conflict of interests/funding:** not reported  
**Adverse events/harm:** not reported  
**Data handling by review authors:** study did not allocate intervention to specific group labels. For the purposes of this systematic review, Group A is the ketoprofen arm, Group B the benzocaine arm and Group C the control arm.  
**Other information of note:** data for means and standard deviations were received via correspondence with the author. Orthodontic intervention involved in the study was described as “fixed orthodontic treatment”. This was clarified through correspondence with the author as involving retie of an 0.016” or 0.018” NiTi archwire 4-week washout period allowed between interventions

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source: Eslamian 2014 (Continued)</td>
<td><strong>Random sequence generation (selection bias)</strong></td>
<td><strong>Allocation concealment (selection bias)</strong></td>
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<tr>
<td>------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Unclear risk</td>
<td>Low risk</td>
</tr>
<tr>
<td><strong>Quote:</strong> &quot;Thirty patients were randomly divided into three groups of 10&quot;; “In the first session patients 1-10 receive ketoprofen, 11-20 receive benzocaine, 21-30 receive placebo gums. In the next visit 1-10 benzocaine, 11-20 placebo, 21-30 ketoprofen; and in the last visit 1-10 placebo, 11-20 ketoprofen, 21-30 benzocaine”</td>
<td><strong>Quote:</strong> “Thirty patients were randomly divided into three groups of 10”; “random allocation by a third person who was responsible for explaining to the patients”</td>
<td><strong>Quote:</strong> “The placebo chewing gum was manufactured with the same shape and packaging as the experimental gums. Patients and those administering the gums among patients were blinded to the type of chewing gums”</td>
</tr>
<tr>
<td><strong>Comment:</strong> inadequate information and methods regarding method of randomisation, therefore unable to make a judgement on appropriateness</td>
<td><strong>Comment:</strong> appeared to be adequate method of allocation concealment.</td>
<td><strong>Comment:</strong> adequate method of blinding</td>
</tr>
</tbody>
</table>
### Methods

**Setting:** Orthodontics Department of Shahid Beheshti University, School of Dentistry, Tehran, Iran  
**Design:** cross-over (3 arms)  
**Number of centres:** 1  
**Study duration:** not reported

### Participants

**Inclusion criteria:** undergoing orthodontic treatment, currently experiencing no oral pain, positive history of pain after orthodontic appliance activation  
**Exclusion criteria:** currently taking analgesics, or medication with contraindications related to drug use  
**Orthodontic intervention:** mid-treatment  
**Patient sampling:**  
- n = 30 recruited and randomized  
- n = 10 dropouts/excluded from analysis (protocol violations or unwillingness to cooperate (7))  
- n = 20 data analyzed (7 male:13 female, mean age 19.5 years range 15 to 25 years)

### Interventions

**Comparison:** Local anaesthetic vs placebo  
**Local anaesthetic vs placebo gel:** provided postoperatively following activation of loop/archwire placement  
**Group A:** 5% benzocaine gel twice a day (at 10 am and 10 pm) for 3 days  
**Group B:** 5% ketoprofen gel twice a day (at 10 am and 10 pm) for 3 days  
**Group C:** placebo gel twice a day (at 10 am and 10 pm) for 3 days

### Outcomes

**Pain score (VAS graded 0-4) - recorded at 2 h, 6 h, 24 h after gel application. and 2, 3 and 7 days after loop placement**

### Notes

**Conflict of interests/funding:** not reported  
**Adverse events/harm:** not reported  
**Data handling by review authors:** data were presented as mean and 95% confidence intervals. We were unable to calculate standard deviation and therefore the data from this trial did not contribute to the analyses.  
**Other information of note:** 4-week washout period allowed between interventions

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Low risk | Quote: “By the use of a random number table, each patient was prescribed one of the three gels for the next three appointments”  
Comment: adequate method of randomisation |
| Allocation concealment (selection bias) | Low risk | Quote: “The same nurse conducted the crossover under the supervision of the clinician, who was unaware of the content of the gel tubes.”  
Comment: adequate method of allocation |
### Eslamian 2016a  *(Continued)*

<table>
<thead>
<tr>
<th>Bias</th>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding of participants and personnel (performance bias) All outcomes</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The colour and odour of all gels were identical and the tubes were not labelled, to make them indistinguishable to the patients and clinician.” <strong>Comment:</strong> adequate method of randomisation</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias) All outcomes</td>
<td>Unclear risk</td>
<td><strong>Comment:</strong> described as double-blind, but inadequate information provided regarding how blinding of outcome assessment was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes</td>
<td>High risk</td>
<td>10/30 dropouts = 33.3% attrition (66.7% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this review were reported appropriately. We were unable to extract data for inclusion in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other source of bias detected.</td>
</tr>
</tbody>
</table>

### Eslamian 2016b

| Setting: Orthodontics Department of Shahid Beheshti University, School of Dentistry, Tehran, Iran |
| Design: cross-over (2 arms) |
| Number of centres: 1 |
| Study duration: 14 months (January 2011 up to March 2012) |

<table>
<thead>
<tr>
<th>Participants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion criteria:</strong> signed informed consent of the included subjects or their legally authorised representatives, no current chronic or acute pain in the oral cavity, positive history of pain after first orthodontic appliance activation, and subject was in the levelling and alignment phase of treatment</td>
<td></td>
</tr>
<tr>
<td><strong>Exclusion criteria:</strong> taking analgesics or antibiotics, history of severe kidney or liver disease, and history of allergic reaction to local anaesthetic drugs or a history of methemoglobinemia</td>
<td></td>
</tr>
<tr>
<td><strong>Orthodontic intervention:</strong> mid-treatment adjustments</td>
<td></td>
</tr>
<tr>
<td><strong>Patient sampling:</strong></td>
<td></td>
</tr>
<tr>
<td>n = 30 recruited and randomized</td>
<td></td>
</tr>
<tr>
<td>n = 5 dropouts/excluded from analysis (n = 1 refusal to continue, n = 2 imprecision in obeying the study protocol, n = 2 use of other pain relieving drugs during the study (exclusion of these participants is a bias))</td>
<td></td>
</tr>
<tr>
<td>n = 25 data analyzed (8 male:17 female, mean age 19.5 years range 15 to 25 years)</td>
<td></td>
</tr>
<tr>
<td><strong>Group A</strong> (n = 13) data for age and gender not presented</td>
<td></td>
</tr>
<tr>
<td><strong>Group B</strong> (n = 12) data for age and gender not presented</td>
<td></td>
</tr>
</tbody>
</table>
### Interventions

**Comparison: Local anaesthetic vs placebo**

**Local anaesthetic vs placebo gel**: provided postoperatively following appliance adjustments

- **Group A**: 5% benzocaine gel twice a day (at 10 am and 10 pm) for 3 days
- **Group B**: placebo gel twice a day (at 10 am and 10 pm) for 3 days

### Outcomes

Pain score (VAS) - recorded at 2 h, 6 h, 24 h and day 2 at 10 am and 6 pm, day 3 10 am and 6 pm and 7 days after appliance adjustment

### Notes

**Conflict of interests/funding**: not reported

**Adverse events/harm**: not reported

**Data handling by review authors**: The data presented for the analysis were based on Figure 1, which showed mean pain scores (mean + SEM). The SEM was used to calculate SD.

**Other information of note**: 4-week washout period allowed between interventions. We clarified that the orthodontic intervention involved in the study involved retie of an 0.016” or 0.018” NiTi archwire through correspondence with the author

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote</strong>: “Randomization and sequence generation were carried out with the aid of random number generator in SPSS software”&lt;br&gt;<strong>Comment</strong>: adequate method of randomisation</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote</strong>: “Allocation concealment was achieved with sequentially numbered letters in opaque envelopes containing gel tube numbers.”&lt;br&gt;<strong>Comment</strong>: adequate method of allocation concealment</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias)&lt;br&gt;<strong>All outcomes</strong></td>
<td>Low risk</td>
<td><strong>Quote</strong>: “Adequate method of allocation concealment. The tubes were essentially the same, and neither the subjects nor the clinicians knew whether the tubes contained placebo or benzocaine.”&lt;br&gt;<strong>Comment</strong>: adequate method of blinding</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)&lt;br&gt;<strong>All outcomes</strong></td>
<td>Unclear risk</td>
<td><strong>Comment</strong>: inadequate information regarding method of blinding of outcome assessment, therefore unable to make a judgement on appropriateness</td>
</tr>
</tbody>
</table>
Incomplete outcome data (attrition bias)  
All outcomes  
High risk  
5/30 dropouts = 16.7% attrition (83.3% completion). Participants were excluded as they used other pain relieving drugs - this is a source of bias as these were probably the participants experiencing the greatest pain.

Selective reporting (reporting bias)  
High risk  
Data for outcomes of this review were not reported appropriately. The cross-over structure of the data was ignored in the trialists' presentation and analysis of the data.

Other bias  
Low risk  
No other source of bias detected.

Farzanegan 2012

Methods  
**Setting:** Orthodontic clinic of Mashhad University of Medical Sciences in Iran  
**Design:** parallel (5 arms)  
**Number of centres:** 1  
**Study duration:** not reported

Participants  
**Inclusion criteria:** female orthodontic patients between 13 and 18 years of age, scheduled for fixed orthodontic treatment, with no systemic diseases and not receiving analgesic therapy; with moderate crowding (4 mm to 8 mm) according to Little's irregularity index (Little 1975)  
All participants needed extraction of the 4 first premolars for orthodontic reasons, and the extractions were scheduled to be finished at least 2 weeks before the placement of the orthodontic appliances.  
**Exclusion criteria:** none specified  
**Orthodontic intervention:** initial archwire placement  
**Patient sampling:**  
n = 50 recruited and randomized and analyzed  
**Group 1** (n = 10) female only, age data not reported  
**Group 2** (n = 10) female only, age data not reported  
**Group 3** (n = 10) female only, age data not reported  
**Group 4** (n = 10) female only, age data not reported  
**Group 5** (n = 10) female only, age data not reported

Interventions  
**Comparison:** NSAID vs placebo  
Ibuprofen (400 mg) vs placebo vs chewing gum vs soft viscoelastic bite wafer vs hard viscoelastic bite wafer; provided after initial archwire placement  
**Group 1:** ibuprofen immediately after archwire placement and at 8-h intervals for a week if pain persisted  
**Group 2:** placebo immediately after archwire placement and at 8-h intervals for a week if pain persisted  
**Group 3:** gum chewed for 5 minutes immediately after archwire placement and at 8-h intervals for a week if pain persisted  
**Group 4:** soft bite wafer chewed or bitten down on for 5 minutes at 8-h intervals for a week if pain persisted
Group 5: hard bite wafer chewed or bitten down on for 5 minutes at 8-h intervals for a week if pain persisted

Outcomes

Pain score (VAS) - recorded at 2 h, 6 h, bedtime, 24 h and 2, 3 and 7 days after placement of initial archwires

Pain was recorded during the following activities:
- chewing
- biting (not an outcome of this review)
- fitting front teeth together (not an outcome of this review)
- fitting posterior teeth together (not an outcome of this review)

Notes

Conflict of interests/funding: not reported
Adverse events/harm: not reported. "None had used any analgesics"
Data handling by review authors: study reports Group 1 as placebo arm and Group 2 as ibuprofen arm. For the purposes of aligning with this systematic review's own protocol, the figures for Groups 1 and 2 have been inverted to reflect ibuprofen as an intervention and placebo as its control. Data for Groups 3, 4 and 5 have not been included for the purposes of this review
Other information of note: only pain during chewing data were reflected in this systematic review

Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td>Quote: “The subjects were randomly assigned to 1 of 5 parallel groups in a 1:1:1:1:1 ratio according to their clinical entrance number and a random number table.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comment: block randomisation carried out, therefore it can be assumed that this was adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Unclear risk</td>
<td>Quote: “The subjects were randomly assigned to 1 of 5 parallel groups”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comment: inadequate information regarding method of allocation concealment, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of participants and personnel</td>
<td>Low risk</td>
<td>Quote: “The subjects in these 2 groups (ibuprofen &amp; placebo) were blinded about the drug that they took.”</td>
</tr>
<tr>
<td>(performance bias)</td>
<td></td>
<td>Comment: adequate method of blinding was carried out where appropriate for Group 1 and Group 2. Not possible to blind participants and personnel regarding allocation to Groups 3, 4 or 5</td>
</tr>
</tbody>
</table>
**Blinding of outcome assessment (detection bias)**

| All outcomes | Unclear risk | Inadequate information regarding method of blinding of outcome assessment |

**Incomplete outcome data (attrition bias)**

| All outcomes | Low risk | 0/50 dropouts = 0% attrition (100% completion) |

**Selective reporting (reporting bias)**

| Low risk | Data for outcomes of this review were reported appropriately |

**Other bias**

| Low risk | No other source of bias detected. |

---

**Setting:** Department of Orthodontics, AECS Maaruti College of Dental Sciences and Research Centre, Bangalore, India

**Design:** parallel (3 arms)

**Number of centres:** 1

**Study duration:** not reported

**Inclusion criteria:** patients undergoing bonding and initial archwire placement using a 0.014"/0.016" NiTi wire in at least in 1 arch

**Exclusion criteria:** taking any antibiotics or analgesics; allergy to NSAIDs; oral pathology; had a tooth extracted within 2 weeks before bonding

**Orthodontic intervention:** initial archwire placement

**Patient sampling:**

- n = 45 recruited and randomized (23 female:22 male; aged 15-22 years)
- n = 0 lost to follow-up
- n = 45 data analyzed

**Group 1** (n = 15) 8 male:7 female, age data not reported

**Group 2** (n = 15) 7 male:8 female, age data not reported

**Group 3** (n = 15) 7 male:8 female, age data not reported

**Comparisons: NSAID vs paracetamol, NSAID vs etoricoxib, and NSAID vs placebo**

Paracetamol (500 mg) vs etoricoxib (60 mg) vs placebo: provided 1 h before initial archwire placement and postoperatively

**Group 1:** paracetamol 1 h before and thrice daily for 3 days after archwire placement

**Group 2:** etoricoxib 1 h before and once daily for 3 days after archwire placement

**Group 3:** placebo 1 h before and thrice daily for 3 days after archwire placement

**Pain score (VAS) - recorded at 2 h, 6 h, bedtime, 24 h and 2nd day at nighttime, 48 h after initial archwire placement and 3rd day at nighttime**

**Conflict of interests/funding:** "M. Gupta, S. Kandula, S.M. Laxmikant, S.S. Vyavahare, B.H.R. Satheesha, and C.S. Ramachandra state that there are no conflicts of interest. All studies on humans described in the present manuscript were carried out with the approval of the responsible ethics committee and in accordance with national law and the Helsinki Declaration of 1975 (in its current, revised form). Informed consent was
obtained from all patients included in studies.”

**Adverse events/harm:** not reported. “None of them had resorted to using any kind of additional medication”

**Data handling by review authors:** study reported Group 2 as placebo arm and Group 3 as etoricoxib arm. For the purposes of aligning with this systematic review’s own protocol, the figures for Groups 2 and 3 have been inverted to reflect etoricoxib as an intervention and placebo as its control

**Other information of note:** time points for 1st day bedtime, 2nd and 3rd day night-times were not specified. 1st day bedtime has been assumed to be approximately 10 h, 2nd day night-time has been assumed to be approximately 31 h and 3rd day night-time as approximately 53 h

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td>Quote: “Patients were randomly assigned to three different groups and blinding was done using the SNOSE technique (sequentially numbered opaque sealed envelopes)” Comment: randomisation appears to be adequate.</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td>Quote: “Patients were randomly assigned to three different groups and blinding was done using the SNOSE technique (sequentially numbered opaque sealed envelopes).” Comment: allocation concealment appears to be adequate.</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias) All outcomes</td>
<td>Unclear risk</td>
<td>Quote: “Patients were enrolled in this double-blind, prospective study” Comment: described as double-blind, but inadequate information regarding how blinding was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias) All outcomes</td>
<td>Unclear risk</td>
<td>Quote: “Patients were enrolled in this double-blind, prospective study” Comment: described as double-blind, but inadequate information regarding how blinding was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes</td>
<td>Low risk</td>
<td>0/45 dropout = 0% (100% completion)</td>
</tr>
</tbody>
</table>
### Gupta 2014 (Continued)

<table>
<thead>
<tr>
<th>Selective reporting (reporting bias)</th>
<th>Low risk</th>
<th>Data for outcomes of this review were reported appropriately</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other source of bias detected.</td>
</tr>
</tbody>
</table>

### Kawamoto 2010

**Methods**

- **Setting:** 2 private practices in Lee's Summit, Missouri
- **Design:** parallel (3 arms)
- **Number of centres:** 2
- **Study duration:** not reported

**Participants**

- **Inclusion criteria:** started orthodontic treatment that required banding of posterior teeth and placement of 2 or more separators; able to swallow analgesic pills; English speaking; 9 to 17 years of age; minimum weight requirement of 88 pounds based on mg/kg paediatric dosage recommendations
- **Exclusion criteria:** existing orthodontic or space maintenance appliances; contraindication to the use of acetaminophen or ibuprofen; taking antibiotics or analgesics; cognitive impairment, or any systemic disease that in the assessment of the investigator might impact pain perception
- **Orthodontic intervention:** separator placement
- **Patient sampling:**
  - n = 35 enrolled
  - n = 9 dropouts/excluded from analysis (Group 1 = 4, Group 2 = 2, Group 3 = 3 all failed to return questionnaires)
- n = 26 data analyzed for:
  - **Group 1** (n = 7) 1 male:6 female, mean age 12.7 ± 1.3 years
  - **Group 2** (n = 10) 3 male:7 female, mean age 13.0 ± 1.6 years
  - **Group 3** (n = 9) 5 male:4 female, mean age 12.6 ± 1.8 years

**Interventions**

- **Comparisons:** NSAID vs placebo, NSAID vs paracetamol, and paracetamol vs placebo
- **Ibuprofen (400 mg) vs paracetamol (650 mg) vs placebo (640 mg avicel):** provided pre-emptively and post-treatment for separator placement
  - **Group 1:** ibuprofen 1 h before placement and 6 h after initial dose
  - **Group 2:** paracetamol 1 h before placement and 6 h after initial dose
  - **Group 3:** placebo 1 h before placement and 6 h after initial dose

**Outcomes**

- **Pain score (VAS) - recorded immediately before and after, 2 h, 6 h, bedtime, 24 h after separator placement**
- Pain was recorded during the following activities:
  - chewing
  - teeth not touching (not an outcome of this review)
  - biting (not an outcome of this review)

**Notes**

- **Conflict of interests/funding:** not reported
- **Adverse events/harm:** not reported
- **Data handling by review authors:** study reports Group 1 as placebo arm and Group 3 as...
ibuprofen arm. For the purposes of aligning with this systematic review’s own protocol, the figures for Groups 1 and 3 have been inverted to reflect ibuprofen as an intervention and placebo as its control.

