

## Review Article

# Adhesives for Fixed Orthodontic Bands

## A Systematic Review

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### ABSTRACT

**Objective:** To evaluate the effectiveness of adhesives used to attach bands to teeth during fixed appliance treatment.

**Material and Methods:** Electronic databases, conference proceedings and the Internet were searched. There was no restriction with regard to publication status or language of publication. Randomized controlled trials (RCTs) and controlled clinical trials (CCTs) (including split-mouth studies) of adhesives used to attach orthodontic bands to molar teeth were selected. Patients with full arch fixed orthodontic appliance(s) who had bands attached to molars were included. All review authors were involved in study selection, validity assessment, and data extraction. Disagreements were resolved by discussion. Comparisons were made between the main types of adhesive.

**Results:** Five RCTs and three CCTs were identified, all of split-mouth design. Four trials compared chemically cured zinc phosphate and chemically cured glass ionomer; three trials compared chemically cured glass ionomer cement with light-cured compomer; and one trial compared chemically cured glass ionomer with a chemically cured glass polyphosphonate. Data analysis was often inappropriate within the studies. Meta-analysis was not feasible.

**Conclusions:** There is insufficient high-quality evidence with regard to the most effective adhesive for attaching orthodontic bands to molar teeth. Further RCTs are required. (*Angle Orthod.* 2009; 79:193–199.)

**KEY WORDS:** Orthodontic bands; Adhesives; Systematic reviews

### INTRODUCTION

A contributor to the success of fixed appliance therapy is reliable attachment of the bonded or banded components to the teeth so that they survive masticatory and mechanical forces during the treatment episode. Bonded attachments are used routinely as part of fixed appliance therapy; however, bands rather than bonded tubes remain popular for molars.<sup>1,2</sup> Orthodon-

tic bands are subjected to a large number of forces in the mouth, resulting in complex stress distribution within the adhesive and its junctions with the enamel and the band interior.<sup>3,4</sup> Optimally, adhesive strength should be sufficient to keep the band on the tooth for the length of the treatment but not of such a magnitude that the tooth surface is damaged when the band is removed. In addition, the adhesive should ideally be easy to use, protective against dental caries, and of reasonable cost.

Band retention is affected mechanically by its close adaptation to the tooth assisted by the cement lute.<sup>5</sup> Zinc phosphate, zinc silicophosphate, and zinc polycarboxylate cements were used as principal band cements until the early 1990s.<sup>6</sup> Zinc phosphate cements have solubility intraorally and rely entirely on mechanical adhesion for their retentive effect.<sup>7,8</sup> In contrast, polycarboxylate cements react chemically with enamel and stainless steel,<sup>7</sup> but high viscosity, short setting time, and high intraoral solubility led to their waning popularity as a band luting agent.<sup>8</sup>

Some zinc phosphate-based cements are still used by a small proportion of orthodontists, although most

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now use a glass ionomer or glass ionomer-based cement.<sup>9</sup> Glass ionomer cements have become the most commonly used cement for band cementation because of their favorable properties of fluoride release and uptake,<sup>10</sup> microbial inhibition,<sup>11</sup> and adhesion to both enamel and metal.<sup>6,12</sup> These cements, however, require up to 24 hours to reach maximum strength and are susceptible to moisture contamination during the setting reaction.<sup>13</sup> Adding resin to the cement formulation has allowed light curing, a snap set, and rapid strength development.<sup>14</sup>

These newer cements may be classified as follows<sup>15</sup>: (1) polyacid-modified composite resin (compomer) and (2) resin-modified glass ionomer cements. In vitro studies of modified composites<sup>16–18</sup> and resin-modified glass ionomers<sup>16,17</sup> have shown significantly greater bond strengths compared with zinc phosphate<sup>16</sup> or glass ionomer cement.<sup>17,18</sup> Glass polyphosphate has also been used as an orthodontic band cement, but it does not belong to the zinc phosphate or glass ionomer groups.<sup>19</sup> Because of the number of adhesives available to apply bands to teeth, it is important to understand which group bonds most reliably and which reduces or prevents dental decay during the treatment period.

