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SCIENTIFIC SECTION

# Orthodontic adhesives: a systematic review

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## Abstract

*Objectives* To evaluate which orthodontic adhesives (a) bond orthodontic brackets to teeth more reliably and (b) are more effective at preventing decalcification.

*Data sources* The search strategy for the literature review was carried out according to the standard Cochrane systematic review methodology. The Cochrane Clinical Trials Register and the Cochrane Oral Health Group Specialized Register were searched for randomized clinical trials and controlled clinical trials. All volumes that had not already been assessed by the Oral Health Group in the *European Journal of Orthodontics*, *American Journal of Orthodontics*, *Journals of Orthodontics*, and *Angle Orthodontist* were hand-searched. Inclusion and exclusion criteria were applied when considering the studies to be included in this review.

*Data selection* The primary outcome measure was the failure of the orthodontic adhesive. A secondary outcome of decalcification occurring around the orthodontic bracket was also recorded, if data were available.

*Data extraction* Two randomized clinical trials and one controlled clinical trial were identified that fulfilled all the inclusion and exclusion criteria. The trials compared: (a) light- and chemically-cured composite; (b) chemically-cured composite and conventional glass ionomer cement; and (c) chemically-cured composite and light-cured compomer.

*Data synthesis* Each paper was quality assessed by two people independently. A qualitative analysis of the trials in the review is presented. The data presentation, for the majority of the trials, precluded the use of suggested Cochrane Health Group statistical analysis.

*Conclusions* It is difficult to draw any conclusions from this review; however, suggestions are made for methods of improving future research involving orthodontic adhesives.

*Index words:*
bond failure, Cochrane Oral Health Group, Cochrane systematic review, decalcification, orthodontic adhesives, per cent debond.

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## Introduction

The aim of this review was to evaluate which orthodontic adhesive group is the most reliable for bonding fixed appliances and to assess whether any of the adhesives were more effective at preventing decalcification around bonded brackets during treatment. These factors are important because the need to replace brackets during treatment slows down progress, and can be costly in terms of clinical time, materials, and patient inconvenience. In addition, decalcification constitutes a significant risk of orthodontic treatment with decalcification rates reported between 2 and 95 per cent.[1–6]

Since there are many orthodontic bonding studies published, it is difficult for the clinician to read all the literature and come to any valid conclusions about the best adhesive to use. This problem may be overcome by completing a systematic review using the clearly defined process outlined in the Cochrane Library handbook. Information from randomized clinical trials and controlled clinical trials can then be collated, summarized, and regularly updated, to aid clinicians in their decision making.

This paper will present the results of a systematic review of orthodontic bonding adhesives.

## Materials and methods

The method for this review is presented according to Cochrane guidelines and further details of the method-

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ology may be obtained from the Cochrane Oral Health Group.[7]

*Types of studies considered in the review*

Randomized clinical trials (RCTs) and controlled clinical trials (CCTs) were included that compared at least two different adhesives.

*Types of participants*

Patients receiving fixed appliances were included apart from the following exclusions: patients with cleft lip and/or palate or any other syndrome; patients who received surgery including orthognathic surgery or surgical exposure and bonding of impacted teeth.

*Type of intervention*

Studies were only included where stainless steel brackets were bonded to all the teeth (except molars). Studies were excluded which:

- compared adhesives from the same group, that used the same curing mechanism;
- only reported decalcification as an outcome;
- used ceramic or plastic brackets;
- used lingual appliances;
- varied etching times;
- did not follow the patients to the end of appliance treatment;
- reported the statistical analysis in an inappropriate or unclear way .

*Note:* studies investigating different bracket bases were included only if adhesive types were compared between brackets with the same base type. Bracket failures for both adhesives and both bracket bases were reported.

*Type of outcome measures*

The main outcome measure was debond or failure of brackets bonded with each orthodontic adhesive group. The secondary outcome measure was decalcification at the end of treatment, if recorded.

## Comparison of orthodontic adhesive groups

A comparison was made among the adhesive group and then within groups according to whether the polymerization mechanism was chemically- or light-cured. It is important to note that if a study compared two adhesives from the same group with the same polymerization mechanism, e.g. two chemically-cured composites, the trial was excluded from the review. Potential adhesive groups used for comparison were:

- conventional composite (will be referred to as 'Composite');
- conventional glass ionomer cement (GIC);
- resin-modified GIC;
- polyacid-modified composites (compomers).

## Search strategy

Medline and Embase Electronic Registers were searched from 1970 to 2000. The Cochrane Clinical trials Register (CCTR) and the Cochrane Oral Health Group Specialized Register were searched to identify all RCTs and CCTs using the search term 'Orthodontic brackets', and free text terms 'orthodont' with 'glass ionomer' and 'orthodont' with 'composite'. Hand searching of the following journals was carried out for the years that were not currently included on the Cochrane Oral Health Group Specialized Register. This meant that all publications in the following journals were hand searched (years up to and including):

*American Journal of Orthodontics (and Dentofacial Orthopedics)*: 1970–2000
*British Journal of Orthodontics*: 1973–2000
*European Journal of Orthodontics*: 1979–2000
*Angle Orthodontist*: 1978–2000

All the first authors of trials were contacted in an attempt to identify any unpublished studies and clarify information about published trials (including missing data, method of randomization, blinding, and withdrawals). In addition, conference proceedings and abstracts from the British Orthodontic Conference and European Orthodontic Conference were searched for the same time period as the hand searching. No language restrictions were placed. The references quoted in the included studies were screened for any further trials.