**Other information of note:** only pain during chewing data were reflected in this systematic review.

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “Computer generated random patient coding and group allocation was utilized”</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Comment:</strong> randomisation appears to be adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The random allocation assignments were concealed and inaccessible to the investigator.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Comment:</strong> allocation concealment appears to be adequate</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The ibuprofen, acetaminophen, and placebo tablets were compounded by a licensed pharmacist (O’Brien Pharmacy, Kansas City, MO) according to specifications and were all provided in identical white opaque capsules. Medications and placebo tablets were packed and distributed in sealed, coded envelopes”; “Subjects, patients and investigator would be blinded to group allocation”</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Comment:</strong> adequate method of blinding</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The random allocation assignments were concealed and inaccessible to the investigator”; “Subjects, patients and investigator would be blinded to group allocation”</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Comment:</strong> adequate method of blinding</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>High risk</td>
<td>9/35 dropouts = 25.7% attrition (74.3% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
</tbody>
</table>
**Kawamoto 2010** *(Continued)*

<table>
<thead>
<tr>
<th>Other bias</th>
<th>High risk</th>
<th>Large gender variation at baseline, more females in all groups indicating sampling bias</th>
</tr>
</thead>
</table>

**Kluemper 2002**

| Methods | Setting: Graduate Orthodontic Clinic at the University of Kentucky College of Dentistry and the full-time and part-time faculty practices  
Design: parallel (2 arms)  
Number of centres: unclear  
Study duration: not reported |

| Participants | Inclusion criteria: orthodontic treatment included full, fixed orthodontic appliances (braces); males and females; periodontal tissues were in good health; no systemic disease that would compromise normal healing (e.g. diabetes); no medications being taken at the time of the study  
Exclusion criteria: none specified  
Orthodontic intervention: initial bracket placement without archwire  
Patient sampling: n = 80 randomized (Group 1 n = 40; Group 2 n = 40)  
n = 10 dropouts/excluded from analysis (lost to follow-up: not returning questionnaire = 7; did not require pain relief = 3)  
n = 70 data analyzed for:  
Group 1 (n = 35) 18 male:17 female, mean age 23.8 ± 10.3 years  
Group 2 (n = 35) 16 male:19 female, mean age 25.2 ± 8.6 years  
Age P = 0.5  
Sex: P = 0.6 |

| Interventions | Comparison: local anaesthetic wax vs placebo  
Benzocaine wax vs placebo: provided post-treatment for topical use, not applied until 24 h after treatment  
Group 1: orthodontic menthol wax, medicated with 20% benzocaine  
Group 2: unmedicated orthodontic wax (without menthol) |

| Outcomes | Pain score (VAS) - recorded at baseline, 1 h, 17 h, 29 h, 41 h, 53 h after baseline |

| Notes | Conflict of interests/funding: not reported. The benzocaine wax product received a patent by the United States Patent and Trademark Office (Patent No.6,074,674)  
Adverse events/harm: not reported  
Data handling by review authors: only intervention study data included in this review. Study did not allocate intervention to specific group labels. For the purposes of this systematic review, Group 1 has been allocated as the benzocaine arm and group 2 as the control arm  
Although multiple time points measured, intervention not taken until 24 h after visit, therefore data from this study has not contributed to analyses in this systematic review  
Other information of note: much of the detail in the paper related to the pilot (e.g. the inclusion criteria) prior to the RCT. Both are presented collectively in the paper |

**Risk of bias**
<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Unclear risk</td>
<td><strong>Quote:</strong> &quot;The medicated and unmedicated waxes were randomized and were contained in numerically coded cases.&quot; <strong>Comment:</strong> inadequate information regarding method of randomisation, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> &quot;The medicated and unmedicated waxes were randomized and were contained in numerically coded cases.&quot; <strong>Comment:</strong> allocation concealment appears to be adequate</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> &quot;The patients received dental wax without knowing whether the anaesthetic was incorporated into the wax&quot; <strong>Comment:</strong> described as double-blind, both identically prepared, however, &quot;neither the benzocaine nor the menthol&quot; was included in the placebo. Intervention and control possessed different tastes, but patients unlikely to recognise whether active drug or not, or to discuss with other participants</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Unclear risk</td>
<td><strong>Quote:</strong> &quot;Randomised double-blind prospective RCT&quot;. <strong>Comment:</strong> described as double-blind, but inadequate information provided regarding how blinding was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low risk</td>
<td>10/80 dropouts = 12.5% attrition (87.5% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other source of bias detected.</td>
</tr>
</tbody>
</table>
### Kohli 2011

**Methods**

- **Setting:** Department of Orthodontics & Dentofacial Orthopedics, Hitkarini Dental College & Hospital, Jabalpur, India
- **Design:** parallel (3 arms)
- **Number of centres:** 1
- **Study duration:** not reported

**Participants**

- **Inclusion criteria:** at least 13 years of age and not older than 20 years; beginning orthodontic treatment for the first time; reporting no contraindications or adverse reactions related to ibuprofen and piroxicam; not using any antibiotics; and meeting a minimum weight requirement of 88 pounds, as per Food and Drug Administration approved-over-the-counter paediatric dosage labelling guidelines; required to provide written informed consent for participation in the study.
- **Exclusion criteria:** none specified
- **Orthodontic intervention:** separator placement
- **Patient sampling:**
  - n = 90 randomized (Group 1 n = 30; Group 2 n = 30; Group 3 n = 30)
  - n = 0 dropouts/excluded from analysis
  - n = 90 analyzed (45 male: 45 female)
  - **Group 1** (n = 30) 15 male:15 female, mean age 14.7 ± 3.4 years
  - **Group 2** (n = 30) 15 male:15 female, mean age 14.2 ± 2.8 years
  - **Group 3** (n = 30) 15 male:15 female, mean age 15.1 ± 3.6 years

**Interventions**

- **Comparisons:** NSAID vs placebo vs NSAID
  - Ibuprofen (400 mg) vs piroxicam (20 mg) vs placebo; provided 1 h pre-emptively
  - **Group 1:** ibuprofen 1 h before separator placement
  - **Group 2:** placebo 1 h before separator placement
  - **Group 3:** piroxicam 1 h before separator placement

**Outcomes**

- **Pain score (VAS)** - recorded at 2 h, 6 h, bedtime, 24 h and 2, 3 and 7 days after separator placement
- Pain was recorded during the following activities:
  - chewing
  - biting (not an outcome of this review)
  - fitting front teeth together (not an outcome of this review)
  - fitting posterior teeth together (not an outcome of this review)

**Notes**

- **Conflict of interests/funding:** not reported
- **Adverse events/harm:** not reported. "None of them had resorted to the usage of any kind of 'rescue medication.'"
- **Data handling by review authors:** study reports Group 1 as placebo arm of trial, Group 2 as ibuprofen arm and Group 3 as piroxicam arm. For the purposes of aligning with this systematic review's own protocol, the figures for Groups 1 and 2 have been inverted to reflect ibuprofen as an intervention and piroxicam and placebo as its controls
- **Additional information received through correspondence with the author**
- **Other information of note:** only pain during chewing data were reflected in this systematic review

### Risk of bias

---

**Pharmacological interventions for pain relief during orthodontic treatment (Review)**

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<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
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<td><strong>Quote:</strong> “30 patients were randomly assigned to the three experimental groups”</td>
</tr>
<tr>
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<td></td>
<td><strong>Comment:</strong> inadequate information regarding method of randomisation, therefore unable to make a judgement on appropriateness</td>
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<td><strong>Comment:</strong> inadequate information regarding method of allocation concealment, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias) All outcomes</td>
<td>Unclear risk</td>
<td><strong>Quote:</strong> “The investigational drug pharmacy at the institute dispensed the drugs so that the investigator would be blinded to the experimental group.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Comment:</strong> described as double-blind, but inadequate information regarding how blinding of participants was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias) All outcomes</td>
<td>Low risk</td>
<td><strong>Quote:</strong> “The investigational drug pharmacy at the institute dispensed the drugs so that the investigator would be blinded to the experimental group.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Comment:</strong> adequate method of blinding.</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes</td>
<td>Low risk</td>
<td>0/90 dropouts =0% attrition (100% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other source of bias detected.</td>
</tr>
</tbody>
</table>
## Methods

**Setting:** San Raffaele Hospital, Madrid  
**Design:** parallel (2 arms)  
**Number of centres:** 1  
**Study duration:** not reported

## Participants

**Inclusion criteria:** male and female mobile patients; aged between 18-40 years; fitted with a brace; moderate or severe pain in the mouth region measured using the VAS; at least 1 of the 2 signs of inflammation (oedema or hyperaemia) of a moderate intensity, or severe on a point scale from 0 to 3; written consent provided by the patient  
**Exclusion criteria:** none specified  
**Orthodontic intervention:** initial archwire placement  
**Patient sampling:**  
\( n = 120 \) patients selected and randomized  
\( n = 0 \) dropouts/excluded from analysis  
\( n = 120 \) data analyzed for:  
- **Group 1 (n = 60)** gender and age data not reported  
- **Group 2 (n = 60)** gender and age data not reported

## Interventions

**Comparison:** NSAID vs NSAID  
**Ketoprofen (160 mg) vs benzidamine chloride (22.5 mg); mouthwash provided post-operatively**  
- **Group 1:** ketoprofen 10 ml in 100 ml of water twice a day (after breakfast and the evening meal) for up to 7 days  
- **Group 2:** benzidamine chloride 15 ml twice a day (after breakfast and the evening meal) for up to 7 days

## Outcomes

**Primary outcome:** pain score (VAS) - recorded at baseline, on days 1, 2, 3, 4, 5, 6, and 7, 1 h after breakfast and 1 h after the evening meal  
**Secondary outcome:** the seriousness of the following signs - oedema and hyperaemia were measured on a graduated scale of 0-3 (3 being intense pain). The pain was measured by the person conducting the experiment, on examination of the oral cavity when the brace was initially fitted, on the second visit and on the third and final visit. Resolution of any signs of inflammation was deducted from the data produced regarding seriousness, following the same marking procedure (complete remission of inflammation, a good improvement, slight improvement, no effect)  
0 = a complete remission

## Notes

**Conflict of interests/funding:** not reported  
**Adverse events/harm:** not discussed  
**Data handling by review authors:** although multiple time points were measured, data were only presented for 4 days. Therefore, data from this study have not been used for this systematic review  
No information is provided relating to dropouts, so we have assumed that all participants returned questionnaires and contributed to the final analysis  
**Other information of note:** this paper was translated from Italian, with additional correspondence from the author

## Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>

*Pharmacological interventions for pain relief during orthodontic treatment (Review)*  
Copyright © 2017 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Risk Level</th>
<th>Description</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk | **Quote:** "Randomised study in the single caesium for parallel groups"  
**Comment:** inadequate information regarding method of randomisation, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias) | Unclear risk | **Quote:** "Randomised study in the single caesium for parallel groups"  
**Comment:** inadequate information regarding method of allocation concealment, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) | Unclear risk | **Quote:** "The study was carried out in 120 patients submitted to orthodontic therapy by oral route, under single blind conditions."  
**Comment:** described as single-blind, but inadequate information regarding how blinding was carried out, therefore unable to make a judgement on appropriateness |
| Blinding of outcome assessment (detection bias) | Unclear risk | **Quote:** "The study was carried out in 120 patients submitted to orthodontic therapy by oral route, under single blind conditions."  
**Comment:** described as single-blind, but inadequate information regarding how blinding was carried out, therefore unable to make a judgement on appropriateness |
| Incomplete outcome data (attrition bias) | Low risk     | 0/120 dropouts = 0% attrition (100% completion) |
| Selective reporting (reporting bias)   | High risk    | Data for outcomes at all time points recorded were not reported, only data for 4 days were available |
| Other bias                            | High risk    | There are no data presented in the paper concerning baseline characteristics of the groups |
### Methods

**Setting:** University of Florida orthodontic clinic  
**Design:** parallel (3 arms)  
**Number of centres:** 1  
**Study duration:** 37 months

### Participants

**Inclusion criteria:** at least 13 and not older than 30 years of age; not pregnant; beginning orthodontic treatment for the first time; orthodontic treatment required the placement of at least 1 separator in each of the 4 quadrants; no contraindications or adverse reactions to ibuprofen or almonds; and written informed consent to participate.  
**Exclusion criteria:** none specified  
**Orthodontic intervention:** separator placement  
**Patient sampling:**  
$n = 51$ enrolled  
$n = 0$ dropouts/excluded from analysis  
$n = 51$ data analyzed for:  
- **Group A** ($n = 16$) 6 male:10 female, mean age $17.6 \pm 5.0$ years  
- **Group B** ($n = 17$) 10 male:7 female, mean age $14.9 \pm 2.7$ years  
- **Group C** ($n = 18$) 5 male:13 female, mean age $16.4 \pm 3.6$ years

### Interventions

**Comparison:** NSAID vs placebo  
**Ibuprofen (400 mg) vs placebo:** provided pre- and post-treatment to separator placement, or post-treatment, or both  
- **Group A:** ibuprofen 1 h before placement, 3 h after and 7 h after placement  
- **Group B:** placebo 1 h before placement, ibuprofen 3 h and 7 h after placement  
- **Group C:** placebo 1 h before placement, placebo 3 h and 7 h after placement

### Outcomes

**Pain score (VAS)** - recorded at pre-treatment expectation of pain, 2 h, 6 h, 10 h, bedtime, 17 h, awakening, 24 h and 2, 3 and 7 days after separator placement  
**Pain** was recorded during the following activities:  
- chewing  
- biting (not an outcome of this review)  
- fitting front teeth together (not an outcome of this review)  
- fitting posterior teeth together (not an outcome of this review)  
**Masticatory efficiency test** (masticatory performance index (not an outcome of this review)  
**Expectation of pain (VAS)** (not an outcome of this review)  
**Affective states** (State and Trait Anxiety Inventory (STAI))

### Notes

**Conflict of interests/funding:** none reported  
**Adverse events/harm:** not discussed  
**Data handling by review authors:** only pain during chewing data required for this systematic review, however it was unclear from the published data what the VAS measurements presented - Table III labelled as ‘chewing’ but the Discussion stated that the data for chewing was not included. Mean VAS data for 24 h showed values of over 10 cm, despite a 10 cm VAS being used. Therefore, data for 24 h has been excluded for the purposes of this review  
For the purposes of this review, data from Group B have not been used, data from Group A and C have been used for the comparison of NSAID versus placebo  
**Other information of note:** pain during chewing data as presented in Table III is
reflected in this systematic review

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias)  | Unclear risk       | **Quote:** “They were randomly assigned to 1 of 3 groups stratified by sex.”  
**Comment:** inadequate information regarding method of randomisation, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias)      | Unclear risk       | **Quote:** “They were randomly assigned to 1 of 3 groups stratified by sex.”  
**Comment:** inadequate information regarding method of allocation, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel       | Unclear risk       | **Quote:** “Placebo-controlled, double-blind, parallel arm, prospective study”  
**Comment:** described as double-blind, but inadequate information regarding how blinding of participants and personnel was ensured, therefore unable to make a judgement on appropriateness |
| Blinding of outcome assessment (detection bias) | Unclear risk       | **Quote:** “Placebo-controlled, double-blind, parallel arm, prospective study”  
**Comment:** described as double-blind, but inadequate information regarding how blinding of outcome assessment was ensured, therefore unable to make a judgement on appropriateness |
| Incomplete outcome data (attrition bias)     | Low risk           | 0/51 dropouts = 0% attrition (100% completion)                                         |
| Selective reporting (reporting bias)         | High risk          | Study protocol not available. Individual VAS scores for biting, chewing, fitting front teeth, and fitting back teeth were not recorded. 10 cm VAS used, but measurements show values of > 10 cm at 24 h for all 3 groups |
| Other bias                                   | Low risk           | No other sources of bias detected.                                                   |
### Methods

**Setting:** Orthodontic Clinic of Dental School at Shiraz University of Medical Sciences, Iran  
**Design:** parallel (3 arms)  
**Number of centres:** 1  
**Study duration:** not reported

### Participants

**Inclusion criteria:** patients needing separator placement to begin orthodontic treatment in the maxillary arch; aged 15 years or older; were informed and signed the written informed consent; not using antibiotics, analgesics, anti-inflammatory, anti-coagulative, diuretics, oral anti diabetics, lithium, cyclosporine, or methotrexate; no need for antibiotic prophylaxis; no chronic systemic disease or clotting disorders; not reporting contraindication for NSAIDs; not pregnant or nursing  
**Exclusion criteria:** none specified, but excluded participants who took additional analgesics

**Orthodontic intervention:** separator placement  
**Patient sampling:**  
\( n = 349 \) assessed for eligibility (Group 1 = 107, Group 2 = 107, Group 3 = 107)  
\( n = 28 \) excluded (12 did not meet inclusion criteria, 16 decided not to participate)  
\( n = 321 \) enrolled and randomized  
\( n = 16 \) dropouts (Group 1 = 5, Group 2 = 7, Group 3 = 4 lost to follow-up)  
\( n = 64 \) excluded from analysis (Group 1 = 26, Group 2 = 24, Group 3 = 14 did not complete questionnaire correctly (n = 46)/took additional analgesics (n = 18))  
\( n = 241 \) data analyzed for:  
- **Group 1** (n = 76) 21 male:55 female, mean age 22.1 ± 3.2 years  
- **Group 2** (n = 76) 19 male:57 female, mean age 21.7 ± 3.5 years  
- **Group 3** (n = 89) 21 male:68 female, mean age 21.2 ± 3.8 years

### Interventions

**Comparisons:** NSAID vs NSAID, and NSAID vs paracetamol  
Ibuprofen (400 mg) vs paracetamol (650 mg) vs meloxicam (7.5 mg); provided pre-emptively to separator placement  
- **Group 1:** ibuprofen 1 h before separator placement  
- **Group 2:** paracetamol 1 h before separator placement  
- **Group 3:** meloxicam 1 h before separator placement

### Outcomes

**Pain score (VAS)** - recorded immediately, and at 2 h, 6 h, 24 h and 48 h after separator placement  
Pain was recorded during the following activities:  
- chewing  
- rest (not an outcome of this review)  
- fitting posterior teeth together (not an outcome of this review)

### Notes

**Conflict of interests/funding:** this work was supported by the Vice-Chancellery of Shiraz University of Medical Science (2168). The authors declare that they have no competing interests  
**Adverse events/harm:** not reported  
**Data handling by review authors:** study does not allocate intervention to specific group labels. For the purposes of this systematic review, Group 1 has been allocated as the ibuprofen arm, Group 2 as the paracetamol arm and group 3 as the meloxicam arm  
Although referred to as acetaminophen in the study, this group has been referred to as
paracetamol for the purposes of this review

**Other information of note:** only pain during chewing data were reflected in this systematic review

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias)   | Low risk           | **Quote:** "The block randomization method was used with block length 9, and number of repetition for each group n=3, to allocate subjects in each group. This method was used separately for each sex group to provide groups with equal numbers of male and female."  
**Comment:** randomisation appears to be adequate |
| Allocation concealment (selection bias)       | Low risk           | **Quote:** "The block randomization method was used with block length 9, and number of repetition for each group n=3, to allocate subjects in each group. This method was used separately for each sex group to provide groups with equal numbers of male and female."  
**Comment:** inadequate information regarding method of allocation, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) All outcomes | Low risk           | **Quote:** "In each group, all tablets were covered by identical gelatin cover, so the investigators, the patients, and the statistician were all blind to the treatment groups."  
**Comment:** blinding appears to be adequate |
| Blinding of outcome assessment (detection bias) All outcomes | Low risk           | **Quote:** "In each group, all tablets were covered by identical gelatin cover, so the investigators, the patients, and the statistician were all blind to the treatment groups."  
**Comment:** blinding appears to be adequate |
| Incomplete outcome data (attrition bias) All outcomes | High risk           | 80/321 = 25% dropouts (75% completion) |
| Selective reporting (reporting bias)          | Low risk           | Data for outcomes of this review were reported appropriately |
Ngan 1994

Methods

| Setting: | Ohio State University Orthodontic Clinic |
| Design:  | parallel (arms)                          |
| Number of centres: | 1                                         |
| Study duration: | not reported                             |

Participants

| Inclusion criteria: | not specified                           |
| Exclusion criteria: | not specified                           |
| Orthodontic intervention: | separator placement, 2nd stage of initial archwire placement |
| Patient sampling:  |                                          |
| n = ? selected      |                                          |
| n = ? excluded/refused to participate |                                          |
| 84 patients randomized; 28 per group. 34 female:43 male. |                                          |
| n = 7 dropouts/excluded from analysis; Group 1 = 5, Group 2 = 0, Group 3 = 2 |                                          |
| n = 77 separators and 56 archwires data analyzed for: |                                          |
| Group A separators (n = 23) 15 male:8 female, mean age 16.1 ± 5.5 years |                                          |
| Group A archwire (n = 17) 11 male:6 female, mean age data not available |                                          |
| Group B separators (n = 28) 16 male:12 female, mean age 15.4 ± 6.9 years |                                          |
| Group B archwire (n = 17) 10 male:7 female, mean age data not available |                                          |
| Group C separators (n = 26) 12 male:14 female, mean age 18.1 ± 7.3 years |                                          |
| Group C archwire (n = 22) 11 male:11 female, mean age data not available |                                          |

Interventions

| Comparisons: | NSAID vs placebo, NSAID vs aspirin, and aspirin vs placebo |
| Ibuprofen (400 mg) vs aspirin (650 mg) vs placebo(beta-lactose); provided immediately after separator and initial archwire placement |                                          |
| Group A: | ibuprofen immediately after placement |
| Group B: | aspirin immediately after placement |
| Group C: | placebo immediately after placement |

Outcomes

Pain score VAS - recorded at 2 h, 6 h, 24 h and 2, 3 and 7 days after separator or initial archwire placement
Pain was recorded during the following activities:
- chewing
- biting (not an outcome of this review)
- fitting front teeth together (not an outcome of this review)
- fitting posterior teeth together (not an outcome of this review)

Notes

Conflict of interests/funding: none reported
Adverse events/harm: not discussed
Data handling by review authors: VAS data were recorded for chewing, biting, fitting or putting front teeth together, and fitting on the back teeth. However data were combined for analysis in the study and these have been used for this review, as the individual data were not available
Other information of note: different initial archwires and appliances were used, "11 had upper and lower arch Begg fixed appliances fitted with 0.016-inch base arch wires.
In the remaining 45 patients, 0.022-inch edgewise brackets were bonded to the upper and lower arches, and all brackets fully engaged with an initial 0.0175-inch Response archwire.”