This article is based on a Cochrane review published in *The Cochrane Library*.<sup>20</sup> Cochrane reviews are regularly updated as new evidence emerges and in response to comments and criticisms, and the Cochrane Library should be consulted for the most recent version of the review. The aim of this review was to evaluate the effectiveness of the adhesives used to attach bands to teeth during fixed appliance treatment, in terms of how often the bands come off during treatment and whether they protect the banded teeth against decay during fixed appliance treatment.

## MATERIALS AND METHODS

To be included in the review trials had to meet the following criteria:

- Study design: Randomized and controlled clinical trials, including split-mouth design.
- Participants: Patients with full arch fixed orthodontic appliance(s) that had bands attached to molars. Patients with cleft lip or palate or other craniofacial syndromes were excluded.
- Interventions: Any adhesives used to attach orthodontic bands to molar teeth. This excludes adhesives used to cement brackets to teeth, which was the subject of a separate review.<sup>21</sup>
- Exclusions: Studies were excluded that used headgear to molar bands, intermaxillary elastic traction to molar bands, soldered lingual or palatal arches to molar teeth, bands cemented to primary molars or

premolars, or different molar types on opposite sides of the mouth. Studies in which patients were followed up for less than 12 months were also excluded.

- Outcome measures: The primary outcome measures were adhesive band failure and decalcification.

Dichotomous data on the success of each adhesive (whether the metal band stays cemented to the tooth or not) were recorded. Where these data were not available, annualized failure rates of adhesives were noted. The presence or absence of decay (decalcification) associated with or around the bands was recorded, along with the size/area of decalcifications if available. Data on adverse events, length of treatment, treatment cost, and time to replace bands with an adhesive were also recorded.

## Search Strategy for Identification of Studies

The following electronic databases were searched: the Cochrane Oral Health Group's Trials Register (March 2007), the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library Issue 4, 2007*), MEDLINE (1966 to March 2007), and EMBASE (1980 to March 2007). The search strategy for MEDLINE, via OVID, was as follows:

1. exp ORTHODONTICS/
2. orthodontic\$.
3. band\$.
4. (1 or 2) and 3
5. exp Composite Resins/
6. exp Glass Ionomer Cements/
7. Resin Cements/
8. exp Dental Bonding/
9. (resin\$ or cement\$ or bond\$ or "polyacid-modified composite resin\$" or compomer\$ or composite\$ or glass-ionomer\$ or adhesive\$)
10. or/5-9
11. 4 and 10

Similar search strategies were developed for the other databases. Conference proceedings and abstracts were searched. A search of the Internet was also undertaken. Manufacturers and first authors of trial reports were contacted in an attempt to identify any unpublished or ongoing clinical trials and to clarify data as necessary. Reference lists of included studies were screened for further trials. There was no restriction with regard to publication language.

## Assessment of Relevance, Validity, and Data Extraction

Study selection, validity assessment, and data extraction were undertaken without blinding to the au-

thors or results obtained. Each stage was carried out independently by all members of the review team. Disagreements were resolved by discussion.

Four key quality criteria were assessed: random sequence generation, allocation concealment, blind outcome assessment, and handling/reporting of withdrawals. An overall assessment of risk of bias (high, medium, low) was undertaken for each included trial using criteria given in the Cochrane Handbook.<sup>22</sup> All studies were assessed for the appropriateness of their analysis. Statistical analysis was considered inappropriate if a split-mouth design 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. A statistician was to be consulted with regard to data analysis and where doubt existed.

### Data Synthesis

Comparisons were made first between any of the main types of adhesive (zinc silicophosphate, zinc phosphate, zinc polycarboxylate, conventional glass ionomer, polyacid-modified composite resin [compomer], resin-modified glass ionomer, and glass polyphosphate). If possible, comparisons were to be made within groups and, where appropriate, between chemical and light-cured adhesives.