## Quality assessment

Two people independently assessed the quality of each paper included. In the case of any discrepancies, the paper was assessed by a third person. The quality assessment included a record of randomization blinding, sample size calculation, inclusion and exclusion criteria, completeness of follow-up, management of study drop-

outs, and examiner blinding. A full copy of the quality assessment for included and excluded studies is available on the Cochrane Oral Health Group website.[7]

*Assessment of the appropriateness of the statistical analysis*

Two authors, who are senior statisticians, assessed all the eligible studies for the appropriateness of their statistical analysis. The results of the assessments were compared during a consensus meeting. The statistical analysis was considered inappropriate if:

- a split mouth design where an inappropriate statistical test was used, that did not take the clustering of the teeth or 'pairing' into account;
- all failures were included without taking into account multiple failures on the same tooth.

## Results

*Description of the studies*

Three trials were identified which fulfilled all the inclusion and exclusion criteria. Two were randomized clinical trials and one was a controlled clinical trial. All trials were carried out in a hospital setting. Two trials were carried out were UK and one in Sweden. All three trials used a split mouth design and one trial reported decalcification as a secondary outcome. It is also worth noting that, overall, authors generally reported percentage bracket failure rate for the orthodontic adhesives. The trials were divided for comparison of orthodontic adhesives as follows:

- Chemically cured composite versus light cure composite: one trial
- Chemically cured composite versus conventional glass ionomer cement: one trial
- Chemically cured composite versus compomer: one trial

*Studies that were excluded from the review*

A large number of studies were excluded from this systematic review mainly for the reasons summarized in Appendix 1. The most common reason for exclusion was inappropriate or unclear statistical analysis. Two trained and senior statisticians examined each study and concluded that nine were analysed inappropriately and one was unclear; therefore, these trials were excluded from the review. In the split-mouth studies, it is important that the data were analysed taking the clustering or pairing within the patient into account. Six trials failed to do this[8–13] and the analysis was unclear in a further split mouth study.[14] Two full mouth studies analysed teeth as though they were independent, ignoring clustering within patients. [15,16] A further study conducted a survival analysis including second time failures.[17]

Where the statistical analysis was appropriate, the data tended to be presented without standard deviations or with statistical techniques, which were not amenable to meta-analysis. Therefore, the results of the trials included in the review will be presented in narrative only.

The second main reason for exclusion was studies that only compared two adhesives from the *same* group. It is important to note that they were excluded only because the aim of the review was to attempt to evaluate which adhesive type was best for orthodontic bonding.

*Quality assessment*

In summary, the studies generally achieved greater than 80 per cent patient follow-up. However, the quality of reporting was poor since studies often did not:

- report a sample size calculation;
- clearly define their inclusion/exclusion criteria;
- describe whether there were any patient withdrawals or dropouts from the studies;
- described the trial as single or double blind (i.e. whether, if possible, the patients were blind to adhesive allocation).

## Comparison of different orthodontic adhesives

*Chemical cure (CC) composite versus light cure (LC) composite*

Table 1 summarizes the proportion of bracket failures for a CC and LC composite with two different bracket bases. It is suggested that there was no statistically significant differences in bracket failure rates between the CC and LC composites studied; however, the adhesive names where not reported as they were experimental.

*CC composite versus standard CC glass ionomer cement (GIC)*

The one trial for this adhesive comparison[18] suggested that standard CC GIC exhibited statistically significantly higher bracket failure rates compared with CC

**Table 1** Light cured composite versus chemical cure composite

| Author (date) | Composite/ bracket base (adhesive names not quoted) | No. brackets placed (No. failed) | % Bracket failure |
|---|---|---|---|
| O'Brien[20] (1989) | Mesh foil base | | |
| | 'Lightcure' | 128 (5) | 3.9 |
| | 'Chemical cure' | 123 (6) | 4.9 |
| | Micro-loc base | | |
| | 'Lightcure' | 127 (7) | 5.5 |
| | 'Chemical cure' | 107 (8) | 7.5 |

*Difference between groups is statistically significant ($P < 0.05$).

**Table 2** Failure rates when comparing chemical cure composite and conventional glass ionomer cement

| Author (date) | Adhesive/ bracket base | No. brackets placed (no. failed) | % Bracket failure |
|---|---|---|---|
| Norevall[18] (1996) | Unitwin mesh foil base Unite | 255 (18) | 7* |
| | Aquacem (conventional GIC) | 256 (56) | 22 |
| Norevall[18] (1996) | Dynalok Cut groove base Unite | 238 (54) | 23* |
| | Aquacem | 236 (118) | 50 |

*Difference between groups is statistically significant ($P < 0.001$).

composite ($P < 0.05$; Table 2). It was surprising that decalcification rates were not reported as a secondary outcome.