### Risk of bias

<table>
<thead>
<tr>
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<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk       | **Quote:** “Randomly divided into three groups”.  
**Comment:** inadequate information regarding how randomisation was ensured, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias) | Unclear risk       | **Comment:** inadequate information regarding method of allocation, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) | Low risk           | **Quote:** “The capsules appeared identical and were coded by number with the code kept by the pharmaceutical company who encapsulated the placebo and medications. The code was not revealed until the study was completed.”  
**Comment:** blinding appears to be adequate |
| Blinding of outcome assessment (detection bias) | Low risk           | **Quote:** “The capsules appeared identical and were coded by number with the code kept by the pharmaceutical company who encapsulated the placebo and medications. The code was not revealed until the study was completed.”  
**Comment:** blinding appears to be adequate |
| Incomplete outcome data (attrition bias) | Low risk           | 7/84 = 8% dropouts (92% completion)                                                   |
| Selective reporting (reporting bias) | High risk          | Data for outcomes of this study were not reported appropriately. We were unable to extract data for use in pooled analysis |
| Other bias            | Low risk           | No other sources of bias detected.                                                   |
**Nik 2016**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Setting: Dental faculty of Tehran University of Medical Sciences Design: parallel (3 arms) Number of centres: 1 Study duration: not reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td><strong>Inclusion criteria:</strong> participants started orthodontic treatment that required separators; had no systemic or GI diseases, not taking analgesics or any other drugs; no contraindication to the use of either acetaminophen (paracetamol) or liquefied ibuprofen; weight above 40 kg; first molar was without decay, filling or periodontal problem (this criterion was checked through clinical observation, probing and panoramic radiographs) <strong>Exclusion criteria:</strong> none specified, however, later stated they would exclude people who had taken additional analgesics <strong>Orthodontic intervention:</strong> separator placement <strong>Participant sampling:</strong> n = 101 randomized n = 12 dropouts/excluded from analysis (did not take drugs correctly = 8; did not complete questionnaire = 3) n = 89 data analyzed for: <strong>Group 1</strong> (n = 29) 13 male:16 female, mean age 15.6 ± 4.17 years <strong>Group 2</strong> (n = 32) 14 male:18 female, mean age 15.8 ± 3.49 years <strong>Group 3</strong> (n = 28) 12 male:16 female, mean age 15.3 ±3.15 years</td>
</tr>
<tr>
<td>Interventions</td>
<td><strong>Comparisons:</strong> NSAID vs placebo, paracetamol vs placebo, and NSAID vs paracetamol <strong>Ibuprofen (400 mg) vs paracetamol (650 mg) vs placebo:</strong> provided pre-emptively to separator placement <strong>Group 1:</strong> ibuprofen 1 h before separator placement and every 6 h until 24 h (5 doses) <strong>Group 2:</strong> paracetamol 1 h before separator placement and every 6 h until 24 h (5 doses) <strong>Group 3:</strong> placebo 1 h before separator placement and every 6 h until 24 h (5 doses)</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Pain score (VAS) - recorded immediately, and at 2 h, 6 h, bedtime and 24 h after separator placement</td>
</tr>
<tr>
<td>Notes</td>
<td><strong>Conflict of interests/funding:</strong> not reported <strong>Adverse events/harm:</strong> not reported <strong>Data handling by review authors:</strong> study did not allocate intervention to specific group labels. For the purposes of this systematic review, Group 1 has been allocated as the ibuprofen arm, Group 2 as the paracetamol arm and Group 3 as the placebo arm Although referred to as ‘acetaminophen’ in the study, we have referred to this group as paracetamol for the purposes of this review Gender data presented as a percentage, calculated as values for the purposes of this review <strong>Other information of note:</strong> no baseline information provided about groups before drop out. Mean age for Group 2 differed throughout study. For the purposes of the review, the data from Table 1 have been used</td>
</tr>
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</table>

**Risk of bias**

<table>
<thead>
<tr>
<th>Bias</th>
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<th>Support for judgement</th>
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</table>

Pharmacological interventions for pain relief during orthodontic treatment (Review)  
Copyright © 2017 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
| Random sequence generation (selection bias) | Unclear risk | **Quote:** “To divide the patients into three groups, block randomization method was used. Each block contained three coded pockets (acetaminophen, liquefied ibuprofen, and placebo) and consisted of one sex (male or female),”  
**Comment:** inadequate information regarding how randomisation was carried out, therefore unable to make a judgement on appropriateness |
|--------------------------------------------|--------------|-------------------------------------------------|
| Allocation concealment (selection bias)    | Low risk     | **Quote:** “The random allocation and coding of drugs was performed by an operator outside the study and was concealed in an envelope.”  
**Comment:** allocation concealment appears to be adequate |
| Blinding of participants and personnel (performance bias) | Low risk | **Quote:** “To ensure that the patients were blind to the experimental group, the analgesics and placebo were placed in identical capsules”; “In each group, the male to female ratio was equal, and the patient and the operator were blind of the kind of drug.”  
**Comment:** blinding appears to be adequate |
| Blinding of outcome assessment (detection bias) | Low risk | **Quote:** “The patients were asked to put each questionnaire in a pocket and seal it after marking the scale”; “randomized triple blinded clinical trial”  
**Comment:** blinding appears to be adequate |
| Incomplete outcome data (attrition bias)    | Low risk     | 12/101 = 12% dropouts (88% completion) |
| Selective reporting (reporting bias)        | Low risk     | Data for outcomes of this review were reported appropriately |
| Other bias                                  | Low risk     | No other sources of bias detected. |
Ousehal 2009

Methods

Setting: orthodontic consultation and dental treatment unit, Ibn Rochid Hospital Center, Casablanca, Morocco
Design: parallel (2 arms)
Number of centres: 1
Study duration: not reported

Participants

Inclusion criteria: no drug treatment during the study; good oral hygiene; good general health; adults stratified by age group with presenting malocclusion requiring orthodontic treatment; consent provided
Exclusion criteria: contra-indication to the use of paracetamol or ibuprofen; taking medication including short-term anti-inflammatory analgesics or long-term corticosteroids; dropouts; non-compliance
Orthodontic intervention: initial archwire placement
Participant sampling:
n = 56 randomized and analyzed:
Group A (n = 27)
Group B (n = 29)
Overall: 17 male:39 female; age < 15 years = 21.4%; aged > 15 years = 78.6%

Interventions

Comparison: NSAID vs paracetamol
Ibuprofen (600 mg; 2 x 300 mg/day for 5 days) vs paracetamol (2 g; 4 x 500 mg/day for 7 days)
Group A: ibuprofen provided immediately post-treatment, daily oral dose thereafter
Group B: paracetamol provided immediately post-treatment, daily oral dose thereafter

Outcomes

Pain score (VAS) - recorded at 2 h, 6 h, 24 h and 2, 3 and 7 days after placement of initial archwire

Notes

Conflict of interests/funding: not reported
Adverse events/harm: not reported
Data handling by review authors: additional information received through correspondence with the author
Other information of note: original paper translated from French to English.

Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td>Quote: “The randomisation was carried out by a computer algorithm; random block was performed by the software”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comment: computer-generated block randomisation carried out, therefore appears to be adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td>Quote: “The distribution of study subjects was determined by a biostatistician who gave us the list of participants to the study”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comment: allocation concealment appears</td>
</tr>
</tbody>
</table>
Ousehal 2009  (Continued)

<table>
<thead>
<tr>
<th>Bias</th>
<th>Risk</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding of participants and personnel (performance bias)</td>
<td>High</td>
<td><strong>Quote:</strong> “Double-blind was impossible because the patient could read the tablet trade name”&lt;br&gt;<strong>Comment:</strong> blinding of the drugs was not carried out, therefore it was assumed that the researcher supplying the intervention and the participants were not blinded</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low</td>
<td><strong>Quote:</strong> “Drug distribution was done with a single-blind method, single investigators were unaware of the drug”&lt;br&gt;<strong>Comment:</strong> blinding appears to be adequate</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low</td>
<td>0/56 = 0% dropout (100% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Unclear</td>
<td>Baseline information on gender and age not given by group.</td>
</tr>
</tbody>
</table>

Paganelli 1993

**Methods**

- **Setting:** Orthodontic Clinic, Dental School, University of Brescia, Italy
- **Design:** parallel (3 arms)
- **Number of centres:** 1
- **Study duration:** not reported

**Participants**

- **Inclusion criteria:** healthy; 12 to 16 years of age; oral membrane lesions from 2 mm-6 mm caused by wearing a fixed brace; available to participate in the study
- **Exclusion criteria:** already treated for orthodontic or systemic pain during the last month; syndromes or mental retardation; unavailable to participate to the study; not suffering from anxiety according to parents’ rating; no history of dental treatment refusal
- **Orthodontic intervention:** within 1 month of having a fixed or removable appliance fitted
- **Participant sampling:**
  - n = 60 selected, randomized and analyzed: (30 male:30 female; < 14 years n = 30; > 14 years n = 30)
  - **Group 1** (n = 20) 10 male:10 female, mean age 14 + 2 years
  - **Group 2** (n = 20) 10 male:10 female, mean age 14 + 2 years
  - **Group 3** (n = 20) 10 male:10 female, mean age 14 + 2 years
Interventions

Comparison: NSAID vs placebo
Flurbiprofen (10 ml 0.25% mouthwash 3 times daily for 7 days) vs placebo (10 ml mouthwash 2-minute rinse duration 3 times daily for 7 days) vs control
Group 1: flurbiprofen; provided postoperatively after separator placement
Group 2: placebo; provided postoperatively after separator placement
Group 3: control, no treatment

Outcomes
Pain score (VAS) - recorded at baseline, 3 and 7 days after separator placement

Notes
Conflict of interests/funding: not reported
Adverse events/harm: "2 cases of reduced taste sensation with Flurbiprofen which did not cause discontinuation"; "No local or systemic ADRs were reported"
Data handling by review authors: additional information received through correspondence with the author. Although multiple time points measured, due to variations in the time points of interest to this review, data from this study have not been used for this systematic review
Other information of note: original paper translated from Italian to English. All participants had pre-existing ulceration and had started orthodontic treatment within the last month

Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td>Quote: “Separated randomization lists furnished by the statistical department of our university, conceived with a variable block size of 3, 6 and 9, and stratified for lesion type (vestibular ulcers, lower labial frenum lesions, keratinized mucosa lesions, aphthous ulcers, decubitus ulcers), age (more than 14 and less than 14 years) and gender (5x2x2=20 strata), in order to obtain homogeneous and comparable group.” Comment: randomisation appears to be adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Low risk</td>
<td>Quote: “Allocation concealment was obtained identifying patients with a progressive numeration from 1 to 60, after a casual names draw, and groups with a letter from A to C, assigned by lot.” Comment: allocation concealment appears to be adequate</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias) All outcomes</td>
<td>High risk</td>
<td>Quote: “Single blinding: patients were not aware of the treatment received” Comment: adequate blinding of partici-</td>
</tr>
</tbody>
</table>
### Paganelli 1993 (Continued)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low risk</td>
<td>Quote: “The statistician who analyzed outcome data were not blind regarding study aims but he was blind regarding treatment assigned to every single patient.”</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low risk</td>
<td>0/50 dropouts = 0% attrition (100% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other sources of bias detected.</td>
</tr>
</tbody>
</table>

### Patel 2011

**Methods**
- **Setting:** University of Florida Orthodontic clinic
- **Design:** cross-over study (4 arms)
- **Number of centres:** 1
- **Study duration:** 57 days approximately

**Participants**
- **Inclusion criteria:** between 18 and 30 years; not pregnant; second premolars, first molars and second molars in contact allowing the placement of 2 separators in each quadrant; not taking pain medications; no contraindications to the drugs under study or almonds; no need for antibiotic prophylaxis before dental treatment; informed consent for participation in the study
- **Exclusion criteria:** none specified
- **Orthodontic intervention:** separator placement
- **Patient sampling:**
  - n = 24 randomized
  - n = 0 dropouts/excluded from analysis
  - n = 24 data analyzed for:
    - **Group 1** (n = 24) 13 male:11 female, mean age 26.4± 2.5 years
    - **Group 2** (n = 24) 13 male:11 female, mean age 26.4± 2.5 years
    - **Group 3** (n = 24) 13 male:11 female, mean age 26.4± 2.5 years
    - **Group 4** (n = 24) 13 male:11 female, mean age 26.4± 2.5 years

**Interventions**
- **Comparisons: Ibuprofen (400 mg) vs naproxen sodium (500 mg/250 mg) vs paracetamol (650 mg) vs placebo;** provided before and after separator placement
- **Group 1:** ibuprofen; provided 1 h pre-operatively, and 3 h and 7 h postoperatively
- **Group 2:** naproxen sodium (500 mg) 1 h pre-operatively, placebo 3 h postoperatively and naproxen sodium (250 mg) 7 h postoperatively
- **Group 3:** paracetamol; provided 1 h pre-operatively, and 3 h and 7 h postoperatively
- **Group 4:** placebo; provided 1 h pre-operatively, and 3 h and 7 h postoperatively
### Outcomes

Pain score (VAS) - recorded at: 2 h, 6 h, bedtime, awakening, and 24 h of separator placement.

### Notes

**Conflict of interests/funding:** not reported

**Adverse events/harms:** the authors reported no commercial, proprietary, or financial interest in the products or companies described in this article.

**Data handling by review authors:** outcomes calculated as summary scores from biting, chewing, fitting front teeth together and fitting back teeth together in the paper. Estimated means as reported in Figure. Additional information received from the author to clarify baseline groups and methodology, however no data for standard deviations was available.

**Other information of note:** SES reported as 75% White; 13% Asian; 8% Other; 4% Hispanic.

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias)               | Low risk           | **Quote:** "Balanced incomplete block design. Crossover trial, each subject received 3 out of 4 possible interventions (A, I, N, P) so 4 possible combinations: AIN, AIP, INP, APN. Within each block 6 possible orders: AIN, ANI, INA, IAN, NAI or NIA. Gives 24 possible drugs and orders and each person randomly assigned one of the combinations/orders. Due to incomplete block design, this leads to 18 observations for each drug."  
**Comment:** through correspondence with the author, randomisation appears to have been adequate. |
| Allocation concealment (selection bias)                   | Unclear risk       | **Comment:** inadequate information regarding how allocation was carried out, therefore unable to make a judgement on appropriateness. |
| Blinding of participants and personnel (performance bias) | Unclear risk       | **Quote:** "Investigational Drug Service at Shands hospital, Gainesville encapsulated and dispensed the tablets, researchers blinded"  
**Comment:** described as double blind, but inadequate information regarding how blinding was ensured, therefore unable to evaluate method of blinding. |
**Patel 2011** (Continued)

<table>
<thead>
<tr>
<th>Outcome Assessment/ Bias</th>
<th>Risk of Bias</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding of outcome assessment (detection bias) All outcomes</td>
<td>Unclear risk</td>
<td>Quote: “The study was double-blind.” Comment: described as double blind but inadequate information regarding how blinding was ensured, therefore unable to evaluate method of blinding</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes</td>
<td>Low risk</td>
<td>0/50 dropouts = 0% attrition</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this review were reported appropriately. We were unable to extract data for inclusion in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other sources of bias detected.</td>
</tr>
</tbody>
</table>

**Pelisson 2008**

**Methods**

- **Setting:** Institution of IASP Education - Institute for Support in Dentistry, Londrina, Parana, Brazil
- **Design:** parallel RCT (6 arms)
- **Number of centres:** 1
- **Study duration:** not reported

**Participants**

- **Inclusion criteria:** aged between 18 and 28 years; classified as healthy during the clinical history; able to provide written consent; not under prophylactic antibiotic coverage; absence of systemic disease with the use of drugs; no antibiotics or analgesics for a minimum of 15 days prior to the study; no contraindication for the use of the proposed study drugs; no extraction of teeth at least 2 weeks prior to installation of fixed orthodontic appliance; Index of Orthodontics Need (IOTN) Dental Health Component score 3 or above
- **Exclusion criteria:** history of hypersensitivity to the study drug (normal or idiosyncratic reaction to the drug); evidence of organ dysfunction or clinically significant deviation from normal; history of any psychiatric illness that might compromise the ability to provide written consent; history of GI, liver disease, renal, cardiovascular, pulmonary, neurologic or haematologic, diabetes, or glaucoma; consumption of more than 20 cigarettes per day or difficulty in refraining from smoking during the study period; history of drug or alcohol abuse; pregnant or lactating; participated in any similar clinical study during 6 weeks preceding the study. Participants were also excluded if they suffered an adverse reaction or allergic reaction clearly related to the drugs; were diagnosed with a systemic disease unrelated to the drugs during the study, that would require concomitant therapy; or did not fulfil the requirements of the Protocol, including rules related to the use of drugs, alcohol or lack of co-operation during the study
- **Orthodontic intervention:** initial archwire placement

**Patient sampling:**

n = 180 recruited and randomized
n = 0 excluded
n = 180 analyzed

**Group 1** (n = 30) 15 male:15 female, age data not reported
Pelisson 2008  (Continued)

| Group 2 (n = 30) 15 male:15 female, age data not reported |
| Group 3 (n = 30) 15 male:15 female, age data not reported |
| Group 4 (n = 30) 15 male:15 female, age data not reported |
| Group 5 (n = 30) 15 male:15 female, age data not reported |
| Group 6 (n = 30) 15 male:15 female, age data not reported |

Interventions

Comparisons: NSAID vs control (lactose placebo), and NSAID vs NSAID

**Group 1:** diclofenac sodium 50 mg 1 h before placement

**Group 2:** lumiracoxib 400 mg 1 h before placement

**Group 3:** dexamethasone 4 mg 1 before placement

**Group 4:** nimesulide 100 mg 1 h before placement

**Group 5:** ibuprofen 400 mg 1 h before placement

**Group 6:** placebo 1 h before placement

Outcomes

Pain score (VAS) - recorded at 2 h, 12 h, 24 h and 2, and 7 days after initial archwire placement

Pain was recorded during the following activities:

- chewing
- biting (not an outcome of this review)
- fitting back teeth together (not an outcome of this review)
- fitting front teeth together (not an outcome of this review)

Notes

**Conflict of interests/funding:** no source of funding reported

**Adverse events/harm:** no harms reported

**Data handling by review authors:** this paper was translated from Portuguese. The data presented for the analysis are based on Figure 1 which shows mean pain scores (mean + SEM). The SEM was used to calculate SD, but we were unable to calculate SD for lumiracoxib at 24 h from Figure 1. Data from Group 2 and Group 6 have been inverted to reflect lumiracoxib as an intervention and placebo as its control. Data from Group 3 did not contribute to the analyses

**Other information of note:** “This study was conducted in accordance with the guidelines established by Resolution 196/96 of the National Council of Health Ministry of Health published on October 10, 1996 and the Code of Professional Ethics Dental, according to Resolution 179/93 CFO ... This study was approved by the Ethics Committee of the Faculty of Dentistry and Dental Research Center São Leopoldo Mandic under protocol 06/333”

Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk | Quote: "Patients were randomly assigned to 1 of 3 experimental groups"; "The randomization of which of the three experimental conditions the patients were assigned to was computer generated"

Comment: described as randomized, but inadequate information regarding method or randomisation to make a judgement on...
**Pelisson 2008 (Continued)**

<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Risk</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Unclear</td>
<td>inadequate information regarding method of allocation concealment</td>
</tr>
<tr>
<td>Blinding of participants and personnel</td>
<td>Unclear</td>
<td>inadequate information regarding method of blinding</td>
</tr>
<tr>
<td>All outcomes</td>
<td></td>
<td>&quot;The drugs were divided into different numeric codes&quot;.</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Unclear</td>
<td>inadequate information regarding method of blinding</td>
</tr>
<tr>
<td>All outcomes</td>
<td></td>
<td>&quot;The study was double-blind.&quot;</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low</td>
<td>0/180 dropouts = 0% attrition</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Unclear</td>
<td>No data presented regarding age of participants in groups which could have resulted in sampling bias</td>
</tr>
</tbody>
</table>

**Polat 2005a**

**Methods**

- **Setting**: unspecified location, Turkey
- **Design**: parallel (6 arms)
- **Number of centres**: not reported
- **Study duration**: not reported

**Participants**

- **Inclusion criteria**: no prophylactic antibiotic cover required; no systemic diseases; no current use of antibiotics or analgesics; no contraindication to the use of NSAID; minimum weight requirement based on Food and Drug Administration-approved over the counter paediatric dosage labelling guidelines; no teeth extraction at least 2 weeks before bonding
- **Exclusion criteria**: patients with minor or extreme crowding and patients with open bite
- **Orthodontic intervention**: initial archwire placement.
- **Patient sampling**:
  - n = 150 randomized
  - n = 30 dropouts/excluded from analysis (n = 22 did not return questionnaires; n = 8 over 30 years of age)
  - n = 120 data analyzed for:
    - **Group 1** (n = 20) 10 male:10 female, mean age 15.0 + 3.7 years
    - **Group 2** (n = 20) 15 male:5 female, mean age 15.0 + 2.8 years
    - **Group 3** (n = 20) 13 male:7 female, mean age 15.0 + 4.5 years
    - **Group 4** (n = 20) 15 male: 5 female, mean age 16.0 + 4.6 years
Group 1: aspirin 1 h before, and 6 h after bonding appointment
Group 2: ibuprofen 1 h before, and 6 h after bonding appointment
Group 3: flurbiprofen 1 h before, and 6 h after bonding appointment
Group 4: paracetamol 1 h before, and 6 h after bonding appointment
Group 5: naproxen sodium; provided 1 h pre-operatively
Group 6: placebo; provided 1 h pre-operatively

Outcomes

Pain score (VAS) - recorded at 2 h, 6 h, bedtime, 24 h and 2, 3 and 7 days after initial archwire placement
Pain was recorded during the following activities:
- chewing
- biting (not an outcome of this review)
- fitting front teeth together (not an outcome of this review)
- fitting posterior teeth together (not an outcome of this review)

Notes

Conflict of interests/funding: not reported
Adverse events/harm: no harms found. “None had taken additional medication”.
Data handling by review authors: study reports Group 1 as placebo arm of trial and Group 6 as aspirin arm. For the purposes of aligning with this systematic review's own protocol, the figures for Groups 1 and 3 have been inverted to reflect aspirin as an intervention and placebo as a control
Although referred to as acetaminophen, this group has been referred to as paracetamol for the purposes of this review
Other information of note: only pain during chewing data were reflected in this systematic review

Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Unclear risk</td>
<td>Quote: “Patients were randomly assigned to one of six experimental groups.” Comment: inadequate information regarding how randomisation was carried out therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Unclear risk</td>
<td>Quote: “Patients were randomly assigned to one of six experimental groups.” Comment: inadequate information regarding how allocation was carried out,</td>
</tr>
</tbody>
</table>
### Polat 2005a

(Continued)

<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Risk Level</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Blinding of participants and personnel (performance bias) | Low risk   | *Quote:* "All tablets were identical in color, and the patient and research assistant were both blind"
| All outcomes                                           |            | *Comment:* blinding appears to be adequate                                                      |
| Blinding of outcome assessment (detection bias)         | Unclear risk| *Quote:* "All tablets were identical in color, and the patient and research assistant were both blind"
| All outcomes                                           |            | *Comment:* inadequate information regarding assessment, unclear if assessor was blinded to the intervention |
| Incomplete outcome data (attrition bias)                | Low risk   | 22/150 dropouts = 15% attrition (85% completion)                                                   |
| Selective reporting (reporting bias)                    | Low risk   | Data for outcomes of this review were reported appropriately                                        |
| Other bias                                              | Low risk   | No other sources of bias detected.                                                                |

### Polat 2005b

Methods

- **Setting:** unspecified location, Turkey
- **Design:** parallel (3 arms)
- **Number of centres:** not reported
- **Study duration:** not reported