Clinical heterogeneity was assessed by considering the characteristics of included trials. Statistical heterogeneity was to be assessed by inspecting a graphical display of the estimated treatment effects from the trials along with their 95% confidence intervals and by Cochran's test for homogeneity undertaken before each meta-analysis. Any heterogeneity was to be investigated. Meta-analyses were to be undertaken only on studies of similar comparisons reporting the same outcome measures. Risk ratios, along with 95% confidence intervals, were to be calculated for individual trials and combined using a random-effects model. The number needed to treat was to be calculated as appropriate. Sensitivity analyses were to be undertaken with regard to the individual quality criteria, risk of bias and publication status.

### RESULTS

Twenty-four trials were deemed potentially relevant to the review. After subsequent assessment of the full articles only eight were found to meet the inclusion criteria: five randomized controlled trials<sup>19,23–26</sup> and three controlled clinical trials.<sup>27–29</sup> Sixteen studies were excluded, details of which are presented in the full Cochrane review.<sup>20</sup> A description of each included trial is presented in Table 1.

All included trials were of split-mouth design. Interventions assessed were zinc phosphate cement, glass

ionomer cement, polyacid-modified composite resin (compomer), resin-modified glass ionomer cement, and glass polyphosphate cement. No trial examined the effectiveness of zinc silicophosphate cement or zinc polycarboxylate.

All trials reported failure, typically defined as band loosening. Only two trials stated the date used for assessing failure: one trial recorded the date the patient returned for band recementation<sup>23</sup> and another recorded the date the patient became aware of band loosening.<sup>25</sup> Only two trials clearly reported follow-up of patients until the end of the treatment period.<sup>23,29</sup> In one study the observation period was unclear.<sup>25</sup>

The methodologic quality of the included trials is presented in Table 2. The generation of the random number sequence was considered adequate in only three trials.<sup>19,25,26</sup> All three trials used a random numbers table. The generation of the sequence was unclear in three trials,<sup>23,24,29</sup> and in the other trials adhesives were allocated using a quasi-random method.<sup>27,28</sup> Only one of the trials reported adequate allocation concealment,<sup>26</sup> and in none of the trials was it clear whether outcome assessment was truly blind. Only one of the trials reported an a priori sample-size calculation.<sup>26</sup> In four trials there were no dropouts.<sup>19,24,26,27</sup> In two trials, the number of dropouts was clearly described, although reasons were not reported.<sup>23,29</sup> In two trials, the number of dropouts was unclear.<sup>25,28</sup> Only one trial was considered to be at low risk of bias.<sup>26</sup> Data analysis was not always appropriate within the included trials.

### Chemically Cured Zinc Phosphate and Chemically Cured Glass Ionomer

Four trials compared chemically cured zinc phosphate and chemically cured glass ionomer.<sup>24,25,27,29</sup> However, Stirrups<sup>25</sup> presented failure of bands by site (upper/lower, right/left molars), but information as to the number of patients experiencing a failed band was not presented. Galarraga and Croce<sup>29</sup> recruited 40 participants, and 166 bands were placed. Data regarding the number of lost, loose, or broken bands are not presented at a patient level. However, data regarding demineralization show that eight participants experienced demineralization (one with glass ionomer only, four with zinc phosphate only, and three with both adhesives).