*CC composite versus Compomer*

Millett *et al.*[19] (Table 3) are the only authors to have reported a clinical trial for this comparison group. No statistically significant differences were found between Dyract Ortho (compomer) and Right-On for bracket failure rates, but the compomer offered better protection against decalcification ($P < 0.05$).

## Discussion

The systematic review of the literature, prior to application of the exclusion criteria in Appendix 1, has highlighted that there are many clinical trials of orthodontic adhesives, notably comparing CC composite with either LC composite or conventional CC GIC. Fewer studies have included materials, such as compomers or resin-modified LC GIC.

**Table 3** Bracket failure when chemical cured composite and a LC compomer were compared

| Author (date) | Adhesive | No. brackets placed (no. failed) | % Bracket failure |
|---|---|---|---|
| Millett[19] (2000) (CCT) | Right-On | 213 (36) | 16.9 |
| | Dyract Ortho (LC compomer) | 213 (43) | 20.2 |

It was disappointing that several studies had to be excluded from the review because of inappropriate statistical analysis. In addition, a formal meta-analysis could not be carried out on pooled data because although the percentage of bracket failure rates were reported, the means and standard deviations for each group were not always published.

Several studies were excluded because of the use of inappropriate statistical techniques. Split mouth studies were frequently analysed by chi-square tests that failed to take the pairing of the data within the patient's mouths into account. Other studies were excluded as teeth were treated independently in the analysis, ignored the clustering of teeth within the mouth. Another issue was the inappropriateness of conducting survival analysis using second time failures.

*Qualitative comparison of orthodontic adhesives*

*CC composite versus LC composite*. It was notable that many composite adhesives from different manufacturers have been studied. However, when stringent exclusion criteria and quality analysis are used, it proved impossible to make generalizations about whether a light cure or chemical cure composite should be used. This is disappointing, since the review has highlighted a lack of scientific evidence to support the perceived clinical advantage of light cure systems.

*CC composite versus CC conventional GIC*. The use of a composite resin adhesive over conventional glass ionomer cement, at their present stage of development, is supported. However, it was surprising that decalcification was not investigated by this comparative study.

*CC composite versus Compomer*. The only trial to carry out this comparison suggested that a compomer had a comparable bracket failure rate to a CC composite. This suggests that the role of compomers for future orthodontic bonding may merit further investigation, particu-

larly in view of their possible potential for reducing decalcification.

*Reporting quality*

The high rates of patient follow-up suggest that it is possible to minimize 'attrition bias' in trials comparing orthodontic adhesives. However, for other quality indicators the reporting quality was low. In particular, for describing patient withdrawals or dropouts, and for attempts to make the studies either single-blind or double-blind.

It would be possible to blind both the patient and the operator if both adhesives being compared were either light or chemical cured, and had the same mixing requirements. If the patient explanations for the trial were done carefully, patients only could be blinded if adhesives with different polymerization mechanisms were used.

*Search strategy*

The search strategy used for this review searched the main orthodontic journals. It is possible that trials may have been missed in other dental journals. These trials will be detected in due course as the Cochrane Oral Health Group hand-searching database increases. In addition, each systematic review is updated every two years when more trials are likely to be added.

## Conclusions and implications for clinical practice

It is not possible to draw any conclusions from this systematic review of orthodontic adhesives. However, there are a number of suggestions that may be made for future research, the majority of which are based on the quality of reporting of clinical trials. Researchers might consider:

- A randomized clinical trial comparing all generic groups of adhesive.
- Following all patients to the end of fixed appliance treatment.
- Calculating a sample size.
- Clear inclusion and exclusion criteria.
- Describing patient withdrawal and dropouts, and modifying the statistical analysis if appropriate.
- Assessing for occlusal interferences that may affect bond failure.
- Attempting to make studies single blind (patient) or double blind (patient and operator) if feasible.
- Treat all patients in the same way apart from the intervention.
- Inclusion of standard deviation in addition to mean number of bond failures.
- Measuring decalcification as a secondary outcome where appropriate.
- Use of appropriate statistical analysis and involve a statistician in the design and analysis.

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## Appendix 1: summary of reasons for excluded studies

| Reason for trial exclusion | Trial author (first author) |
|---|---|
| Comparison of two chemically- cured composites | Zachrisson[21]<br>Underwood[22]<br>Banks[23]<br>Mitchell[24]<br>Chung[25]<br>Turner[26]<br>Ash[27] |
| Comparison of two light –cured composites | Sonis[28] |
| Statistical analysis unclear or inappropriate | Miguel[8]<br>Trimpaneers[9]<br>Sunna[10]<br>Fricker[11–13]<br>Cacciafesta[14]<br>Miller[15]<br>Shamma[16]<br>Lovius[17] |
| Trial patients not followed through to the end of treatment | Gaworski[29]<br>Saeytijd[30]<br>Galindo[31] |