Participants

- **Inclusion criteria:** no prophylactic antibiotic cover required; no systemic diseases; no current use of antibiotics or analogics; no contraindication to the use of NSAID; minimum weight requirement based on Food and Drug Administration-approved over the counter paediatric dosage labelling guidelines; no teeth extraction at least 2 weeks before bonding
- **Exclusion criteria:** no patient with a history of systemic disease
- **Orthodontic intervention:** initial archwire placement
- **Patient sampling:**
  - n = 60 randomized
  - n = 0 dropouts/excluded from analysis
  - n = 60 data analyzed for:
    - **Group 1** (n = 20) 14 male:6 female, mean age 15.0 ± 2.2 years
    - **Group 2** (n = 20) 13 male:7 female, mean age 17.0 ± 7.0 years
    - **Group 3** (n = 20) 10 male:10 female, mean age 16.0 ± 6.1 years

Interventions

- **Comparisons:** NSAID vs placebo, and NSAID vs NSAID
- Naproxen sodium (550 mg; 1 dose) vs ibuprofen (400 mg; 1 dose) vs placebo
Polat 2005b  (Continued)

(lactose; 1 dose): pre-emptively before archwire placement  
**Group 1:** naproxen sodium; provided 1 h pre-operatively  
**Group 2:** ibuprofen; provided 1 h pre-operatively  
**Group 3:** placebo; provided 1 h pre-operatively  

### Outcomes

Pain score (VAS) - recorded at 2 h, 6 h, bedtime, 24 h and 2, 3 and 7 days after initial archwire placement  
Pain was recorded during the following activities:  
- chewing  
- biting (not an outcome of this review)  
- fitting front teeth together (not an outcome of this review)  
- fitting posterior teeth together (not an outcome of this review)  

### Notes

**Conflict of interests/funding:** not reported  
**Adverse events/harm:** no harms found. “None of them had taken additional medication”  
**Data handling by review authors:** study reported Group 1 as placebo arm of trial, Group 2 as ibuprofen arm and Group 3 as naproxen sodium arm. For the purposes of aligning with this systematic review's own protocol, the figures for Groups 1 and 3 have been inverted to reflect naproxen sodium as an intervention and placebo as its control. Although referred to as acetaminophen, this group has been referred to as paracetamol for the purposes of this review  
**Other information of note:** only pain during chewing data are reflected in this systematic review  

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk       | Quote: “Twenty patients were randomly assigned to each of the three experimental groups.”  
Comment: inadequate information regarding how randomisation was carried out, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias)   | Unclear risk       | Quote: “Twenty patients were randomly assigned to each of the three experimental groups.”  
Comment: inadequate information regarding how allocation was carried out therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) All outcomes | Low risk           | Quote: “The patient and research assistant were blinded to each subject’s experimental group”  
Comment: blinding appears to be adequate |
Polat 2005b  (Continued)

<table>
<thead>
<tr>
<th>Bias</th>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
</table>
| Blinding of outcome assessment (detection bias)| Unclear risk | Quote: “The patient and research assistant were blinded to each subject’s experimental group”  
Comment: inadequate information regarding assessment, unclear if assessor was blinded to the intervention |
| Incomplete outcome data (attrition bias)       | Low risk | 0/60 dropouts = 0% attrition (100% completion)                               |
| Selective reporting (reporting bias)           | Low risk | Data for outcomes of this review were reported appropriately                |
| Other bias                                     | Low risk | No other sources of bias detected.                                           |

Salmassian 2009

**Methods**

**Setting:** Orthodontic Graduate Clinic, University of Colorado School of Dentistry  
**Design:** parallel (3 arms)  
**Number of centres:** 1  
**Study duration:** not reported

**Participants**

**Inclusion criteria:** scheduled to begin comprehensive orthodontic treatment (banding/bonding of at least 10 teeth in 1 arch and archwire placement in at least 1 arch); extractions, if required, performed at least 2 weeks before appliance and archwire placement; healthy with no significant medical findings; no prophylactic antibiotic coverage required; not taking antibiotics or analgesics; no contraindications to the use of acetaminophen or ibuprofen; no lactose intolerance; minimum age of 12 years and minimum weight of 88 pounds (as required by the FDA for the use of over-the-counter paediatric dosage label guidelines); and maximum age of 18 years to exclude adults  
**Exclusion criteria:** none specified  
**Orthodontic intervention:** initial archwire placement  
**Patient sampling:**  
- n = 66 enrolled  
- n = 6 excluded from analysis (did not return in timely manner for follow-up appointments (n = 4), consent withdrawn after archwire placement (n = 2))  
- n = 60 data analyzed for:  
  - **Group 1** (n = 21) 9 male:12 female, age data not reported  
  - **Group 2** (n = 19) 12 male:7 female, age data not reported  
  - **Group 3** (n = 20) 10 male:10 female, age data not reported

**Interventions**

**Comparisons:** NSAID vs placebo, NSAID vs paracetamol, and paracetamol vs placebo  
**Paracetamol (600 mg) vs ibuprofen (400 mg) vs placebo (2 tablets)**  
**Group 1:** paracetamol; immediately after each VAS time point, starting 3 h pre-operatively  
**Group 2:** ibuprofen; immediately after each VAS time point, starting 3 h pre-operatively  
**Group 3:** placebo; immediately after each VAS time point, starting 3 h pre-operatively
### Outcomes

Pain score (VAS) - recorded at 3 h, 7 h, 19 h, 24 h, 31 h and 48 h and 3, 4 and 7 days after initial archwire placement.

### Notes

**Conflict of interests/funding:** “The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.”

**Adverse events/harm:** No harms found. “No patients took additional analgesics during the study period.”

**Data handling by review authors:** Although referred to as acetaminophen in the study report, this group has been referred to as paracetamol for the purposes of this review.

**Other information of note:** No discrimination was made between various activities (eating, chewing, or biting) when VAS was recorded.

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### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk       | **Quote:** "Random group allocation and coding of patients were made by a coinvestigator (W.C.S)”
|                                   |                    | **Comment:** Inadequate information regarding how randomisation was carried out, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias) | Unclear risk       | **Quote:** "Random group allocation and coding of patients were made by a coinvestigator (W.C.S)”
|                                   |                    | **Comment:** Inadequate information regarding how allocation was carried out, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) All outcomes | Low risk           | **Quote:** "The subjects and the main investigator (R.S) were blinded to the group allocation”; “The ibuprofen, acetaminophen, and placebo tablets ... were all identical in shape and colour”
|                                   |                    | **Comment:** Blinding appears to be adequate |

**Pharmacological interventions for pain relief during orthodontic treatment (Review)**

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**Salmassian 2009**  (Continued)

<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Level of Risk</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low risk</td>
<td>6/66 dropout = 9.1% attrition (90.9% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other sources of bias detected.</td>
</tr>
</tbody>
</table>

**Steen-Law 2000**

**Methods**
- **Setting:** University of Iowa College of Dentistry's Department of Orthodontics
- **Design:** parallel (3 arms)
- **Number of centres:** 1
- **Study duration:** not reported

**Participants**
- **Inclusion criteria:** scheduled to begin comprehensive orthodontic treatment; required no prophylactic antibiotic coverage; no debilitating systemic diseases; not using antibiotics or analgesics; no contraindication to the use of ibuprofen; and maximum age of 16 years and a minimum weight of 88 pounds. This weight requirement was based on FDA-approved over-the-counter paediatric dosage labelling guidelines.
- **Exclusion criteria:** none specified
- **Orthodontic intervention:** separator placement
- **Patient sampling:**
  - n = 115 selected
  - n = 4 refused to participate
  - n = 111 randomized
  - n = 52 dropouts/lost to follow-up (did not receive separators at their next appointment = 28, did not take medications and return questionnaires = 3)
  - n = 63 data analyzed (15 male:38 female)
- **Group A** (n = 22) 10 male:12 female, mean age 13.4 ± 1.7 years
- **Group B** (n = 19) 6 male:13 female, mean age 13.3 ± 1.4 years
- **Group C** (n = 22) 9 male:13 female, mean age 13.1 ± 1.8 years

**Interventions**
- **Comparisons:** NSAID vs placebo, and pre-emptive vs post-treatment
- **Ibuprofen (400 mg) pre-emptive vs ibuprofen (400 mg) post-treatment vs placebo (lactose);** provided pre-emptively to separator placement, or post-treatment
  - **Group A:** ibuprofen 1 h before separator placement, placebo immediately after appointment
  - **Group B:** placebo 1 h before separator placement, ibuprofen immediately after appointment
  - **Group C:** placebo 1 h before separator placement, placebo immediately after appointment

**Outcomes**
- **Pain score (VAS)** - recorded at 2 h, 6 h, 24 h and 2, 3 and 7 days after separator placement
- Pain was recorded during the following activities:
  - chewing
  - biting (not an outcome of this review)
  - fitting front teeth together (not an outcome of this review)
### Notes

**Conflict of interests/funding:** not reported  
**Adverse events/harm:** not reported. Rescue analgesia required in 10 participants: n = 4 (18%) Group A; n = 6 (32%) Group B  
**Data handling by review authors:** the data presented for the analysis are based on Figure 1, which shows mean pain scores (mean + SEM) for chewing. The SEM was used to calculate SD  
Data from Group C did not contribute to the analyses, Groups A and B data were used for the comparison of pre-emptive versus postoperative analgesia  
**Other information of note:** only pain during chewing data are reflected in this systematic review. No baseline information was provided regarding the initial groups at randomisation before loss to follow-up

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk | **Quote:** “Subjects were randomly assigned to 1 of 3 experimental conditions”  
**Comment:** inadequate information regarding how randomisation was carried out, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias) | Unclear risk | **Quote:** “Subjects were randomly assigned to 1 of 3 experimental conditions”  
**Comment:** inadequate information regarding how allocation was carried out, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias)  
All outcomes | Low risk | **Quote:** “The ibuprofen and placebo tablets were alike in appearance. The placebo tablets were hardpressed and not readily dissolved, thus preventing a detectable difference in taste. The investigator, clinician, and patient were blinded to each subject’s experimental group.”  
**Comment:** blinding appears to be adequate |
| Blinding of outcome assessment (detection bias)  
All outcomes | Low risk | **Quote:** “The ibuprofen and placebo tablets were alike in appearance. The placebo tablets were hardpressed and not readily dissolved, thus preventing a detectable difference in taste. The investigator, clinician, and patient were blinded to each subject’s experimental group.” |
Steen-Law 2000  
(Continued)

<table>
<thead>
<tr>
<th>Comment: blinding appears to be adequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes High risk 52/111 dropouts = 46.8% attrition (53.2% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias) Low risk Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias Low risk No other sources of bias detected.</td>
</tr>
</tbody>
</table>

Sudhakar 2014

<table>
<thead>
<tr>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting: Department of Orthodontics and Dentofacial Orthopaedics, Sathyabama University Dental College, India</td>
</tr>
<tr>
<td>Design: parallel (4 arms)</td>
</tr>
<tr>
<td>Number of centres: 1</td>
</tr>
<tr>
<td>Study duration: not reported</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusion criteria: age 14-21 years; no previous orthodontic treatment; not under any medication for systemic problems; no allergies to NSAIDs; no history of asthma, gastritis, bleeding disorders; no teeth extraction at least 2 weeks before or after separator placement; no missing teeth</td>
</tr>
<tr>
<td>Exclusion criteria: none specified</td>
</tr>
<tr>
<td>Orthodontic intervention: separator placement</td>
</tr>
<tr>
<td>Patient sampling: n = 154 selected and randomized n = 16 dropouts/lost to follow-up (Group 1 = 4, Group 2 = 3, Group 3 = 2, Group 4 = 7; male = 11, female = 5) n = 138 data analyzed (66 male:72 female)</td>
</tr>
<tr>
<td>Group 1 (n = 34) 15 male (mean age 19.8 years):19 female (mean age 19.5 years)</td>
</tr>
<tr>
<td>Group 2 (n = 36) 18 male (mean age 19.5 years):18 female (mean age 18.9 years)</td>
</tr>
<tr>
<td>Group 3 (n = 34) 16 male (mean age 19.1 years):18 female (mean age 18.6 years)</td>
</tr>
<tr>
<td>Group 4 (n = 34) 17 male (mean age 18.9 years):17 female (mean age 18.0 years)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparisons: Paracetamol vs NSAID, paracetamol vs placebo, NSAID vs placebo, NSAID vs NSAID</td>
</tr>
<tr>
<td>Paracetamol (650 mg) vs ibuprofen (400 mg) vs aspirin (300 mg) vs placebo: provided pre-emptively and post-treatment following separator placement</td>
</tr>
<tr>
<td>Group 1: paracetamol 1 h before separator placement, and 6 h after</td>
</tr>
<tr>
<td>Group 2: ibuprofen 1 h before separator placement, and 6 h after</td>
</tr>
<tr>
<td>Group 3: aspirin 1 h before separator placement, and 6 h after</td>
</tr>
<tr>
<td>Group 4: placebo 1 h before separator placement, and 6 h after</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain score (VAS) - recorded at 2 h, 6 h, bedtime on the day of the appointment, next day morning, 2 days, 3 days, and 7 days after separator placement Pain was recorded during the following activities:</td>
</tr>
<tr>
<td>chewing food</td>
</tr>
</tbody>
</table>
Sudhakar 2014  (Continued)

- teeth not touching (not an outcome of this review)
- biting back teeth (not an outcome of this review)

Notes

**Conflict of interests/funding:** no conflict of interest declared. Funding not reported

**Adverse events/harm:** none reported

**Data handling by review authors:** data presented in the paper showed mean pain scores only. Data relating to chewing was presented in Figure 3

**Other information of note:** only pain during chewing data are reflected in this systematic review

<table>
<thead>
<tr>
<th>Risk of bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Unclear risk</td>
<td><strong>Quote:</strong> ”Patients were randomly divided into four groups”. <strong>Comment:</strong> inadequate information regarding how randomisation was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Unclear risk</td>
<td><strong>Comment:</strong> inadequate information regarding how allocation was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> ”Patients and the research assistant were blind to experimental groups” <strong>Comment:</strong> blinding appears to be adequate</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low risk</td>
<td><strong>Quote:</strong> ”Patients and the research assistant were blind to experimental groups” <strong>Comment:</strong> blinding appears to be adequate</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low risk</td>
<td>16/154 dropouts = 10% attrition (90% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this review were reported not appropriately. We were unable to extract data for use in pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other sources of bias detected.</td>
</tr>
</tbody>
</table>

Pharmacological interventions for pain relief during orthodontic treatment (Review)  
Copyright © 2017 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
| Methods          | Setting: unspecified location, Turkey  
|                 | Design: parallel (3 arms)  
|                 | Number of centres: not reported  
|                 | Study duration: not reported  

| Participants     | Inclusion criteria: no prophylactic antibiotic coverage required; no history of systemic diseases or allergies; not using antibiotics or analgesics; no contraindication to the use of NSAID; no teeth extraction at least 4 weeks before bonding; no history of orthodontic treatment; not being in the menstrual period for female patients; and minimal crowding of maximum 7 mm that could be treated without extractions  
|                 | Exclusion criteria: open bites; and participants who had additional doses of analgesic, although not stated as an exclusion criterion  
|                 | Orthodontic intervention: initial archwire placement  
|                 | Patient sampling:  
|                 | n = 60 selected  
|                 | n = 12 excluded/refused to participate (reasons not reported)  
|                 | n = 48 randomized  
|                 | n = 3 dropout/lost to follow-up (Group 1 = 2 additional dose consumption, Group 2 = 0, Group 3 = 1 lost to follow-up)  
|                 | n = 45 data analyzed (14 male:31 female)  
|                 | Group 1 (n = 15) 17 male:8 female, mean age 114.66 ± 2.06 years  
|                 | Group 2 (n = 15) 4 male:11 female, mean age 14.36 ± 1.91 years  
|                 | Group 3 (n = 15) 3 male:12 female, mean age 14.5 ± 2.0 years  

| Interventions    | Comparisons: NSAID vs placebo, NSAID vs paracetamol, and paracetamol vs placebo  
|                 | Ibuprofen (400 mg) vs paracetamol (500 mg) vs placebo (lactose): provided pre-emptively and post-treatment following archwire placement  
|                 | Group 1: ibuprofen 1 h before archwire placement, and 6 h after  
|                 | Group 2: paracetamol 1 h before archwire placement, and 6 h after  
|                 | Group 3: placebo 1 h before archwire placement, and 6 h after  

| Outcomes         | Pain score (VAS) - recorded at: pre-treatment, post-treatment and 1, 2, 3, 7 days after initial archwire placement  
|                 | Pain was recorded during the following activities:  
|                 | • chewing  
|                 | • fitting front teeth together (not an outcome of this review)  
|                 | • fitting back teeth together (not an outcome of this review)  
|                 | Prostaglandin E2 levels in the gingival crevicular fluid at the time points specified (not an outcome of this review)  

| Notes            | Conflict of interests/funding: not reported  
|                 | Adverse events/harm: not reported  
|                 | Data handling by review authors: median and IQR data presented in the paper - author contacted to obtain mean and standard deviation data however standard deviation data was not available  
|                 | Other information of note: only pain during chewing data is reflected in this systematic review  

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Pharmacological interventions for pain relief during orthodontic treatment (Review)  
Copyright © 2017 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Unclear risk       | **Quote:** "Forty-six patients were randomly allocated to one of three study groups in order"
**Comment:** inadequate information regarding how randomisation was carried out, therefore unable to make a judgement on appropriateness |
| Allocation concealment (selection bias)  | Unclear risk       | **Quote:** "Forty-six patients were randomly allocated to one of three study groups in order"
**Comment:** inadequate information regarding how allocation was carried out, therefore unable to make a judgement on appropriateness |
| Blinding of participants and personnel (performance bias) | Low risk           | **Quote:** "The groups were named as A, B, and C and both the patient and the investigator (ZT), who was responsible from the clinical part of the study, did not have any knowledge about the type of analgesic that were given to each group. The tablets were identical in shape and colour and did not have any markings or labels that represented brand name. The tablets were put in small pill boxes with a sticker containing the name of the group. The pills were put in the boxes by the second investigator, and the first investigator who coordinated the clinical part of the study did not have any knowledge about the grouping."
**Comment:** blinding appears to be adequate |
| Blinding of outcome assessment (detection bias) | Unclear risk       | **Quote:** "Prospective, randomized, double-blind, placebo-controlled study"
**Comment:** inadequate information regarding blinding, unable to make a judgement on appropriateness |
| Incomplete outcome data (attrition bias) | Low risk           | 3/46 dropouts = 6% attrition (94% completion)                                          |
Selective reporting (reporting bias)  High risk  Data for outcomes of this review were not reported appropriately. We were unable to use the data in pooled analysis

Other bias  High risk  Large gender variation at baseline, more males in Group A, more females in Groups B and C, indicating possible selection bias

**Wang 2012**

**Methods**

**Setting:** West China Stomatology Hospital of Sichuan University  
**Design:** parallel (3 arms)  
**Number of centres:** 1  
**Study duration:** 12 months

**Participants**

**Inclusion criteria:** aged over 10 years; able to comprehend and complete the study; consented to the research procedures and signed an informed consent form; minors with permission from a parent or legal guardian.  
**Exclusion criteria:** previous orthodontic treatment; recently experienced a toothache; diagnosed concurrently as having infectious diseases and/or systemic diseases; used analgesics within 3 days prior to orthodontic treatment or exhibited a contraindication to NSAIDs; displayed excessive anxiety as confirmed by the Trait-Anxiety Inventory (T-AI) score (males, ≥ 56; females, ≥ 57) and State-Anxiety Inventory (S-AI) score (males, ≥ 53; females, ≥ 55) (Shek 1993); pain threshold was < 3 seconds or > 60 seconds; or their endurance time was > 5 minutes according to the cold pressor test (CPT; Johnson 1997).  
**Orthodontic intervention:** initial archwire placement

**Patient sampling:**

n = 502 assessed for eligibility  
n = 52 excluded (14 did not meet criteria, 33 declined to participate, 5 other reasons)  
n = 450 randomized  
n = 21 dropouts/lost to follow-up (7 did not wish to complete follow-up questionnaire (Group 1 = 3, Group 2 = 1, Group 3 = 3); 7 withdrew due to discomfort of orthodontic treatment (Group 1 = 2, Group 2 = 2, Group 3 = 3); 4 lost questionnaires (Group 1 = 1, Group 2 = 1, Group 3 = 2); 2 felt they had not received treatment (Group 1 = 1, Group 2 = 1; 1 unknown Group 3))  
n = 429:  
**Group 1** (n = 143) 48 male:95 female, mean age 16.57 + 5.0 years  
**Group 2** (n = 145) 37 male:108 female, mean age 17.68 + 5.53 years  
**Group 3** (n = 141) 57 male:84 female, mean age 16.27 + 5.02 years

**Interventions**

**Comparison:** NSAID vs placebo  
Cognitive behavioural therapy (CBT) vs ibuprofen (300 mg) vs control (no treatment)  
**Group 1:** CBT immediately after archwire placement, structured phone procedure at days 8, 9, 10, 14 and 30  
**Group 2:** ibuprofen 6 h, 12 h and 24 h after initial archwire placement  
**Group 3:** placebo; routine diet and hygiene. Calls on days 8, 9,10, 14 and 30 after
Wang 2012  (Continued)

| Outcomes | **Primary outcome**: pain score (VAS) - recorded at 1, 2, 3, 7, 14 and 30 days after initial archwire placement  
**Secondary outcome**: quality of life assessed by the SF-36 and SAS at baseline and at 30 days |
|---|---|
| Notes | **Conflict of interests/funding**: “This study was financially supported by the National Natural Science Foundation of China (30801304, 81071273, and 31170929) and the Science & Technology Department of Sichuan Province (2010SZ0116). The author(s) declare no potential conflicts of interest with respect to the authorship and/ or publication of this article.”  
**Adverse events/harm**: not discussed  
**Data handling by review authors**: data presented for characteristics of groups at baseline were prior to drop out, no data available for age after drop out  
Study did not allocate intervention to specific group labels. For the purposes of this systematic review, Group 1 has been allocated as the CBT arm, Group 2 as the ibuprofen arm and Group 3 as the placebo arm. Data from Group 1 did not contribute to the analyses, Groups 2 and 3 data were used for the comparison of pharmacological interventions only  
We were unable to calculate standard deviation for Group 2 at 14 days or 30 days due to scale of graph. No further information available on correspondence with the author  
**Other information of note**: additional published information available in the study’s appendix |

### Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors’ judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
</table>
| Random sequence generation (selection bias) | Low risk | **Quote**: “Eligible patients were randomized into three groups via a computer generated sequence”  
**Comment**: randomisation appears to be adequate |
| Allocation concealment (selection bias) | Low risk | **Quote**: “The randomization sequences were stored in opaque envelopes by two clinicians who were not involved in the enrolment, intervention implementation, or outcome assessments.”  
**Comment**: allocation concealment appears to be adequate |
| Blinding of participants and personnel (performance bias) | High risk | Due to the nature of the interventions, it was not possible to blind participants or personnel to the intervention |
### Wang 2012 (Continued)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blinding of outcome assessment (detection bias)</td>
<td>Low risk</td>
<td><strong>Quote</strong>: “The outcome assessors and statisticians were blinded to the allocation.” <strong>Comment</strong>: blinding appears to be adequate</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias)</td>
<td>Low risk</td>
<td>21/450 dropouts = 4.67% attrition (95.33% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>Low risk</td>
<td>Data for outcomes of this review were reported appropriately</td>
</tr>
<tr>
<td>Other bias</td>
<td>Low risk</td>
<td>No other source of bias detected.</td>
</tr>
</tbody>
</table>

### Young 2006

| Setting | Baylor Orthodontic Department and Dallas private practices, USA |
| Design | parallel (3 arms) |
| Number of centres | unclear |
| Study duration | not reported |

#### Participants

- **Inclusion criteria**: bracket placement to begin in the maxillary or mandibular arches (or both); 18 years of age or older; no antibiotic prophylaxis needed; no chronic systemic diseases or clotting disorders; not taking antibiotics or analgesics for any reason; not lactose intolerant; not pregnant or nursing; and no contraindications for the use of valdecoxib
- **Exclusion criteria**: existing brackets on any teeth
- **Orthodontic intervention**: initial archwire placement
- **Patient sampling**: n = 70 randomized
- **Inclusion criteria**: bracket placement to begin in the maxillary or mandibular arches (or both); 18 years of age or older; no antibiotic prophylaxis needed; no chronic systemic diseases or clotting disorders; not taking antibiotics or analgesics for any reason; not lactose intolerant; not pregnant or nursing; and no contraindications for the use of valdecoxib
- **Exclusion criteria**: existing brackets on any teeth
- **Orthodontic intervention**: initial archwire placement
- **Patient sampling**: n = 70 randomized
- **Inclusion criteria**: bracket placement to begin in the maxillary or mandibular arches (or both); 18 years of age or older; no antibiotic prophylaxis needed; no chronic systemic diseases or clotting disorders; not taking antibiotics or analgesics for any reason; not lactose intolerant; not pregnant or nursing; and no contraindications for the use of valdecoxib
- **Exclusion criteria**: existing brackets on any teeth
- **Orthodontic intervention**: initial archwire placement
- **Patient sampling**: n = 70 randomized
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- **Exclusion criteria**: existing brackets on any teeth
- **Orthodontic intervention**: initial archwire placement
- **Patient sampling**: n = 70 randomized

#### Interventions

- **Comparison**: NSAID pre-emptive vs post-treatment
- **Valdecoxib (40 mg) pre-emptive vs valdecoxib (40 mg) post-treatment**: provided pre-emptively and post-treatment to initial archwire placement
- **Group 1**: placebo at least 30 minutes before initial archwire placement, 2 h after, and every 12 h starting the morning after bonding for 4 additional doses
- **Group 2**: placebo at least 30 minutes before initial archwire placement and 40 mg valdecoxib 2 h later, followed by 20 mg valdecoxib every 12 h for 4 additional doses
- **Group 3**: valdecoxib (40 mg) before initial archwire placement and placebo 2 h later, followed by 20 mg valdecoxib every 12 h for 4 additional doses
Outcomes

Pain score (VAS) - recorded at least 30 minutes before, 2 h, 6 h, 24 h and 2 days after initial archwire placement

Notes

Conflict of interests/funding: not reported
Adverse events/harm: not reported
Data handling by review authors: data from Group 1 have not contributed to the analyses.
Other information of note: none

Risk of bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Authors' judgement</th>
<th>Support for judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random sequence generation (selection bias)</td>
<td>Low risk</td>
<td>Quote: &quot;Patients were randomly assigned to the placebo or active treatment groups using a random numbers table&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comment: randomisation appears to be adequate</td>
</tr>
<tr>
<td>Allocation concealment (selection bias)</td>
<td>Unclear risk</td>
<td>Comment: inadequate information regarding how allocation was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of participants and personnel (performance bias) All outcomes</td>
<td>Unclear risk</td>
<td>Comment: described as &quot;double blind&quot;, however inadequate information provided regarding how blinding was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Blinding of outcome assessment (detection bias) All outcomes</td>
<td>Unclear risk</td>
<td>Comment: described as &quot;double blind&quot;, however inadequate information provided regarding how blinding was carried out, therefore unable to make a judgement on appropriateness</td>
</tr>
<tr>
<td>Incomplete outcome data (attrition bias) All outcomes</td>
<td>Low risk</td>
<td>6/70 dropouts = 20% attrition (80% completion)</td>
</tr>
<tr>
<td>Selective reporting (reporting bias)</td>
<td>High risk</td>
<td>Data for outcomes of this review were not reported appropriately. We were unable to extract data to included in a pooled analysis</td>
</tr>
<tr>
<td>Other bias</td>
<td>Unclear risk</td>
<td>Large age variation in overall sample, no data presented regarding age of participants in groups, therefore could have resulted in sampling bias</td>
</tr>
</tbody>
</table>
**Abbreviations**
ADR: Adverse drug reaction
GI: gastrointestinal
IASP: International Association for the Study of Pain
IQR: inter-quartile range(s)
NiTi: nickel-titanium
PGE2: prostaglandin E2
RCT: randomized controlled trial
SD: standard deviation
SEM: standard error of the mean
SES: Socio-economic status
VAS: visual analogue scale
VDS: verbal descriptive scale

**Characteristics of excluded studies [ordered by study ID]**

<table>
<thead>
<tr>
<th>Study</th>
<th>Reason for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Melh 2017</td>
<td>Inappropriate study design</td>
</tr>
<tr>
<td>Cherubini 2003</td>
<td>Abstract: insufficient information for inclusion</td>
</tr>
<tr>
<td>Eslamian 2013</td>
<td>Inappropriate study design</td>
</tr>
<tr>
<td>Eslamian 2017a</td>
<td>Inappropriate study design</td>
</tr>
<tr>
<td>Ireland 2016</td>
<td>Possible confounding due to co-interventions and therefore not possible to attribute effect to specific analgesics; comparison group used positive control</td>
</tr>
<tr>
<td>Murdock 2010</td>
<td>Possible confounding due to co-interventions and therefore not possible to attribute effect to specific analgesics; comparison group used positive control</td>
</tr>
<tr>
<td>Ogata 1999</td>
<td>Abstract: insufficient information for inclusion</td>
</tr>
<tr>
<td>Parks 2001</td>
<td>Abstract: insufficient information for inclusion</td>
</tr>
<tr>
<td>Soheilifar 2016</td>
<td>Inappropriate study design</td>
</tr>
</tbody>
</table>
### Characteristics of studies awaiting assessment [ordered by study ID]

#### Eslamian 2017b

**Methods**
- **Setting:** Orthodontic Department of Shahid Beheshti University of Medical Science, Tehran, Iran
- **Design:** parallel RCT (3 arms)
- **Number of centres:** not reported in trial registration
- **Study duration:** not reported in trial registration

**Participants**
- **Inclusion criteria:** orthodontic patients who reported pain in their previous meetings; no pain in the mouth (teeth and gums) at baseline; not using analgesics at baseline; no severe liver or kidney disease or any other contraindications for using the considered drugs; at levelling stage in orthodontic treatment
- **Exclusion criteria:** failure to complete the questionnaire at all recommended times; used other analgesics during the study
- **Orthodontic intervention:** mid-treatment
- **Patient sampling:** n = 115 recruited and randomized. No further information reported in trial registration

**Interventions**
- **Comparison:** NSAID vs placebo
  - Ketoprofen chewing gum vs placebo; ketoprofen gel vs placebo; provided postoperatively following appliance adjustments
  - **Group A:** ketoprofen chewing gum 100 mg every 8 h for 3 days after treatment
  - **Group B:** ketoprofen gel 160 mg per 100 ml every 8 h for 3 days after treatment
  - **Group C:** placebo chewing gum every 8 h for 3 days after treatment

**Outcomes**
- Pain score (5-score VAS) - recorded at 2 h, 6 h, 24 h and day 2 at 10 am and 6 pm, day 3 at 10 am and 6 pm and 7 days after appliance adjustment

**Notes**
- **Conflict of interests/funding:** funding source: Vice Chancellor for Research Shahid Beheshti University of Medical Science
- **Adverse events/harm:** none reported in trial registration
- **Data handling by review authors:** nothing to report
- **Other information of note:** unable to retrieve any further information through contact with the authors

#### Moradinejad 2014

**Methods**
- **Setting:** Dental School, Ahvaz Jundishapur University of Medical Science, Iran
- **Design:** cross-over RCT (3 arms)
- **Number of centres:** 1
- **Study duration:** not reported in trial registration

**Participants**
- **Inclusion criteria:** no specific systemic disease; not using analgesics; no periodontal and endodontics problems
- **Exclusion criteria:** lack of any case inclusion criteria
- **Orthodontic intervention:** separator placement
- **Patient sampling:** n = 54 recruited. No further information reported in trial registration

**Interventions**
- **Comparisons:** NSAID vs placebo, paracetamol vs placebo, and NSAID vs paracetamol; ibuprofen vs paracetamol vs placebo; provided prior to separator placement.
  - **Group A:** 650 mg acetaminophen oral tablet taken half an hour before separator placement.
### Moradinejad 2014  
*(Continued)*

| Group B: 400 mg ibuprofen oral tablet taken half an hour before separator placement  
Group C: (control group) 500 mg starch oral tablet taken half an hour before separator placement |
|---|

**Outcomes**  
- Pain score (VAS) - recorded at 2 h, at bed time and in the morning of days 2, 3, 4 and 5 after separator placement  
- Pain was recorded during the following activities:  
  - chewing  
  - dental contact (not an outcome of this review)  
  - rest with no contact (not an outcome of this review)

**Notes**  
- **Conflict of interests/funding:** none reported in trial registration  
- **Adverse events/harm:** none reported in trial registration  
- **Data handling by review authors:** nothing to report  
- **Other information of note:** unable to retrieve any further information through contact with the authors

### Rooke 2012

**Methods**  
- **Setting:** Australia  
- **Design:** parallel RCT (3 arms)  
- **Number of centres:** not reported in trial registration  
- **Study duration:** not reported in trial registration

**Participants**  
- **Inclusion criteria:** between the ages of 14 and 19 years old at commencement of treatment; agree, with consent of parent/guardian, to follow a strict analgesia protocol during the first 48 h of full fixed orthodontic therapy; agree, with consent of parent/guardian, to complete a 100 mm VAS at predetermined intervals within the first week of full fixed orthodontic therapy; begin full orthodontic fixed appliance therapy as per the following appliance protocols: 0.022-inch slot MBT Low Profile Victory Series brackets, 014 inch NiTi RMO Thermalloy plus archwires, Elastomeric modules; no dental extractions in the 2 weeks prior to fitting of fixed appliances; subject and parent/guardian consent to a randomly assigned analgesia protocol  
- **Exclusion criteria:** requires prophylactic antibiotic coverage; systemic diseases; pregnancy; contraindication to the use of NSAID  
- **Orthodontic intervention:** initial archwire placement  
- **Patient sampling:** it is anticipated at least 185 subjects will be recruited.

**Interventions**  
- **Comparisons:** NSAID vs placebo, paracetamol vs placebo, and NSAID vs paracetamol  
  - **Ibuprofen vs paracetamol vs placebo:** provided prior to placement of initial archwires  
  - **Group A:** 400 mg ibuprofen 1 h prior to ligating the orthodontic arch wire to the braces using elastomeric modules and continuing every 4 h for first 48 h after band-up  
  - **Group B:** 500 mg acetaminophen 1 h prior to ligating the orthodontic arch wire to the braces using elastomeric modules and continuing every 4 h for first 48 h after band-up  
  - **Group C:** (control group) placebo 1 h prior to ligating the orthodontic arch wire to the braces using elastomeric modules and continuing every 4 h for first 48 h after band-up

**Outcomes**  
- Pain score (5-score VAS) - recorded at 2 h, 6 h, night of fitting braces, 24 hs, 2, 3 and 7 days after archwire placement

**Notes**  
- **Conflict of interests/funding:** none reported in trial registration  
- **Adverse events/harm:** none reported in trial registration  
- **Data handling by review authors:** nothing to report  
- **Other information of note:** Unable to retrieve any further information through contact with the authors
**Characteristics of ongoing studies [ordered by study ID]**

### Mohammed 2016

<table>
<thead>
<tr>
<th>Trial name or title</th>
<th>Effectiveness of a preemptive ibuprofen on the control of pain before orthodontic separator placement in children and adolescents: a single center randomized controlled trial</th>
</tr>
</thead>
</table>
| **Methods** | **Setting:** Orthodontic Department of Shahid Beheshti University of Medical Science, Tehran, Iran  
**Design:** parallel RCT (3 arms)  
**Number of centres:** not reported in trial registration  
**Study duration:** not reported in trial registration |
| **Participants** | **Inclusion criteria:** orthodontic patients 15 to 25 years old without pain in the mouth at the start of the study; no renal disease or severe hepatic disease, or any other contraindications to the studied drug  
**Exclusion criteria:** failure to complete the questionnaire at all recommended times; use of other analgesics during the study  
**Orthodontic intervention:** mid-treatment  
**Participant sampling:** n = 115 recruited and randomized. No further information reported in trial registration |
| **Interventions** | **Comparison:** NSAID vs placebo  
Ketoprofen chewing gum vs placebo; ketoprofen gel vs placebo: provided postoperatively following appliance adjustments  
**Group A:** ketoprofen chewing gum 100 mg every 8 h for 3 days after treatment  
**Group B:** ketoprofen gel 160 mg per 100 ml every 8 h for 3 days after treatment  
**Group C:** placebo chewing gum every 8 h for 3 days after treatment |
| **Outcomes** | Pain score (5-score VAS) - recorded at 2 h, 6 h, 24 h and day 2 at 10 am and 6 pm, day 3 at 10 am and 6 pm and 7 days after appliance adjustment |
| **Starting date** | 11 August 2016 |
| **Contact information** | Dr Hisham Mohammed, 63 Al-fatth, Nasr City, Cairo, Egypt, 11727 |
| **Notes** | **Conflict of interests/funding:** funding source: Vice Chancellor for Research Shahid Beheshti University of Medical Science  
**Adverse events/harm:** none reported in trial registration  
**Data handling by review authors:** nothing to report  
**Other information of note:** unable to retrieve any further information through contact with the authors |
Abbreviations
h: hour(s)
RCT: randomized controlled trial
VAS: visual analogue scale
vs: versus
## DATA AND ANALYSES

### Comparison 1. Analgesic versus control

<table>
<thead>
<tr>
<th>Outcome or subgroup title</th>
<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1 2 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1.1 Paracetamol versus control</td>
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<td>107</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
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<td>1.2 NSAID versus control</td>
<td>10</td>
<td>578</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-11.72 [-16.93, -6.51]</td>
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<tr>
<td><strong>2 6 hours</strong></td>
<td></td>
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<tr>
<td>2.1 Paracetamol versus control</td>
<td>4</td>
<td>107</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-19.34 [-24.80, -13.88]</td>
</tr>
<tr>
<td>2.2 NSAID versus control</td>
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<td>428</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
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<tr>
<td><strong>3 24 hours</strong></td>
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<td>3.1 Paracetamol versus control</td>
<td>6</td>
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<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-22.09 [-35.99, -8.18]</td>
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<td>3.2 NSAID versus control</td>
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<td><strong>4 Other pain outcome data</strong></td>
<td></td>
<td></td>
<td>Other data</td>
<td>No numeric data</td>
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</table>

### Comparison 2. NSAID versus paracetamol

<table>
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<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
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<tr>
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<tr>
<td><strong>1 2 hours</strong></td>
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<td></td>
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</tr>
<tr>
<td>1</td>
<td>7</td>
<td>664</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-2.92 [-8.48, 2.65]</td>
</tr>
<tr>
<td><strong>2 6 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>7</td>
<td>664</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-5.17 [-11.71, 1.37]</td>
</tr>
<tr>
<td><strong>3 24 hours</strong></td>
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<td></td>
<td></td>
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<tr>
<td>3</td>
<td>9</td>
<td>734</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
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<td><strong>4 Qualitative pain</strong></td>
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<td>Other data</td>
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### Comparison 3. Ibuprofen pre-emptive versus post-treatment

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<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 hours</td>
<td>1</td>
<td>41</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-11.3 [-16.27, -6.33]</td>
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<tr>
<td>2 6 hours</td>
<td>2</td>
<td>69</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-8.43 [-30.37, 13.50]</td>
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<tr>
<td>3 24 hours</td>
<td>2</td>
<td>69</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-9.74 [-47.88, 28.40]</td>
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### Comparison 4. NSAID versus local anaesthetic

<table>
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<th>No. of studies</th>
<th>No. of participants</th>
<th>Statistical method</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 hours</td>
<td>1</td>
<td>48</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>13.0 [-3.45, 29.45]</td>
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<tr>
<td>2 6 hours</td>
<td>1</td>
<td>48</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>7.0 [-7.16, 21.16]</td>
</tr>
<tr>
<td>3 24 hours</td>
<td>1</td>
<td>48</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>7.0 [-5.19, 19.19]</td>
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</table>
**Analysis 1.1. Comparison 1 Analgesic versus control, Outcome 1 2 hours.**

Review: Pharmacological interventions for pain relief during orthodontic treatment

Comparison: Analgesic versus control

Outcome: 2 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean(SD)[Pain (VAS)]</td>
<td>N</td>
<td>Mean(SD)[Pain (VAS)]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>IV,Random,95% CI</td>
<td></td>
<td>IV,Random,95% CI</td>
<td></td>
</tr>
<tr>
<td>Paracetamol versus control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gupta 2014</td>
<td>15</td>
<td>32 (14)</td>
<td>8</td>
<td>44 (8)</td>
<td>6.4 %</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>10</td>
<td>27.1 (33.9)</td>
<td>4</td>
<td>34.3 (33.3)</td>
<td>1.2 %</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>32</td>
<td>8.8 (14.7)</td>
<td>14</td>
<td>20.6 (16.3)</td>
<td>6.0 %</td>
</tr>
<tr>
<td>Polat 2005a</td>
<td>20</td>
<td>22.8 (26.5)</td>
<td>4</td>
<td>38.1 (32.8)</td>
<td>1.4 %</td>
</tr>
<tr>
<td><strong>Subtotal (95% CI)</strong></td>
<td>77</td>
<td></td>
<td>30</td>
<td></td>
<td>15.0 %</td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.0$; $\chi^2 = 3.0$ (df = 3; $P = 0.99$); $I^2 = 0.0$

Test for overall effect: $Z = 3.61$ (P = 0.00030)

NSAID versus control

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean(SD)[Pain (VAS)]</td>
<td>N</td>
<td>Mean(SD)[Pain (VAS)]</td>
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<tr>
<td></td>
<td></td>
<td>IV,Random,95% CI</td>
<td></td>
<td>IV,Random,95% CI</td>
<td></td>
</tr>
<tr>
<td>Bruno 2011 (1)</td>
<td>9</td>
<td>6 (10)</td>
<td>17</td>
<td>10 (16.6)</td>
<td>5.9 %</td>
</tr>
<tr>
<td>Bruno 2011 (2)</td>
<td>8</td>
<td>6 (10)</td>
<td>17</td>
<td>12.4 (13)</td>
<td>6.3 %</td>
</tr>
<tr>
<td>Farzanegan 2012</td>
<td>10</td>
<td>51 (22)</td>
<td>10</td>
<td>48 (30.6)</td>
<td>2.6 %</td>
</tr>
<tr>
<td>Gupta 2014</td>
<td>15</td>
<td>12 (9)</td>
<td>7</td>
<td>44 (8)</td>
<td>6.9 %</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>7</td>
<td>26.7 (18.6)</td>
<td>5</td>
<td>34.3 (33.3)</td>
<td>1.6 %</td>
</tr>
<tr>
<td>Kohli 2011 (3)</td>
<td>30</td>
<td>31.8 (29.9)</td>
<td>15</td>
<td>41 (30.9)</td>
<td>3.4 %</td>
</tr>
<tr>
<td>Kohli 2011 (4)</td>
<td>30</td>
<td>11.3 (26.6)</td>
<td>15</td>
<td>41 (30.9)</td>
<td>3.5 %</td>
</tr>
<tr>
<td>Minor 2009</td>
<td>16</td>
<td>36 (12)</td>
<td>18</td>
<td>48 (10)</td>
<td>6.9 %</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>29</td>
<td>6.3 (8.8)</td>
<td>14</td>
<td>20.6 (16.3)</td>
<td>6.3 %</td>
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<tr>
<td>Pelisson 2008 (5)</td>
<td>30</td>
<td>23.6 (9.4)</td>
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<td>25.5 (6.7)</td>
<td>7.4 %</td>
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<tr>
<td>Pelisson 2008 (6)</td>
<td>30</td>
<td>22.8 (8)</td>
<td>8</td>
<td>25.5 (6.7)</td>
<td>7.6 %</td>
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<tr>
<td>Pelisson 2008 (7)</td>
<td>30</td>
<td>8.7 (4)</td>
<td>8</td>
<td>25.5 (6.7)</td>
<td>7.8 %</td>
</tr>
<tr>
<td>Pelisson 2008 (8)</td>
<td>30</td>
<td>22.8 (8)</td>
<td>7</td>
<td>25.5 (6.7)</td>
<td>7.5 %</td>
</tr>
<tr>
<td>Polat 2005a (9)</td>
<td>20</td>
<td>25.3 (32)</td>
<td>4</td>
<td>38.1 (32.8)</td>
<td>1.4 %</td>
</tr>
<tr>
<td>Polat 2005a (10)</td>
<td>20</td>
<td>11.9 (20.9)</td>
<td>4</td>
<td>38.1 (32.8)</td>
<td>1.5 %</td>
</tr>
<tr>
<td>Polat 2005a (11)</td>
<td>20</td>
<td>17.1 (22.1)</td>
<td>4</td>
<td>38.1 (32.8)</td>
<td>1.5 %</td>
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<td>37 (27.5)</td>
<td>4</td>
<td>38.1 (32.8)</td>
<td>1.4 %</td>
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</table>

