Self-etch primers and conventional acid–etch technique for orthodontic bonding: A systematic review and meta-analysis

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Introduction: The use of self-etch primers has increased steadily because of their time savings and greater simplicity; however, overall benefits and potential disadvantages and harms have not been assessed systematically. In this study, we reviewed randomized controlled trials to assess the risk of attachment failure, bonding time, and demineralization adjacent to attachments between 1-stage (self-etch) and 2-stage (acid etch) bonding in orthodontic patients over a minimum follow-up period of 12 months. **Methods:** Data sources were electronic databases including MEDLINE, EMBASE, the Cochrane Oral Health Group's Trials Register, and CENTRAL, without language restrictions. Unpublished literature was searched on ClinicalTrials.gov, the National Research Register, and Pro-Quest Dissertation Abstracts and Thesis database. Authors were contacted when necessary, and reference lists of the included studies were screened. Search terms included randomized controlled trial, controlled clinical trial, random allocation, double-blind method, single-blind method, orthodontics, self-etch, SEP, primer, and bonding agent. Randomized clinical trials directly comparing self-etch and acid-etch primers with respect to the predefined outcomes and including patients with full-arch, fixed, and bonded orthodontic appliances (not banded) with follow-up periods of at least 12 months were included. Using predefined forms, 2 authors undertook independent data extraction with conflict resolution by the third author. Randomized clinical trial quality assessment based on the Cochrane Risk of Bias tool was also used. **Results:** Eleven studies met the inclusion criteria; 6 were excluded because of a high risk of bias. In total, 1721 brackets bonded with acid-etch and 1723 with self-etch primer techniques were included in the quantitative synthesis. Relatively low statistical and clinical heterogeneity was observed among the 5 randomized clinical trials (n = 3444 brackets) comparing acid-etch with self-etch primers. A random effects meta-analysis demonstrated a tendency for a higher risk of failure (odds ratio, 1.35; 95% CI, 0.99-1.83; $P = 0.06$) with self-etch primers. A small but statistically significant time saving was also associated with the self-etch primer technique (weighted mean difference, 23.2 seconds per bracket; 95% CI, 20.7-25.8; $P < 0.001$). There was insufficient evidence to assess the effect of bonding modality on demineralization rates. **Conclusions:** There is weak evidence indicating higher odds of failure with self-etch primer than acid etch over 12 months in orthodontic patients, and there is strong evidence that a self-etch primer is likely to result in a modest time savings (8 minutes for full bonding) compared with acid etch. **Funding:** No funding was received for this review. (Am J Orthod Dentofacial Orthop 2012;■:83-95)

Dental bonding was introduced by Bowen[1] after the pioneering work on enamel preparation techniques of Buonocore et al.[2] These principles were subsequently applied to orthodontics, revolutionizing appliances physically and cosmetically, with multibanded systems becoming obsolete and superseded by bonded appliances.[3]

Further progress has been made in relation to bonding with an emphasis on streamlining the process, enhancing performance in a moist environment, and improving resistance to demineralization.[4] In recent years, there has been growing interest in 1-step bonding systems, which do not rely on separate application of etchant and bonding material. Self-etch bonding systems or self-etch primers (SEPs) are routinely used by 29.5% of practitioners in the United States.[5] These systems typically incorporate methacrylated phosphoric acid esters; after application to enamel, the phosphate

group dissolves and removes calcium ions from hydroxy-apatite, becoming incorporated in the network before the primer polymerizes, neutralizing the acid.

The proposed advantages of SEPs include reduced chair-side time, although this is tempered by the requirement for judicious pumicing before bonding procedures to minimize the risk of failure[5]; reduced sensitivity to moisture; and reduced inventory requirements. However, although the performance of SEPs has been compared with conventional acid-etch (AE) techniques in randomized controlled trials, a comparison of these techniques in the context of a systematic review has not been undertaken.

OBJECTIVES

The aims of this study were therefore to compare 1-step and 2-step bonding procedures with respect to attachment failure rates and time taken to place attachments.

MATERIAL AND METHODS

Protocol and registration

The protocol for a systematic review of SEPs was registered on the National Institute of Health Research Database (www.crd.york.ac.uk/prospero, Protocol: CRD42011001601).

Eligibility criteria

The following selection criteria were applied for the review.