Kvam et al<sup>24</sup> recruited 28 participants. In each patient one molar band was cemented with a chemically cured zinc phosphate and one was cemented with glass ionomer cement. No loose bands were identified for either cement type at 1 year. When teeth were examined for decalcification, four teeth were affected with small white spots that were reversed by polishing

**Table 1.** Characteristics of Included Trials.<sup>a</sup>

Study	Methods	Participants	Interventions	Outcomes	Notes
Clark et al <sup>19</sup>	<ul style="list-style-type: none"> <li>- RCT, split-mouth design</li> <li>- 6-month observation period</li> </ul>	<ul style="list-style-type: none"> <li>- 31 consecutive participants undergoing two-arch fixed appliance therapy; 124 bands to first molars</li> <li>- 14 males; 17 females</li> <li>- Age not stated</li> </ul>	<ul style="list-style-type: none"> <li>- Group 1: Glass phosphonate cement (Diamond, KemDent Associated Dental Products Ltd, Swinden, UK); chemical curing; 62 bands</li> <li>- Group 2: Glass polyalkenoate cement (Ketac-Cem, ESPE America, Norristown, PA); chemical curing; 62 bands</li> </ul>	Band failure (not defined) and taste	<ul style="list-style-type: none"> <li>- Overall treatment time not stated</li> <li>- Data on number of failures per patient not known</li> </ul>
Durning <sup>27</sup>	<ul style="list-style-type: none"> <li>- CCT, split-mouth design</li> <li>- 12-month observation period</li> </ul>	<ul style="list-style-type: none"> <li>- 69 participants; 138 bands for bioprogressive; edgewise fixed appliance</li> <li>- 27 males, 42 females</li> <li>- Mean (<math>\pm</math>SD) age = 15.2 <math>\pm</math> 3.4 years</li> </ul>	<ul style="list-style-type: none"> <li>- Group 1: Zinc phosphate (Orthocent, Espe, Seefeld Oberbay, Germany); chemical curing; 69 bands</li> <li>- Group 2: Glass ionomer (Ketac-Cem, Espe, Seefeld Oberbay, Germany); chemical curing; 62 bands</li> </ul>	Band failure defined as band loosening	
Fricker <sup>28</sup>	<ul style="list-style-type: none"> <li>- CCT, split-mouth design</li> <li>- 1-year observation period</li> </ul>	<ul style="list-style-type: none"> <li>- 50 consecutive participants; 188 bands to first molars</li> <li>- Sex not stated</li> <li>- Age not provided</li> </ul>	<ul style="list-style-type: none"> <li>- Group 1: Resin-modified glass ionomer (Fuji II LC, GC International, Alsip, IL, USA); light-activated dual cure; 69 bands</li> <li>- Group 2: Resin with added glass (Bandlok, Reliance Orthodontic Products, Itasca, IL, USA); light-activated dual cure; 62 bands</li> <li>- Group 3: Glass ionomer cement (Ketac-Cem, ESPE America, Norristown, PA); chemical curing; 57 bands</li> <li>- Two of the three cements were selected for each patient by the chairside assistant on a rotational basis</li> </ul>	Failure defined as loose molar band. Weld failures requiring re-plantation and/or transfer of patient to another practice were removed from the sample	Data on number of bands per patient or number of failures per patient not known
Galarraga and Croce <sup>29</sup>	<ul style="list-style-type: none"> <li>- RCT, split-mouth design</li> <li>- Mean treatment period of 26.1 months</li> </ul>	<ul style="list-style-type: none"> <li>- 40 participants; 80 pairs of bands to first permanent molars</li> <li>- 14 males, 24 females (data not available for one participant)</li> <li>- Age range = 13-19 years</li> </ul>	<ul style="list-style-type: none"> <li>- Group 1: Zinc phosphate; assumed chemical curing; 80 bands</li> <li>- Group 2: Glass ionomer; assumed chemical curing; 80 bands</li> </ul>	Failure defined as lost, loose, or broken	Data taken from translation (Country of origin: Venezuela)