(Continued...)
<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
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<tbody>
<tr>
<td>Polat 2005b (13)</td>
<td>20 21.8 (26.8)</td>
<td>10 39.2 (31.8)</td>
<td>-17.40 [-40.34, 5.54]</td>
<td>2.7 %</td>
<td></td>
</tr>
<tr>
<td>Polat 2005b (14)</td>
<td>20 14.3 (26.6)</td>
<td>10 39.2 (31.8)</td>
<td>-24.90 [-47.80, -2.00]</td>
<td>2.7 %</td>
<td></td>
</tr>
</tbody>
</table>

Subtotal (95% CI) 394 184 85.0 % -11.72 [-16.93, -6.51]
Heterogeneity: $\tau^2 = 74.36; \chi^2 = 73.16, df = 18 (P<0.00001); I^2 = 75$
Test for overall effect: $Z = 4.41 (P = 0.00001)$

Total (95% CI) 471 214 100.0 % -11.66 [-16.15, -7.17]
Heterogeneity: $\tau^2 = 61.28; \chi^2 = 73.47, df = 22 (P<0.00001); I^2 = 70$
Test for overall effect: $Z = 5.09 (P < 0.00001)$
Test for subgroup differences: $\chi^2 = 0.00, df = 1 (P = 0.97), I^2 = 0$

(1) Lumiracoxib versus placebo
(2) Lumiracoxib versus control
(3) Ibuprofen versus placebo
(4) Piroxicam versus placebo
(5) Diclofenac sodium versus placebo
(6) Nimesulide versus placebo
(7) Ibuprofen versus placebo
(8) Lumiracoxib versus placebo
(9) Naproxen sodium versus placebo
(10) Aspirin versus placebo
(11) Flurbiprofen versus placebo
(12) Ibuprofen data versus placebo
(13) Ibuprofen versus placebo
(14) Naproxen sodium versus placebo
## Analysis 1.2. Comparison 1 Analgesic versus control, Outcome 2 6 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment

Comparison: 1 Analgesic versus control

Outcome: 2 6 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
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<td>N</td>
<td>Mean(SD) (Pain (VAS))</td>
<td>IV,Random,95% CI</td>
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<td>1 Paracetamol versus control</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gupta 2014</td>
<td>15</td>
<td>31 (8)</td>
<td>8</td>
<td>51 (7)</td>
<td>8.7 %</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>10</td>
<td>49.1 (35.7)</td>
<td>4</td>
<td>50.2 (40.4)</td>
<td>2.0 %</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>32</td>
<td>11.8 (13.1)</td>
<td>14</td>
<td>28.8 (20.8)</td>
<td>7.4 %</td>
</tr>
<tr>
<td>Polat 2005a</td>
<td>20</td>
<td>21.3 (29.4)</td>
<td>4</td>
<td>51.9 (33.1)</td>
<td>2.9 %</td>
</tr>
<tr>
<td><strong>Subtotal (95% CI)</strong></td>
<td><strong>77</strong></td>
<td><strong>30</strong></td>
<td><strong>21.0 %</strong></td>
<td><strong>-19.34 [-24.80, -13.88]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 0.0$; $\chi^2 = 1.21$, df = 3 ($P = 0.75$); $I^2 = 0.0$

Test for overall effect: $Z = 6.94$ ($P < 0.00001$)

2 NSAID versus control

<table>
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<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
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</thead>
<tbody>
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<td>Mean(SD) (Pain (VAS))</td>
<td>N</td>
<td>Mean(SD) (Pain (VAS))</td>
<td>IV,Random,95% CI</td>
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<td>12.9 (14)</td>
<td>17</td>
<td>18.2 (17.8)</td>
<td>7.3 %</td>
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<tr>
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<td>12.9 (14)</td>
<td>17</td>
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<tr>
<td>Farzanegan 2012</td>
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<td>10</td>
<td>64.5 (25.8)</td>
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<tr>
<td>Gupta 2014</td>
<td>15</td>
<td>10 (9)</td>
<td>7</td>
<td>51 (7)</td>
<td>8.6 %</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>7</td>
<td>37.3 (26.7)</td>
<td>5</td>
<td>50.2 (40.4)</td>
<td>2.3 %</td>
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<tr>
<td>Kohli 2011 (3)</td>
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<td>46.9 (31.4)</td>
<td>15</td>
<td>57.8 (29.6)</td>
<td>5.7 %</td>
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<tr>
<td>Kohli 2011 (4)</td>
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<td>17.3 (21.7)</td>
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<td>57.8 (29.6)</td>
<td>6.2 %</td>
</tr>
<tr>
<td>Minor 2009</td>
<td>16</td>
<td>41 (13)</td>
<td>18</td>
<td>85 (13)</td>
<td>8.2 %</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>29</td>
<td>10.5 (10.1)</td>
<td>14</td>
<td>28.8 (20.8)</td>
<td>7.5 %</td>
</tr>
<tr>
<td>Polat 2005a (5)</td>
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<td>12.3 (29.8)</td>
<td>4</td>
<td>51.9 (33.1)</td>
<td>2.9 %</td>
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<tr>
<td>Polat 2005a (6)</td>
<td>20</td>
<td>29.9 (24)</td>
<td>4</td>
<td>51.9 (33.1)</td>
<td>3.0 %</td>
</tr>
<tr>
<td>Polat 2005a (7)</td>
<td>20</td>
<td>12.6 (20.8)</td>
<td>4</td>
<td>51.9 (33.1)</td>
<td>3.0 %</td>
</tr>
<tr>
<td>Polat 2005a (8)</td>
<td>20</td>
<td>27.3 (31.8)</td>
<td>4</td>
<td>51.9 (33.1)</td>
<td>2.9 %</td>
</tr>
<tr>
<td>Polat 2005b (9)</td>
<td>20</td>
<td>34.9 (30.4)</td>
<td>10</td>
<td>51.8 (30.7)</td>
<td>4.7 %</td>
</tr>
<tr>
<td>Polat 2005b (10)</td>
<td>20</td>
<td>16.2 (24)</td>
<td>10</td>
<td>51.8 (30.7)</td>
<td>5.0 %</td>
</tr>
<tr>
<td><strong>Subtotal (95% CI)</strong></td>
<td><strong>274</strong></td>
<td><strong>154</strong></td>
<td><strong>79.0 %</strong></td>
<td><strong>-25.69 [-34.47, -16.92]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 184.66$; $\chi^2 = 55.10$, df = 14 ($P<0.00001$); $I^2 = 75$

Test for overall effect: $Z = 5.74$ ($P < 0.00001$)
<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N Mean(SD)[Vas]</td>
<td>N Mean(SD)[Vas]</td>
<td>IV/Random,95% CI</td>
<td>IV/Random,95% CI</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>351 184</td>
<td>100.0 %</td>
<td>-24.27 [-31.44, -17.11]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $\tau^2 = 143.29; \chi^2 = 66.70, df = 18 (P<0.00001); \, \, I^2 = 73\%$

Test for overall effect: $Z = 6.64 (P < 0.00001)$

Test for subgroup differences: $\chi^2 = 1.45, df = 1 (P = 0.23), \, \, I^2 = 31\%$

(1) Lumiracoxib versus placebo
(2) Lumiracoxib versus control
(3) Ibuprofen versus placebo
(4) Piroxicam versus placebo
(5) Naproxen sodium versus placebo
(6) Flurbiprofen versus placebo
(7) Aspirin versus placebo
(8) Ibuprofen versus placebo
(9) Ibuprofen data
(10) Naproxen sodium versus placebo
### Analysis 1.3. Comparison 1 Analgesic versus control, Outcome 3 24 hours.

*Review:* Pharmacological interventions for pain relief during orthodontic treatment

*Comparison:* 1 Analgesic versus control

*Outcome:* 3 24 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic Mean(SD)(Pain (VAS))</th>
<th>Control Mean(SD)(Pain (VAS))</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>IV, Random, 95% CI</td>
<td>IV, Random, 95% CI</td>
<td></td>
</tr>
<tr>
<td>Paracetamol versus control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gupta 2014</td>
<td>15 32 (8)</td>
<td>8 64 (1.1)</td>
<td>-32.00 [-40.63, -23.37 ]</td>
<td>5.3 %</td>
<td>-32.00 [-40.63, -23.37 ]</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>10 64 (30.9)</td>
<td>4 65.6 (36.1)</td>
<td>-1.60 [-41.83, 38.63 ]</td>
<td>2.0 %</td>
<td>-1.60 [-41.83, 38.63 ]</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>32 22.8 (18.7)</td>
<td>14 58.3 (27)</td>
<td>-35.50 [-51.06, -19.94 ]</td>
<td>4.5 %</td>
<td>-35.50 [-51.06, -19.94 ]</td>
</tr>
<tr>
<td>Polat 2005a</td>
<td>20 13.1 (24.7)</td>
<td>4 59.4 (31.2)</td>
<td>-46.30 [-78.74, -13.86 ]</td>
<td>2.6 %</td>
<td>-46.30 [-78.74, -13.86 ]</td>
</tr>
<tr>
<td>Salmassian 2009</td>
<td>21 35.9 (27.7)</td>
<td>10 40.7 (27.5)</td>
<td>-4.80 [-25.56, 15.96 ]</td>
<td>3.8 %</td>
<td>-4.80 [-25.56, 15.96 ]</td>
</tr>
<tr>
<td>Tuncer 2014</td>
<td>15 64.6 (26.2)</td>
<td>8 64.3 (30.1)</td>
<td>0.30 [-24.42, 25.02 ]</td>
<td>3.4 %</td>
<td>0.30 [-24.42, 25.02 ]</td>
</tr>
<tr>
<td><strong>Subtotal (95% CI)</strong></td>
<td><strong>113</strong></td>
<td><strong>48</strong></td>
<td><strong>-22.09 [-35.99, -8.18 ]</strong></td>
<td><strong>21.6 %</strong></td>
<td><strong>-22.09 [-35.99, -8.18 ]</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: $T^2 = 173.09; \chi^2 = 14.40, df = 5 \ (P = 0.01); I^2 = 65\%$

Test for overall effect: $Z = 3.11 \ (P = 0.0019)$

2 NSAID versus control

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic Mean(SD)(Pain (VAS))</th>
<th>Control Mean(SD)(Pain (VAS))</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>IV, Random, 95% CI</td>
<td>IV, Random, 95% CI</td>
<td></td>
</tr>
<tr>
<td>Bruno 2011 (1)</td>
<td>9 26.5 (23.4)</td>
<td>17 40 (26.5)</td>
<td>-13.50 [-33.31, 6.31 ]</td>
<td>4.0 %</td>
<td>-13.50 [-33.31, 6.31 ]</td>
</tr>
<tr>
<td>Bruno 2011 (2)</td>
<td>8 26.5 (23.4)</td>
<td>17 48.2 (24.3)</td>
<td>-21.70 [-41.61, -1.79 ]</td>
<td>4.0 %</td>
<td>-21.70 [-41.61, -1.79 ]</td>
</tr>
<tr>
<td>Farzanegan 2012</td>
<td>10 44.5 (20.7)</td>
<td>10 74.7 (27.3)</td>
<td>-30.20 [-51.43, -8.97 ]</td>
<td>3.8 %</td>
<td>-30.20 [-51.43, -8.97 ]</td>
</tr>
<tr>
<td>Gupta 2014</td>
<td>15 10 (6)</td>
<td>7 64 (1.1)</td>
<td>-54.00 [-62.70, 45.30 ]</td>
<td>5.3 %</td>
<td>-54.00 [-62.70, 45.30 ]</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>7 52.6 (33)</td>
<td>5 65.6 (36.1)</td>
<td>-13.00 [-52.99, 26.99 ]</td>
<td>2.0 %</td>
<td>-13.00 [-52.99, 26.99 ]</td>
</tr>
<tr>
<td>Kohli 2011 (3)</td>
<td>30 30.5 (29.2)</td>
<td>15 66.6 (21.9)</td>
<td>-36.10 [-51.33, -20.87 ]</td>
<td>4.5 %</td>
<td>-36.10 [-51.33, -20.87 ]</td>
</tr>
<tr>
<td>Kohli 2011 (4)</td>
<td>30 53.2 (18.7)</td>
<td>15 66.6 (21.9)</td>
<td>-13.40 [-26.35, 0.45 ]</td>
<td>4.8 %</td>
<td>-13.40 [-26.35, 0.45 ]</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>29 25.3 (17.1)</td>
<td>14 58.3 (27)</td>
<td>-33.00 [-48.45, -17.55 ]</td>
<td>4.5 %</td>
<td>-33.00 [-48.45, -17.55 ]</td>
</tr>
<tr>
<td>Pelisson 2008 (5)</td>
<td>30 21.1 (9.4)</td>
<td>10 32 (10.7)</td>
<td>-10.90 [-18.34, -3.46 ]</td>
<td>5.4 %</td>
<td>-10.90 [-18.34, -3.46 ]</td>
</tr>
<tr>
<td>Pelisson 2008 (6)</td>
<td>30 27.2 (9.4)</td>
<td>10 32 (10.7)</td>
<td>-4.80 [-12.24, 2.64 ]</td>
<td>5.4 %</td>
<td>-4.80 [-12.24, 2.64 ]</td>
</tr>
<tr>
<td>Pelisson 2008 (7)</td>
<td>30 28.5 (9.4)</td>
<td>10 32 (10.7)</td>
<td>-3.50 [-10.94, 3.94 ]</td>
<td>5.4 %</td>
<td>-3.50 [-10.94, 3.94 ]</td>
</tr>
<tr>
<td>Polat 2005a (8)</td>
<td>20 18.2 (32.3)</td>
<td>4 59.4 (31.2)</td>
<td>-41.20 [-74.89, 7.51 ]</td>
<td>2.5 %</td>
<td>-41.20 [-74.89, 7.51 ]</td>
</tr>
<tr>
<td>Polat 2005a (9)</td>
<td>20 49 (34.7)</td>
<td>4 59.4 (31.2)</td>
<td>-10.40 [-44.55, 23.75 ]</td>
<td>2.5 %</td>
<td>-10.40 [-44.55, 23.75 ]</td>
</tr>
<tr>
<td>Polat 2005a (11)</td>
<td>20 24.5 (32.6)</td>
<td>4 59.4 (31.2)</td>
<td>-34.90 [-68.65, -1.15 ]</td>
<td>2.5 %</td>
<td>-34.90 [-68.65, -1.15 ]</td>
</tr>
</tbody>
</table>

(Continued...)
### Table

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Analgesic</th>
<th>Control</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polat 2005b (12)</td>
<td>20 34.1 (32.7)</td>
<td>10 44.7 (29.7)</td>
<td>-10.60</td>
<td>3.5 %</td>
<td>-33.93, 12.73</td>
</tr>
<tr>
<td>Polat 2005b (13)</td>
<td>20 54.6 (38.2)</td>
<td>10 44.7 (29.7)</td>
<td>9.90</td>
<td>3.4 %</td>
<td>-14.98, 34.78</td>
</tr>
<tr>
<td>Salmassian 2009</td>
<td>19 36.6 (30.1)</td>
<td>10 40.7 (27.5)</td>
<td>-4.10</td>
<td>3.7 %</td>
<td>-25.86, 17.66</td>
</tr>
<tr>
<td>Tuncer 2014</td>
<td>15 43.9 (33.1)</td>
<td>7 64.3 (30.1)</td>
<td>-20.40</td>
<td>3.0 %</td>
<td>-48.29, 7.49</td>
</tr>
<tr>
<td>Wang 2012</td>
<td>145 28 (15.6)</td>
<td>141 59.9 (15.6)</td>
<td>5.6 %</td>
<td>5.6 %</td>
<td>-35.52, -28.28</td>
</tr>
</tbody>
</table>

**Subtotal (95% CI)**: 527 324 78.4 % -21.05 [ -29.44, -12.65 ]

Heterogeneity: $\tau^2 = 258.80$; $\chi^2 = 154.71$, df = 19 ($p < 0.00001$); $I^2 = 88$

Test for overall effect: $Z = 4.91$ ($p < 0.00001$)

**Total (95% CI)**: 640 372 100.0 % -21.19 [ -28.31, -14.06 ]

Heterogeneity: $\tau^2 = 231.49$; $\chi^2 = 170.13$, df = 25 ($p < 0.00001$); $I^2 = 85$

Test for overall effect: $Z = 5.83$ ($p < 0.00001$)

Test for subgroup differences: $\chi^2 = 0.02$, df = 1 ($p = 0.90$), $I^2 = 0.0$

(1) Lumiracoxib versus placebo
(2) Lumiracoxib versus control
(3) Piroxicam versus placebo
(4) Ibuprofen versus placebo
(5) Nimesulide versus placebo
(6) Ibuprofen versus placebo
(7) Diclofenac sodium versus placebo
(8) Aspirin versus placebo
(9) Flurbiprofen versus placebo
(10) Naproxen Sodium versus placebo
(11) Ibuprofen versus placebo
(12) Naproxen Sodium versus placebo
(13) Ibuprofen versus placebo
### Analysis 1.4. Comparison 1 Analgesic versus control, Outcome 4 Other pain outcome data.

#### Other pain outcome data

<table>
<thead>
<tr>
<th>Study</th>
<th>Data from the trial is incomplete and inappropriately presented and cannot be used for pooled analysis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abtahi 2006</td>
<td>&quot;Ibuprofen and Tramadol groups have experienced less pain than Placebo group and the difference between two medication groups was insignificant. In placebo group pain was higher in chewing than biting.&quot;</td>
</tr>
<tr>
<td>Arantes 2009</td>
<td>&quot;Pain intensity in these groups (tenoxicam before and after orthodontic activation) was lower than in the placebo group. The difference in pain intensity between the active and the control was greatest at the assessment made 12 h after activation.&quot;</td>
</tr>
<tr>
<td>Bayani 2016</td>
<td>&quot;ANOVA demonstrated significant between-group differences in pain perceived at chewing, biting, fitting front teeth and fitting back teeth at all time points (p&lt;0.001). The results of the Tukey test revealed that at almost all intervals, pain intensity in the placebo group was comparable to that of the LLRL group (p&gt;0.05), and both groups experienced significantly greater pain than subjects in the bite wafer, ibuprofen and LLIL.&quot;</td>
</tr>
<tr>
<td>Eslamian 2014</td>
<td>&quot;The mean pain score recorded in benzocaine group was lower than that in the ketoprofen and placebo groups but a significant difference was only observed between benzocaine and the ketoprofen groups during the first two hours using Friedman and Wilcoxon tests (P=0.042). Compared to the control group, both ketoprofen and benzocaine chewing gums significantly decreased pain at all time points except for day 7.&quot;</td>
</tr>
<tr>
<td>Eslamian 2016a</td>
<td>Data from cross-over trial inappropriately presented and cannot be used for pooled analysis. &quot;The recorded pain scores were subjected to non-parametric analysis&quot;; &quot;The highest pain was recorded at 2 and 6 hours. Pain scores were significantly different between the three groups (Kruskal-Wallis test, p &lt; 0.01). The overall mean (SD) pain scores for the benzocaine 5%, ketoprofen, and control (placebo) groups were 0.89 (0.41), 0.68 (0.34), and 1.15 (0.81), respectively. The pain scores were significantly different between the ketoprofen and control groups (mean difference = 0.47, p = 0.005).&quot;</td>
</tr>
<tr>
<td>Eslamian 2016b</td>
<td>&quot;The overall mean value of pain intensity for benzocaine and placebo gels was 0.89 and 1.15, respectively. The Mann-Whitney U-test indicated that there was no significant difference between overall pain in both groups (mean difference = 0.258 p &lt; 0.21).&quot;</td>
</tr>
<tr>
<td>Ngan 1994</td>
<td>&quot;A repeated measures analysis of variance and post hoc studentized range statistics showed that the placebo group had significantly more discomfort than either the ibuprofen or the aspirin group at all the time intervals tested.&quot;</td>
</tr>
</tbody>
</table>
| Patel 2011             | Although there was a sophisticated analysis undertaken we can only use the fixed-effect estimates for pain summary score (over 2, 6, bedtime, awaking 24 hours) presented in Table 1 in the paper. These estimates indicated that ibuprofen reduced pain when compared with a placebo with an effect size of -7.89 (95% CI -13.18 to -2.60; P
Other pain outcome data  (Continued)

= 0.003), on 0 to 100 mm VAS. There was some evidence of a difference for naproxen sodium (effect size -5.04, 95% CI -9.94 to -0.14; P = 0.04) when compared with placebo, but not for acetaminophen (effect size 3.67, 95% CI -8.57 to 1.23; P = 0.14)

Sudhakar 2014  “Overall results showed Group 3 (Aspirin 300 mg) patients experienced very less pain in terms of mild discomfort, closely followed by Group 2 (Ibuprofen 400 mg). Group 1 (Paracetamol 650 mg) patients experienced mild to moderate pain on bed time and next day morning, after which gradually reduced to no pain from 3rd day morning. However, Group 4 (Placebo) patients had a bitter experience of moderate to severe pain at all time intervals.”

Young 2006  Unable to draw conclusions due to poor reporting of data.

Analysis 2.1. Comparison 2 NSAID versus paracetamol, Outcome 1 2 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment
Comparison: 2 NSAID versus paracetamol
Outcome: 1 2 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NSAID</th>
<th>Paracetamol</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean(SD)(Pain (VAS))</td>
<td>N</td>
<td>Mean(SD)(Pain (VAS))</td>
<td>IV(Random,95% CI)</td>
</tr>
<tr>
<td>Bradley 2007</td>
<td>77</td>
<td>18.6 (18.3)</td>
<td>82</td>
<td>25.9 (21.9)</td>
<td>15.3 %</td>
</tr>
<tr>
<td>Gupta 2014 (1)</td>
<td>15</td>
<td>12 (9)</td>
<td>15</td>
<td>32 (14)</td>
<td>13.2 %</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>7</td>
<td>26.7 (18.6)</td>
<td>10</td>
<td>27.1 (33.9)</td>
<td>3.9 %</td>
</tr>
<tr>
<td>Najafi 2015 (2)</td>
<td>89</td>
<td>15 (18.6)</td>
<td>38</td>
<td>13.6 (15.6)</td>
<td>15.3 %</td>
</tr>
<tr>
<td>Najafi 2015 (3)</td>
<td>76</td>
<td>13.7 (21.5)</td>
<td>38</td>
<td>13.6 (15.6)</td>
<td>14.7 %</td>
</tr>
<tr>
<td>NiK 2016</td>
<td>29</td>
<td>6.3 (8.8)</td>
<td>32</td>
<td>8.8 (14.7)</td>
<td>15.5 %</td>
</tr>
<tr>
<td>Ousehal 2009</td>
<td>27</td>
<td>47.2 (31)</td>
<td>29</td>
<td>32.4 (31.4)</td>
<td>7.2 %</td>
</tr>
<tr>
<td>Polat 2005a (4)</td>
<td>20</td>
<td>25.3 (32)</td>
<td>5</td>
<td>22.8 (26.5)</td>
<td>3.4 %</td>
</tr>
<tr>
<td>Polat 2005a (5)</td>
<td>20</td>
<td>17.1 (22.1)</td>
<td>5</td>
<td>22.8 (26.5)</td>
<td>3.9 %</td>
</tr>
<tr>
<td>Polat 2005a (6)</td>
<td>20</td>
<td>37 (27.5)</td>
<td>5</td>
<td>22.8 (26.5)</td>
<td>3.7 %</td>
</tr>
<tr>
<td>Polat 2005a (7)</td>
<td>20</td>
<td>11.9 (20.9)</td>
<td>5</td>
<td>22.8 (26.5)</td>
<td>3.9 %</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>400</td>
<td>264</td>
<td></td>
<td>100.0 %</td>
<td>-2.92 [-8.48, 2.65]</td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 42.51; Chi² = 26.81, df = 10 (P = 0.003); I² =63%
Test for overall effect: Z = 1.03 (P = 0.30)
Test for subgroup differences: Not applicable

-20 -10 0 10 20
Favours NSAID  Favours paracetamol
### Analysis 2.2. Comparison 2 NSAID versus paracetamol, Outcome 2 6 hours.

**Review:** Pharmacological interventions for pain relief during orthodontic treatment

**Comparison:** NSAID versus paracetamol

**Outcome:** 2 6 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NSAID</th>
<th>Paracetamol</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradley 2007</td>
<td>77</td>
<td>25.2 (21.2)</td>
<td>35.9 (22.8)</td>
<td>14.4 %</td>
<td>-10.70 [-17.54, -3.86]</td>
</tr>
<tr>
<td>Gupta 2014 (1)</td>
<td>15</td>
<td>10 (9)</td>
<td>15 31 (8)</td>
<td>14.8 %</td>
<td>-21.00 [-27.09, -14.91]</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>7</td>
<td>37.3 (26.7)</td>
<td>10 49.1 (35.7)</td>
<td>3.8 %</td>
<td>-11.80 [-41.48, 17.88]</td>
</tr>
<tr>
<td>Najafi 2015 (2)</td>
<td>76</td>
<td>18.9 (24.2)</td>
<td>38 19.6 (18.4)</td>
<td>13.6 %</td>
<td>-0.70 [-8.69, 7.29]</td>
</tr>
<tr>
<td>Najafi 2015 (3)</td>
<td>89</td>
<td>20.1 (21.4)</td>
<td>38 19.6 (18.4)</td>
<td>14.0 %</td>
<td>0.50 [-6.85, 7.85]</td>
</tr>
<tr>
<td>Nik 2016</td>
<td>29</td>
<td>10.5 (10.1)</td>
<td>32 11.8 (13.1)</td>
<td>15.0 %</td>
<td>-1.30 [-7.14, 4.54]</td>
</tr>
<tr>
<td>Ozsehah 2009</td>
<td>27</td>
<td>41.7 (28.3)</td>
<td>29 38.2 (34.6)</td>
<td>8.2 %</td>
<td>-3.50 [-13.01, 20.01]</td>
</tr>
<tr>
<td>Polat 2005a (4)</td>
<td>20</td>
<td>12.3 (29.8)</td>
<td>5 21.3 (29.9)</td>
<td>3.9 %</td>
<td>-9.00 [-37.89, 19.89]</td>
</tr>
<tr>
<td>Polat 2005a (5)</td>
<td>20</td>
<td>27.3 (31.8)</td>
<td>5 21.3 (29.4)</td>
<td>3.9 %</td>
<td>6.00 [-23.30, 35.30]</td>
</tr>
<tr>
<td>Polat 2005a (6)</td>
<td>20</td>
<td>12.6 (20.8)</td>
<td>5 21.3 (29.4)</td>
<td>4.3 %</td>
<td>-8.70 [-36.03, 18.63]</td>
</tr>
<tr>
<td>Polat 2005a (7)</td>
<td>20</td>
<td>29.9 (24)</td>
<td>5 21.3 (29.4)</td>
<td>4.2 %</td>
<td>8.60 [-19.23, 36.43]</td>
</tr>
</tbody>
</table>

**Total (95% CI)** | **400** | **264** | **100.0 %** | **-5.17 [-11.71, 1.37]** |

Heterogeneity: $\tau^2 = 65.45; \chi^2 = 35.10, \text{df} = 10 (P = 0.00012); I^2 = 72\%$

Test for overall effect: $Z = 1.55 (P = 0.12)$

Test for subgroup differences: Not applicable
Analysis 2.3.  Comparison 2 NSAID versus paracetamol, Outcome 3 24 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment
Comparison: 2 NSAID versus paracetamol
Outcome: 3 24 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NSAID</th>
<th>Paracetamol</th>
<th>Mean(SD)(Pain (VAS))</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradley 2007</td>
<td>77</td>
<td>82</td>
<td>34.6 (14.7)</td>
<td>10.8 %</td>
<td>0.20</td>
<td>[ -5.91, 6.31 ]</td>
</tr>
<tr>
<td>Gupta 2014 (1)</td>
<td>15</td>
<td>15</td>
<td>10 (6)</td>
<td>11.0 %</td>
<td>-22.00</td>
<td>[ -27.06, -16.94 ]</td>
</tr>
<tr>
<td>Kawamoto 2010</td>
<td>7</td>
<td>10</td>
<td>52.6 (33)</td>
<td>4.5 %</td>
<td>-11.40</td>
<td>[ -24.25, 19.6 ]</td>
</tr>
<tr>
<td>Najafi 2015 (2)</td>
<td>89</td>
<td>38</td>
<td>30.5 (28.1)</td>
<td>9.5 %</td>
<td>-0.30</td>
<td>[ -11.40, 10.80 ]</td>
</tr>
<tr>
<td>Najafi 2015 (3)</td>
<td>76</td>
<td>38</td>
<td>36.6 (32.4)</td>
<td>9.3 %</td>
<td>5.80</td>
<td>[ -6.13, 17.73 ]</td>
</tr>
<tr>
<td>nik 2016</td>
<td>29</td>
<td>32</td>
<td>25.3 (17.1)</td>
<td>10.1 %</td>
<td>2.50</td>
<td>[ -4.64, 11.48 ]</td>
</tr>
<tr>
<td>Ousehal 2009</td>
<td>27</td>
<td>29</td>
<td>34.1 (27.7)</td>
<td>8.6 %</td>
<td>3.00</td>
<td>[ -11.27, 17.27 ]</td>
</tr>
<tr>
<td>Polat 2005a (4)</td>
<td>20</td>
<td>5</td>
<td>10.5 (26.2)</td>
<td>5.8 %</td>
<td>-2.60</td>
<td>[ -27.11, 21.91 ]</td>
</tr>
<tr>
<td>Polat 2005a (5)</td>
<td>20</td>
<td>5</td>
<td>18.2 (32.2)</td>
<td>5.5 %</td>
<td>5.10</td>
<td>[ -20.74, 30.94 ]</td>
</tr>
<tr>
<td>Polat 2005a (6)</td>
<td>20</td>
<td>5</td>
<td>24.5 (32.6)</td>
<td>5.5 %</td>
<td>11.40</td>
<td>[ -14.54, 37.34 ]</td>
</tr>
<tr>
<td>Polat 2005a (7)</td>
<td>20</td>
<td>5</td>
<td>49 (34.7)</td>
<td>5.4 %</td>
<td>35.90</td>
<td>[ 9.44, 62.36 ]</td>
</tr>
<tr>
<td>Salmassian 2009</td>
<td>19</td>
<td>21</td>
<td>36.6 (30.1)</td>
<td>7.5 %</td>
<td>0.70</td>
<td>[ -14.29, 18.69 ]</td>
</tr>
<tr>
<td>Tunecer 2014</td>
<td>15</td>
<td>15</td>
<td>43.9 (33.1)</td>
<td>6.6 %</td>
<td>-20.70</td>
<td>[ -42.06, 0.66 ]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>434</strong></td>
<td><strong>300</strong></td>
<td></td>
<td><strong>100.0 %</strong></td>
<td><strong>-0.51 [ -8.93, 7.92 ]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $I^2 = 82\%$

Test for overall effect: $Z = 0.12$ ($P = 0.91$)

Test for subgroup differences: Not applicable

---

Pharmacological interventions for pain relief during orthodontic treatment (Review)

Copyright © 2017 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
(1) Etoricoxib versus paracetamol
(2) Meloxicam versus paracetamol
(3) Ibuprofen versus paracetamol
(4) Naproxen Sodium versus paracetamol
(5) Aspirin versus paracetamol
(6) Ibuprofen versus paracetamol
(7) Flurbiprofen versus paracetamol

Analysis 2.4. Comparison 2 NSAID versus paracetamol, Outcome 4 Qualitative pain.

Qualitative pain

| Study                  | Overall results showed Group 3 (Aspirin 300 mg) patients experienced very less pain in terms of mild discomfort, closely followed by Group 2 (Ibuprofen 400 mg). Group 1 (Paracetamol 650 mg) patients experienced mild to moderate pain on bed time and next day morning, after which gradually reduced to no pain from 3rd day morning. However, Group 4 (Placebo) patients had a bitter experience of moderate to severe pain at all time intervals |

Analysis 3.1. Comparison 3 Ibuprofen pre-emptive versus post-treatment, Outcome 1 2 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment
Comparison: 3 Ibuprofen pre-emptive versus post-treatment
Outcome: 1 2 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Ibuprofen pre-emptive</th>
<th>Ibuprofen post-treatment</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N Mean(SD)[Pain (VAS)]</td>
<td>N Mean(SD)[Pain (VAS)]</td>
<td>IV,Random,95% CI</td>
<td>IV,Random,95% CI</td>
<td></td>
</tr>
<tr>
<td>Steen-Law 2000</td>
<td>22 9.2 (5.9)</td>
<td>19 20.5 (9.6)</td>
<td></td>
<td>100.0 %</td>
<td>-11.30 [-16.27, -6.33]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>22 9.2 (5.9)</td>
<td>19 20.5 (9.6)</td>
<td></td>
<td>100.0 %</td>
<td>-11.30 [-16.27, -6.33]</td>
</tr>
</tbody>
</table>

Heterogeneity: not applicable
Test for overall effect: Z = 4.46 (P < 0.00001)
Test for subgroup differences: Not applicable
Analysis 3.2. Comparison 3 Ibuprofen pre-emptive versus post-treatment, Outcome 2 6 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment
Comparison: 3 Ibuprofen pre-emptive versus post-treatment
Outcome: 2 6 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Ibuprofen pre-emptive Mean(SD)(Pain (VAS))</th>
<th>Ibuprofen post-treatment Mean(SD)(Pain (VAS))</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernhardt 2001</td>
<td>14 5.1 (31.2)</td>
<td>14 27.4 (29.1)</td>
<td>-22.30 [ -44.65, 0.05 ]</td>
<td>39.4 %</td>
<td></td>
</tr>
<tr>
<td>Steen-Law 2000</td>
<td>22 29 (12.7)</td>
<td>19 28.4 (15.1)</td>
<td>0.60 [ -8.02, 9.22 ]</td>
<td>60.6 %</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>36</strong></td>
<td><strong>33</strong></td>
<td><strong>100.0 %</strong></td>
<td><strong>-8.43 [ -30.37, 13.50 ]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 187.53; Chi² = 3.51, df = 1 (P = 0.06); I² =72%
Test for overall effect: Z = 0.75 (P = 0.45)
Test for subgroup differences: Not applicable

Analysis 3.3. Comparison 3 Ibuprofen pre-emptive versus post-treatment, Outcome 3 24 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment
Comparison: 3 Ibuprofen pre-emptive versus post-treatment
Outcome: 3 24 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Ibuprofen pre-emptive Mean(SD)(Pain (VAS))</th>
<th>Ibuprofen post-treatment Mean(SD)(Pain (VAS))</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernhardt 2001</td>
<td>14 46.3 (37.4)</td>
<td>14 34.6 (31.2)</td>
<td>11.70 [ -13.81, 37.21 ]</td>
<td>45.2 %</td>
<td></td>
</tr>
<tr>
<td>Steen-Law 2000</td>
<td>22 23.5 (13)</td>
<td>19 50.9 (16.4)</td>
<td>-27.40 [ -36.56, -18.24 ]</td>
<td>54.8 %</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>36</strong></td>
<td><strong>33</strong></td>
<td><strong>100.0 %</strong></td>
<td><strong>-9.74 [ -47.88, 28.40 ]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 668.76; Chi² = 7.99, df = 1 (P = 0.005); I² =87%
Test for overall effect: Z = 0.50 (P = 0.62)
Test for subgroup differences: Not applicable
### Analysis 4.1. Comparison 4 NSAID versus local anaesthetic, Outcome 1 2 hours.

**Review:** Pharmacological interventions for pain relief during orthodontic treatment  
**Comparison:** 4 NSAID versus local anaesthetic  
**Outcome:** 1 2 hours

| Study or subgroup | NSAID Mean(SD)[Pain (VAS)] | Local anaesthetic Mean(SD)[Pain (VAS)] | Difference Mean Difference Weight Mean Difference |
|-------------------|-----------------------------|----------------------------------------|----------------------------------|-----------------------------|
| N                 | N                           | N                                      | IV/Random,95% CI                | IV/Random,95% CI            |
| Eslamian 2014     | 24 51 (31)                  | 24 38 (27)                             | 13.00 [-3.45, 29.45]            | 100.0% 13.00 [-3.45, 29.45] |
| **Total (95% CI)**| **24**                      | **24**                                 | **100.0% 13.00 [-3.45, 29.45]** |                             |

Heterogeneity: not applicable  
Test for overall effect: Z = 1.55 (P = 0.12)  
Test for subgroup differences: Not applicable

### Analysis 4.2. Comparison 4 NSAID versus local anaesthetic, Outcome 2 6 hours.

**Review:** Pharmacological interventions for pain relief during orthodontic treatment  
**Comparison:** 4 NSAID versus local anaesthetic  
**Outcome:** 2 6 hours

| Study or subgroup | NSAID Mean(SD)[Pain (VAS)] | Local anaesthetic Mean(SD)[Pain (VAS)] | Difference Mean Difference Weight Mean Difference |
|-------------------|-----------------------------|----------------------------------------|----------------------------------|-----------------------------|
| N                 | N                           | N                                      | IV/Random,95% CI                | IV/Random,95% CI            |
| Eslamian 2014     | 24 52 (24)                  | 24 45 (26)                             | 7.00 [-7.16, 21.16]             | 100.0% 7.00 [-7.16, 21.16] |
| **Total (95% CI)**| **24**                      | **24**                                 | **100.0% 7.00 [-7.16, 21.16]** |                             |

Heterogeneity: not applicable  
Test for overall effect: Z = 0.97 (P = 0.33)  
Test for subgroup differences: Not applicable
Analysis 4.3. Comparison 4 NSAID versus local anaesthetic, Outcome 3 24 hours.

Review: Pharmacological interventions for pain relief during orthodontic treatment
Comparison: 4 NSAID versus local anaesthetic
Outcome: 3 24 hours

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NSAID Mean(SD)[Pain (VAS)]</th>
<th>Local anaesthetic Mean(SD)[Pain (VAS)]</th>
<th>Mean Difference</th>
<th>Weight</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td></td>
<td>IV,Random,95% CI</td>
<td>IV,Random,95% CI</td>
</tr>
<tr>
<td>Eslamian 2014</td>
<td>43 (23)</td>
<td>36 (20)</td>
<td>-7.00</td>
<td>100.0 %</td>
<td>7.00 [-5.19, 19.19]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>24</strong></td>
<td><strong>24</strong></td>
<td><strong>100.0 %</strong></td>
<td>7.00</td>
<td><strong>7.00 [-5.19, 19.19]</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: not applicable
Test for overall effect: Z = 1.13 (P = 0.26)
Test for subgroup differences: Not applicable

ADDITIONAL TABLES

Table 1. Paracetamol versus control (no treatment or placebo) - separators

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
<th>I² (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Pain VAS</td>
<td>2 (79)</td>
<td>MD -11.51 (-19.15 to -3.86)</td>
<td>0.003</td>
<td>0.77</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Pain VAS</td>
<td>2 (79)</td>
<td>MD -16.00 (-24.65 to -7.34)</td>
<td>0.0003</td>
<td>0.38</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>24 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Pain VAS</td>
<td>2 (79)</td>
<td>MD -21.51 (-54.10 to 11.09)</td>
<td>0.2</td>
<td>0.04</td>
<td>76%</td>
</tr>
</tbody>
</table>

Abbreviations
CI: confidence interval
MD: mean difference
RR: risk ratio
SMD: standardised mean difference

Pharmacological interventions for pain relief during orthodontic treatment (Review) 
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Table 2. Paracetamol versus control (no treatment or placebo) - bonding

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
<th>$I^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Pain VAS</td>
<td>2 (70)</td>
<td>MD -14.04 (-21.51 to -6.58)</td>
<td>0.0002</td>
<td>0.88</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Pain VAS</td>
<td>2 (70)</td>
<td>MD -21.03 (-27.19 to -14.87)</td>
<td>&lt; 0.00001</td>
<td>0.30</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>24 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Pain VAS</td>
<td>4 (141)</td>
<td>MD -21.55 (-40.42 to -2.68)</td>
<td>0.03</td>
<td>0.0001</td>
<td>85%</td>
</tr>
</tbody>
</table>

**Abbreviations**

CI: confidence interval  
MD: mean difference  
RR: risk ratio  
SMD: standardised mean difference

Table 3. NSAID versus control (no treatment or placebo) - separators

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
<th>$I^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>Pain VAS</td>
<td>4 (152)</td>
<td>MD -12.80 (-17.59 to -8.01)</td>
<td>&lt; 0.00001</td>
<td>0.91</td>
<td>0%</td>
</tr>
<tr>
<td>Lumiracoxib</td>
<td></td>
<td>1 (51)</td>
<td>MD -5.32 (-11.20 to 1.56)</td>
<td>0.13</td>
<td>0.73</td>
<td>0%</td>
</tr>
<tr>
<td>Piroxicam</td>
<td></td>
<td>1 (45)</td>
<td>MD -29.70 (-48.01 to -11.39)</td>
<td>0.001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>5 (248)</td>
<td><strong>-11.10 (-15.78 to -6.42)</strong></td>
<td>&lt; 0.00001</td>
<td>0.25</td>
<td>23%</td>
</tr>
</tbody>
</table>
Table 3. NSAID versus control (no treatment or placebo) - separators