**Table 1.** Continued

Study	Methods	Participants	Interventions	Outcomes	Notes
Gillgrass et al <sup>23</sup>	- RCT, split-mouth design - Observed for duration of treatment; mean time = 20.3 months	- 98 participants; 140 band pairs cemented to first permanent molars - 32 males, 66 females - Mean ( $\pm$ SD) pretreatment ages: 19.1 $\pm$ 3.7 years for males and 17.8 $\pm$ 3.0 years for females	- Group 1: Modified composite (Band-Lok, Reliance Orthodontic Products, Itasca, IL); light cured; 140 bands - Group 2: Conventional glass ionomer (Ketac-Bond, 3M, St Paul, MN); chemically cured; 140 bands - In all participants, preadjusted edgewise appliances were used	Band failure defined as band loosening. Failure date recorded as the day the patient returned for recementation	
Kvam et al <sup>24</sup>	- RCT, split-mouth design - 1-year observation period	- 28 participants; 56 bands to first upper molars; 2% neutral sodium fluoride applied before cementation - Sex not stated - Age not stated (but "young" patients)	- Group 1: Fine-grain phosphate cement; manufacturer not stated; assumed chemical curing; 28 bands - Group 2: Glass ionomer; manufacturer not stated; assumed chemical curing; 28 bands	- Gingival, plaque, enamel, and cement indices - Definition of band failure unclear	
Stirrups <sup>25</sup>	- RCT, split-mouth design - Observation period/treatment time not stated	- 142 consecutive participants; 568 bands cemented to first molars - Sex not stated - Age not stated	- Group 1: Experimental glass ionomer (Dentsply Ltd, York, PA, USA); curing mechanism unclear; 284 bands - Group 2: Zinc phosphate (OrthoGold, Orthomax Ltd, Bradford, UK); chemical cured; 284 bands	Failure defined as loose band. Failure date recorded as day patient became aware of loosening (where possible)	No information as to the number of patients experiencing a failed band
Williams et al <sup>26</sup>	- RCT, split-mouth design - 1-year observation period	- 30 participants; 120 bands to first permanent molars - Sex not stated - Age not stated	- Group 1: Polyacid-modified composite resin (compomer); light cured; 60 bands - Group 2: Resin-modified glass poly (alkenoate) cement; chemically cured; 60 bands	Band failure (not defined) and taste	Data on number of failures per patient not known, although failure rates very low

<sup>a</sup> RCT indicates randomized controlled trial; CCT, controlled clinical trial.

**Table 2.** Methodologic Quality of Included Trials

Trial	Concealed Allocation	Sequence Generation	Blind Outcome	Withdrawals	Risk of bias
Clark et al <sup>19</sup>	Unclear	Adequate	Unclear	No dropouts	Medium
Durning <sup>27</sup>	Not used	Inadequate	No	No dropouts	High
Fricker <sup>28</sup>	Inadequate	Inadequate	Unclear	No dropouts	High
Galarraga and Croce <sup>29</sup>	Unclear	Unclear	Unclear	One dropout; no intention-to-treat analysis	High
Gillgrass et al <sup>23</sup>	Unclear	Unclear	Unclear	Clear description but no intention-to-treat analysis	High
Kvam et al <sup>24</sup>	Unclear	Unclear	Unclear	No dropouts	High
Stirrups <sup>25</sup>	Unclear	Adequate	Unclear	Unclear	Medium
Williams et al <sup>26</sup>	Adequate	Adequate	Unclear	No dropouts	Low



and fluoride application. All cases occurred with the zinc phosphate cement.

Durning<sup>27</sup> recruited 69 participants. Two bands were placed in each participant; one band was cemented using a chemically cured zinc phosphate and one was cemented with glass ionomer cement. Allocation was determined by alternation. The author reports that at approximately 12 months the failure rate was 35% for bands cemented with zinc phosphate and 26% for bands cemented with glass ionomer ( $P > .05$ ). No statistically significant difference was seen in mean survival time between the cemented band groups (zinc phosphate = 471 days; glass ionomer = 524 days).