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pain VAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>4 (150)</td>
<td>MD -23.41 (-41.43 to -5.39)</td>
<td>0.01</td>
<td>0.0001</td>
<td>86%</td>
<td></td>
</tr>
<tr>
<td>Lumiracoxib</td>
<td>1 (51)</td>
<td>MD -7.06 (-16.55 to 2.43)</td>
<td>0.14</td>
<td>0.67</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Piroxicam</td>
<td>1 (45)</td>
<td>MD -40.50 (-57.37 to -23.63)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>5 (248)</td>
<td>MD -8.80 (-13.47 to -4.12)</td>
<td>0.0002</td>
<td>0.97</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>3 (118)</td>
<td>MD -21.85 (-37.33 to -6.37)</td>
<td>0.006</td>
<td>0.07</td>
<td>62%</td>
<td></td>
</tr>
<tr>
<td>Lumiracoxib</td>
<td>1 (51)</td>
<td>MD -17.58 (-31.62 to -3.54)</td>
<td>0.01</td>
<td>0.57</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Piroxicam</td>
<td>1 (45)</td>
<td>MD -36.10 (-51.33 to -20.87)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>4 (214)</td>
<td>MD -23.66 (-32.81 to -14.51)</td>
<td>&lt; 0.00001</td>
<td>0.12</td>
<td>42%</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations
CI: confidence interval
MD: mean difference
N/A: not applicable
RR: risk ratio
SMD: standardised mean difference

Table 4. NSAID versus control (no treatment or placebo) - initial archwire

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
<th>I² (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number of studies (number of participants)</td>
<td>Effect measure RR, MD, SMD (95% CI)</td>
<td>P-value for effect</td>
<td>P-value heterogeneity</td>
<td>I² (%)</td>
</tr>
<tr>
<td></td>
<td>Pain VAS</td>
<td>1 (25)</td>
<td>MD -26.20 (-56.37 to 3.97)</td>
<td>0.09</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Pharmacological interventions for pain relief during orthodontic treatment (Review)
Copyright © 2017 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
<table>
<thead>
<tr>
<th>NSAID</th>
<th>No.</th>
<th>MD</th>
<th>95% CI</th>
<th>p-value</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etoricoxib</td>
<td>1 (30)</td>
<td>-32.00</td>
<td>(-38.09 to -25.91)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Flurbiprofen</td>
<td>1 (25)</td>
<td>-21.00</td>
<td>(-51.34 to 9.34)</td>
<td>0.17</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>3 (75)</td>
<td>-6.02</td>
<td>(-20.52 to 8.47)</td>
<td>0.42</td>
<td>0.45</td>
<td>0%</td>
</tr>
<tr>
<td>Naproxen sodium</td>
<td>2 (55)</td>
<td>-20.80</td>
<td>(-39.42 to -2.18)</td>
<td>0.03</td>
<td>0.55</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>4 (210)</td>
<td>-19.23</td>
<td>(-29.90 to -8.56)</td>
<td>0.0004</td>
<td>0.07</td>
<td>47%</td>
</tr>
</tbody>
</table>

### 6 hours

<table>
<thead>
<tr>
<th>NSAID</th>
<th>No.</th>
<th>MD</th>
<th>95% CI</th>
<th>p-value</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>1 (25)</td>
<td>-39.30</td>
<td>(-69.71 to -8.89)</td>
<td>0.01</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Etoricoxib</td>
<td>1 (30)</td>
<td>-41.00</td>
<td>(-46.77 to -35.23)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Flurbiprofen</td>
<td>1 (25)</td>
<td>-22.00</td>
<td>(-52.86 to 8.86)</td>
<td>0.16</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>3 (75)</td>
<td>-20.87</td>
<td>(-35.21 to -6.52)</td>
<td>0.004</td>
<td>0.91</td>
<td>0%</td>
</tr>
<tr>
<td>Naproxen sodium</td>
<td>2 (55)</td>
<td>-36.87</td>
<td>(-54.82 to -18.92)</td>
<td>&lt; 0.0001</td>
<td>0.84</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>4 (210)</td>
<td>-35.42</td>
<td>(-42.90 to -28.68)</td>
<td>&lt; 0.00001</td>
<td>0.35</td>
<td>10%</td>
</tr>
</tbody>
</table>

### 24 hours

<table>
<thead>
<tr>
<th>NSAID</th>
<th>No.</th>
<th>MD</th>
<th>95% CI</th>
<th>p-value</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>1 (25)</td>
<td>-41.20</td>
<td>(-71.99 to -10.41)</td>
<td>0.09</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Etoricoxib</td>
<td>1 (30)</td>
<td>-54.00</td>
<td>(-60.34 to -47.66)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Flurbiprofen</td>
<td>1 (25)</td>
<td>-10.40</td>
<td>(-41.69 to 20.89)</td>
<td>0.51</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>6 (420)</td>
<td>-19.71</td>
<td>(-33.60 to -5.82)</td>
<td>0.005</td>
<td>0.004</td>
<td>71%</td>
</tr>
</tbody>
</table>
Table 4. NSAID versus control (no treatment or placebo) - initial archwire (Continued)

<table>
<thead>
<tr>
<th>NSAID sodium</th>
<th>Number of studies (number of participants)</th>
<th>MD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naproxen sodium</td>
<td>2 (55)</td>
<td>MD -28.61 (-66.08 to 8.86)</td>
<td>0.13</td>
<td>0.05</td>
</tr>
<tr>
<td>Subtotal</td>
<td>7 (555)</td>
<td>MD -26.26 (-37.81 to -14.71)</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

Abbreviations
CI: confidence interval
MD: mean difference
N/A: not applicable
RR: risk ratio
SMD: standardised mean difference

Table 5. NSAID versus control (no treatment or placebo) - mid-treatment

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketoprofen (chewing gum)</td>
<td>Pain VAS</td>
<td>1 (48)</td>
<td>MD -22.00 (-36.14 to -7.86)</td>
<td>0.002</td>
<td>N/A</td>
</tr>
<tr>
<td>Ketoprofen (chewing gum)</td>
<td>Pain VAS</td>
<td>1 (48)</td>
<td>MD -40.50 (-57.37 to -23.63)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
</tr>
<tr>
<td>Ketoprofen (chewing gum)</td>
<td>Pain VAS</td>
<td>1 (48)</td>
<td>MD -40.50 (-57.37 to -23.63)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Abbreviations
CI: confidence interval
MD: mean difference
N/A: not applicable
RR: risk ratio
SMD: standardised mean difference
### Table 6. NSAID versus paracetamol - separators

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
<th>I² (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>Pain VAS</td>
<td>4 (351)</td>
<td>MD -3.36 (-7.00 to 0.28)</td>
<td>0.07</td>
<td>0.46</td>
<td>0%</td>
</tr>
<tr>
<td>Meloxicam</td>
<td></td>
<td>1 (127)</td>
<td>MD 1.40 (-4.89 to 7.69)</td>
<td>0.66</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>4 (478)</td>
<td>MD -2.16 (-5.44 to 1.12)</td>
<td>0.20</td>
<td>0.37</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>Pain VAS</td>
<td>4 (351)</td>
<td>MD -4.53 (-10.23 to 1.18)</td>
<td>0.12</td>
<td>0.14</td>
<td>44%</td>
</tr>
<tr>
<td>Meloxicam</td>
<td></td>
<td>1 (127)</td>
<td>MD 0.50 (-6.85 to 7.85)</td>
<td>0.89</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>4 (478)</td>
<td>MD -3.35 (-8.05 to 1.35)</td>
<td>0.16</td>
<td>0.15</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>24 hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>Pain VAS</td>
<td>4 (351)</td>
<td>MD 1.38 (-3.22 to 5.98)</td>
<td>0.56</td>
<td>0.71</td>
<td>0%</td>
</tr>
<tr>
<td>Meloxicam</td>
<td></td>
<td>1 (127)</td>
<td>MD -0.30 (-11.40 to 10.80)</td>
<td>0.96</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>4 (478)</td>
<td>MD 1.14 (-3.11 to 5.39)</td>
<td>0.60</td>
<td>0.83</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Abbreviations**

CI: confidence interval  
MD: mean difference  
N/A: not applicable  
RR: risk ratio  
SMD: standardised mean difference
Table 7. NSAID versus paracetamol - initial archwire

<table>
<thead>
<tr>
<th>Experimental intervention</th>
<th>Outcome</th>
<th>Number of studies (number of participants)</th>
<th>Effect measure RR, MD, SMD (95% CI)</th>
<th>P-value for effect</th>
<th>P-value heterogeneity</th>
<th>I² (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>Pain VAS</td>
<td>1 (25)</td>
<td>MD -10.90 (-35.87 to 14.07)</td>
<td>0.39</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Etoricoxib</td>
<td></td>
<td>1 (30)</td>
<td>MD -20.00 (-28.42 to -11.58)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Flurbiprofen</td>
<td></td>
<td>1 (25)</td>
<td>MD -5.70 (-20.82 to 9.42)</td>
<td>0.46</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td></td>
<td>2 (81)</td>
<td>MD 14.63 (0.77 to 28.50)</td>
<td>0.04</td>
<td>0.97</td>
<td>0%</td>
</tr>
<tr>
<td>Naproxen sodium</td>
<td></td>
<td>1 (25)</td>
<td>MD 2.50 (-24.63 to 29.63)</td>
<td>0.86</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>3 (201)</td>
<td>MD -2.230 (-16.06 to 11.61)</td>
<td>0.75</td>
<td>0.002</td>
<td>73%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>Pain VAS</td>
<td>1 (25)</td>
<td>MD -8.70 (-36.03 to 18.63)</td>
<td>0.53</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Etoricoxib</td>
<td></td>
<td>1 (30)</td>
<td>MD -21.00 (-27.09 to -14.91)</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Flurbiprofen</td>
<td></td>
<td>1 (25)</td>
<td>MD 8.60 (-19.23 to 36.43)</td>
<td>0.54</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td></td>
<td>2 (81)</td>
<td>MD 4.10 (-10.28 to 18.48)</td>
<td>0.58</td>
<td>0.88</td>
<td>0%</td>
</tr>
<tr>
<td>Naproxen sodium</td>
<td></td>
<td>1 (25)</td>
<td>MD -9.00 (-37.89 to 19.89)</td>
<td>0.54</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td>3 (201)</td>
<td>MD -5.66 [-18.97 to 7.64]</td>
<td>0.40</td>
<td>0.02</td>
<td>63%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>Pain VAS</td>
<td>1 (25)</td>
<td>MD 5.10 (-20.77 to 30.97)</td>
<td>0.70</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Table 7. NSAID versus paracetamol - initial archwire  (Continued)

<table>
<thead>
<tr>
<th>Drug</th>
<th>N</th>
<th>MD</th>
<th>CI</th>
<th>RR</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etoricoxib</td>
<td>1</td>
<td>-22.00</td>
<td>-27.06 to -16.94</td>
<td>&lt; 0.00001</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Flurbiprofen</td>
<td>1</td>
<td>35.90</td>
<td>9.44 to 62.36</td>
<td>0.008</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>4</td>
<td>-1.36</td>
<td>-13.04 to 10.33</td>
<td>0.82</td>
<td>0.21</td>
<td>33%</td>
</tr>
<tr>
<td>Naproxen sodium</td>
<td>1</td>
<td>-2.60</td>
<td>-27.11 to 21.91</td>
<td>0.84</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5</td>
<td>-0.37</td>
<td>-14.41 to 13.67</td>
<td>0.96</td>
<td>&lt; 0.00001</td>
<td>82%</td>
</tr>
</tbody>
</table>

Abbreviations
CI: confidence interval
MD: mean difference
N/A: not applicable
RR: risk ratio
SMD: standardised mean difference

APPENDICES

Appendix 1. Cochrane Oral Health Trials Register search strategy
1 (orthodontic*:ti,ab) AND (INREGISTER)
2 ((pain* or discomfort or headache* or migraine* or neuralgi* or earache* or ear-ache* or "ear ache*" or toothache* or tooth-ache* or "tooth ache*" or odontalgi*):ti,ab) AND (INREGISTER)
3 (analgesi*:ti,ab) AND (INREGISTER)
4 (((local or topical*) and (anaesthe* or anesthe*)):ti,ab) AND (INREGISTER)
5 ("anti inflammatory agent*" or "antiinflammatory agent*" or "anti-inflammatory agent*" or "aspirin like agent*" or "aspirin-like agent*" or NSAID*:ti,ab) AND (INREGISTER)
6 ((opioid* or aspirin* or paracetamol* or acetaminophen* or medication* or drug*:ti,ab) AND (INREGISTER)
7 (#3 or #4 or #5 or #6) AND (INREGISTER)
8 (#1 and #2 and #7) AND (INREGISTER)
Appendix 2. Cochrane Central Register of Controlled Clinical Trials (CENTRAL) search strategy

#1 MeSH descriptor Orthodontics explode all trees
#2 orthodontic* in All Text
#3 (#1 or #2)
#4 MeSH descriptor Pain this term only
#5 MeSH descriptor Facial pain this term only
#6 MeSH descriptor Headache this term only
#7 MeSH descriptor Neuralgia this term only
#8 MeSH descriptor Earache this term only
#9 MeSH descriptor Toothache this term only
#10 MeSH descriptor Pain measurement this term only
#11 (pain* in All Text or discomfort in All Text or headache* in All Text or migraine* in All Text or neuralgia* in All Text or earache* in All Text or ear-ache* in All Text or “ear ache”* in All Text or toothache* in All Text or tooth-ache* in All Text or “tooth ache”* in All Text or odontalgia* in All Text)
#12 (#4 or #5 or #6 or #7 or #8 or #9 or #10 or #11)
#13 MeSH descriptor Analgesics explode all trees
#14 analgesi* in All Text
#15 MeSH descriptor Anesthetics, Local this term only
#16 ( (local in All Text or topical in All Text) and (anaesthe* in All Text or analgesi* in All Text or anesthe* in All Text) )
#17 MeSH descriptor Anti-inflammatory agents, non-steroidal explode all trees
#18 (“anti inflammatory agent”* in All Text or “antiinflammatory agent”* in All Text or “anti-inflammatory agent”* in All Text or “nonsteroidal analgesi”* in All Text or “non-steroidal analgesi”* in All Text or “aspirin like agent”* in All Text or “aspirin-like agent”* in All Text or NSAID* in All Text)
#19 (opioid* in All Text or aspirin* in All Text or paracetamol* in All Text or aceti
minophen* in All Text or medication* in All Text or drug* in All Text)
#20 (#13 or #14 or #15 or #16 or #17 or #18 or #19)
#21 (#3 and #12 and #20)

Appendix 3. MEDLINE Ovid search strategy

1. exp Orthodontics/
2. orthodontic.mp.
3. 1 or 2
4. Pain/
5. Facial pain/
6. Headache/
7. Neuralgia/
8. Earache/
9. Toothache/
10. Pain measurement/
11. (pain$ or discomfort or headache$ or migraine$ or neuralgia$ or earache$ or ear-ache$ or “ear ache”$ or toothache$ or tooth-ache$ or “tooth ache”$ or odontalgia$).mp.
12. or/4-11
13. exp Analgesics/
14. analgesi$.mp.
15. Anesthetics, Local/
16. ((local or topical) and (anaesthe$ or analgesi$ or anesthe$)).mp.
17. exp Anti-inflammatory agents, non-steroidal/
18. (“anti inflammatory agent$” or “antiinflammatory agent$” or “anti-inflammatory agent$” or “nonsteroidal analges$” or “non-steroidal analges$” or “aspirin like agent$” or “aspirin-like agent$” or NSAID$).mp.
19. (opioid$ or aspirin$ or paracetamol$ or aceti
minophen$ or medication$ or drug$).mp.
20. or/13-19
This subject search was linked to the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomized trials in MEDLINE: sensitivity-maximising version (2008 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of *The Cochrane Handbook for Systematic Reviews of Interventions*, Version 5.1.0 [updated March 2011] (Lefebvre 2011).

1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. exp animals/ not humans.sh.
11. 9 not 10

**Appendix 4. Embase Ovid search strategy**

1. exp Orthodontics/
2. orthodontic.mp.
3. 1 or 2
4. Pain/
5. Face pain/
6. Headache/
7. Neuralgia/
8. Oraalgia/
9. Tooth pain/
10. Pain assessment/
11. (pain$ or discomfort or headache$ or migraine$ or neuralgi$ or earache$ or ear-ache$ or ”ear ache” or toothache$ or tooth-ache$ or ”tooth ache” or odontalgia$).mp.
12. or/4-11
13. exp Analgesic agent/
14. analgesi$.mp.
15. Local anesthetic agent/
16. ((local or topical) and (anaesthetic$ or analgesic$ or anesthetic$)).mp.
17. exp Nonsteroid antiinflammatory agent/
18. (”anti inflammatory agent$” or ”antiinflammatory agent$” or ”anti-inflammatory agent$” or ”nonsteroidal analgesic$” or ”nonsteroidal analgesics” or ”non-steroidal analgesics” or ”aspirin like agent$” or ”aspirin-like agent$” or NSAID$).mp.
19. (opioid$ or aspirin$ or paracetamol$ or acetaminophen$ or medication$ or drug$).mp.
20. or/13-19
21. 3 and 12 and 20

The above subject search was linked to Cochrane Oral Health’s filter for identifying RCTs in Embase Ovid:

1. random$.ti,ab.
2. factorial$.ti,ab.
3. (crossover$ or cross over$ or cross-over$).ti,ab.
4. placebo$.ti,ab.
5. (doubi$ adj blind$i$).ti,ab.
6. (singl$i adj blind$i).ti,ab.
7. assign$.ti,ab.
8. allocat$.ti,ab.
9. volunteer$.ti,ab.
10. CROSSOVER PROCEDURE.sh.
Appendix 5. CINAHL EBSCO search strategy

S1 (MH "Orthodontics+")
S2 orthodontic*
S3 S1 or S2
S4 MH "Pain"
S5 MH "Facial Pain"
S6 MH "Headache"
S7 MH "Neuralgia"
S8 MH "Earache"
S9 MH "Toothache"
S10 MH "Pain Measurement"
S11 (pain* or discomfort or headache* or migraine* or neuralg* or earache* or ear-ache* or "ear ache"* or toothache* or tooth-ache* or "tooth ache"* or odontalg*)
S12 S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11
S13 MH "Analgesics+"
S14 analgesi*
S15 (MH "Anesthetics, Local+")
S16 ((local or topical) and (anaesthe* or analgesi* or anesthe*))
S17 (MH "Antiinflammatory Agents, Non-Steroidal+")
S18 ("anti inflammatory agent"* or "antiinflammatory agent"* or "anti-inflammatory agent"* or "nonsteroidal analgesi"* or "non steroidal analgesi"* or "non-steroidal analgesi"* or "aspirin like agent"* or "aspirin-like agent"* or NSAID*)
S19 (opioid* or aspirin* or paracetamol* or acetaminophen* or medication* or drug*)
S20 S13 or S14 or S15 or S16 or S17 or S18 or S19
S21 S3 and S12 and S20

Appendix 6. US National Institutes of Health Ongoing Trials Register (ClinicalTrials.gov) search strategy

orthodontic and pain

Appendix 7. World Health Organization International Clinical Trials Registry Platform search strategy

orthodontic and pain
HISTORY
Protocol first published: Issue 1, 2003
Review first published: Issue 11, 2017

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Description</th>
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<tr>
<td>18 September 2008</td>
<td>Amended</td>
<td>Converted to new review format</td>
</tr>
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</table>

CONTRIBUTIONS OF AUTHORS
Jayne Harrison (JH) conceived the review. James Cooper (JC) and JH wrote the protocol. The review was co-ordinated by Aoife Monk (AM). AM, with the assistance of Anne Littlewood (Information Specialist, Cochrane Oral Health), developed the search strategy and undertook the electronic searches. AM undertook the handsearching. AM, Annabel Teague (AT) and JH screened the search results and retrieved papers, appraised the risk of bias in the papers, extracted data from them and assessed the quality of the evidence overall. Helen Worthington checked the data extraction, undertook the data analysis and assisted with the interpretation of the data. AM and JH wrote the review.

DECLARATIONS OF INTEREST
The review authors declare that there is no financial conflict of interest and that they do not have any associations with industry regarding the subject of this review.

Aoife B Monk: none known

Jayne E Harrison: administrative support for this review was funded by an NHS Research & Development grant. The time I spent on the review was largely outside contractual hours, but meetings were attended within the working day, for which I was given study leave.

Helen V Worthington: none known. I am one of two Co-ordinating Editors of Cochrane Oral Health.

Annabel Teague: none known

SOURCES OF SUPPORT
Internal sources
- The Royal Liverpool and Broadgreen Hospitals NHS Trust, UK.
- The University of Manchester, Manchester Academic Health Sciences Centre (MAHSC) and UKNIHR Manchester Biomedical Research Centre, UK.
External sources

- Cochrane Oral Health Global Alliance, Other.

The production of Cochrane Oral Health reviews has been supported financially by our Global Alliance since 2011 (oralhealth.cochrane.org/partnerships-alliances). Contributors over the past year have been the American Association of Public Health Dentistry, USA; the British Association for the Study of Community Dentistry, UK; the British Society of Paediatric Dentistry, UK; the Canadian Dental Hygienists Association, Canada; the Centre for Dental Education and Research at All India Institute of Medical Sciences, India; the National Center for Dental Hygiene Research & Practice, USA; New York University College of Dentistry, USA; and NHS Education for Scotland, UK; Swiss Society of Endodontology, Switzerland.

- National Institute for Health Research (NIHR), UK.

This project was supported by the NIHR, via Cochrane Infrastructure funding to Cochrane Oral Health. The views and opinions expressed herein are those of the review authors and do not necessarily reflect those of the Systematic Reviews Programme, the NIHR, the NHS or the Department of Health.

Differences between protocol and review

- We altered objectives to include timing of analgesia taken during orthodontic treatment.
- We removed quasi-randomized controlled clinical trials from the inclusion criteria.
- We adjusted exclusion criteria to include participants who had received orthodontic treatment involving the use of temporary anchorage devices.
- We removed duration of pain from primary outcomes.
- We removed handsearching from the methodology.
- We rewrote parts of the review for clarity.