### **Chemically Cured Glass Ionomer Cement and Light-Cured Compomer**

Three trials compared chemically cured glass ionomer cement with light-cured compomer.<sup>23,26,28</sup> The data from Fricker<sup>28</sup> are not presented in an appropriate format. Although failure rates are presented, neither the number of bands per person nor the number of failures per person is presented. Gillgrass et al<sup>23</sup> compared chemically cured glass ionomer cement with light-cured compomer in a split-mouth study (98 participants; 140 band pairs). Four participants had a single band fail when attached using chemically cured glass ionomer cement (Ketac-Cem, Espe, Seefeld Oberbay, Germany) compared with seven band failures (in seven participants) for those attached with the light-cured compomer (Band-Lok, Reliance Orthodontic Products, Itasca, IL, USA). The authors of the trial report that a comparison of changes in mean enamel white spot lesion scores during treatment showed no statistically significant difference between the two cement types ( $P = .16$ ).

A third trial compared chemically cured glass ionomer cement with light-cured polyacid-modified composite resin.<sup>26</sup> The study was split-mouth in design; 30 participants received 120 bands (60 with each band adhesive). Data on the number of failures per patient are not presented, but the number of failures was very low for each band adhesive over the initial 12-month assessment period (two failures with the glass ionomer; one failure with the composite resin). A statistically significant difference, in favor of the glass ionomer, was seen for patient preference with regard to taste.

### **Chemically Cured Glass Ionomer and Chemically Cured Glass Polyphosphonate**

One trial compared a chemically cured glass ionomer with a chemically cured glass polyphosphonate.<sup>19</sup> Data are presented for failure rates for each adhesive group, based on the number of bands failing in each group (overall proportion of band failure for each ad-

hesive type was 0.048). However, no data are provided for the number of failures on a patient basis. There was also no statistically significant difference between the tastes of the two cements, but the authors express caution about this finding as both cements were used at the same sitting, so it is possible that the taste of one cement affected the taste of the other.

## **DISCUSSION**

Following application of the exclusion criteria adopted for this review, only eight trials were identified as relevant. In general, trials were considered to be at medium to high risk of bias. The method of randomization and allocation concealment was often inadequate or poorly reported, and blinding of the outcome assessor was unclear in all trials. A sample-size calculation was only reported in one trial.<sup>26</sup> Five studies had no dropouts; one dropout occurred in one trial, but the number of dropouts was not adequately clarified in two trials. The overall high rates of patient follow-up suggest that it is possible to minimize attrition bias in trials of orthodontic band adhesives; however, all dropouts and withdrawals should still be recorded and included in the analysis.

Reporting of band failure rate was insufficient in all studies. Greater care is required to ensure that the statistical analyses are most appropriate for the trial design adopted. Split-mouth trials can be used when the adhesives being assessed do not release an agent that could influence failure or decalcification. However, where a split-mouth design is used, the mean failure rate or mean survival time per band adhesive type per patient should be reported along with standard deviation or 95% confidence intervals. Where individual patients are allocated to one or other band adhesive type, then the outcome data with respect to adhesive failure /survival should be reported in the same manner. Future trials should involve a statistician in the study design, sample-size calculation, and projected data analyses.

Only two trials report outcome assessment at the completion of the treatment period.<sup>23,29</sup> A previously published systematic review examining the effectiveness of adhesives for fixed orthodontic brackets excluded all trials that did not follow patients until the end of the appliance treatment period.<sup>21</sup> While the current review has been less restrictive in its inclusion criteria, future trials should report outcomes after the completion of treatment to enable a more objective assessment of the effectiveness of one band adhesive over another.

Because of the inherent bias in most of the trials included, their results should be interpreted with great caution. There is insufficient evidence to support or

refute the use of one adhesive over the other with regard to band failure. There is weak evidence from two trials<sup>24,29</sup> that there is less decalcification on teeth where bands had been cemented with glass ionomer rather than zinc phosphate.

## CONCLUSIONS

- There is insufficient evidence to make firm recommendations for the use of one band adhesive over another. Further high quality randomized controlled trials are required.

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