1. Study design: randomized and controlled clinical trials, with split-mouth designs included.
2. Participants: patients with full-arch, fixed, and bonded orthodontic appliances.
3. Interventions: SEPs were used to prepare tooth surfaces before bonding the orthodontic attachments in the intervention sample. The control group's appliances were bonded with the conventional, 2-step AE technique.
4. Exclusion criteria: studies using banded attachments and those involving follow-up periods of less than 12 months were omitted from the review.
5. Outcome measures: the main outcome measure was first-time bond failure with both bonding systems. Secondary outcome measures included time required to place individual brackets and decalcification. The attachment failures with each enamel preparation technique were recorded. When available, the time taken for failures to occur was also recorded. The time taken to place attachments with each technique and the presence of demineraliza-

tion adjacent to the bonded attachments were noted, in addition to the severity of each lesion.

Information sources, search strategy, and study selection

The following electronic databases were searched: MEDLINE (1966 to July 2011; Appendix), EMBASE (1980 to July 2011), Cochrane Oral Health Group's Trials Register (March 2011), Cochrane Central Register of Controlled Trials (CENTRAL, The Cochrane Library Issue 2, 2011). Language restrictions were not applied. Unpublished literature was searched electronically by using ClinicalTrials.gov (www.clinicaltrials.gov) and the National Research Register (www.controlled-trials.com) with the term "orthodontic" and "bond." In addition, the Pro-Quest Dissertation Abstracts and Thesis database was searched (www.lib.umi.com./dissertations) by using "orthodontic*" and "bond*." Conference proceedings and abstracts were also accessed when possible. Authors were contacted to identify unpublished or ongoing clinical trials and to clarify data as required. Reference lists of the included studies were screened for relevant research.

Assessment of research for inclusion in the review, assessment of risk of bias, and extraction of data were performed independently and in duplicate by 2 investigators (P.S.F. and A.J.) who were not blinded to the authors or the results of the research. Disagreements were resolved by discussion and consultation with the third author (N.P.).

Data items and collection

A data extraction form was developed to record study design, observation period, participants, interventions, outcomes, and outcome data of interest, including risk of failure of attachments, time taken to place attachments, and severity of demineralization when applicable.

Risk of bias/quality assessment in individual studies

Seven criteria were analyzed to grade the risk of bias inherent in each study, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of assessors, incomplete outcome data, selective reporting of outcomes, and other potential sources of bias. An overall assessment of risk of bias (high, unclear, low) was made for each included trial by using the Cochrane Collaboration risk of bias tool. Studies with at least 1 criterion designated to be at high risk of bias were regarded as having a high risk of bias overall and excluded from the meta-analysis.

Summary measures and approach to synthesis

Clinical heterogeneity of the included studies was gauged by assessing the treatment protocol—particularly, participants and settings, materials used, timing of data collection, and measurement techniques. Statistical heterogeneity was assessed by inspecting a graphic display of the estimated treatment effects from the trials in conjunction with 95% confidence intervals. The chi-square test was used to assess for heterogeneity; a P value below 0.1 meant significant heterogeneity.[6] I^2 tests for homogeneity were undertaken to quantify the extent of heterogeneity before each meta-analysis. I^2 values above 50% would signify moderate to high heterogeneity and might preclude meta-analysis. A weighted treatment effect was calculated, and the results for attachment failure were expressed as odds ratios. For time required to place attachments, mean differences with 95% confidence intervals were calculated for each trial and combined by using a random-effects model, which was considered more appropriate in view of the variations in populations and settings. For continuous outcomes, mean differences and standard errors were entered for parallel and split-mouth designs. When necessary, standard errors for the split-mouth designs were calculated.[7]

Risk of bias across studies

If more than 10 studies were included in the meta-analysis, standard funnel plots and contoured enhanced funnel plots would be drawn to identify publication bias.[8]

Additional analyses

Sensitivity analyses were prespecified to deal with studies at higher risk of bias, publication bias, and other potential sources of heterogeneity including dominant effects of at least 1 large study and differences in outcome related to specific SEPs to isolate their influence on the overall outcome. Meta-analyses and sensitivity analyses were undertaken using the Stata statistical software package (version 12.1; StataCorp, College Station, Tex) by using "metan" and "metainf" commands.[9]

RESULTS

Study selection and characteristics

Forty-eight trials were initially deemed potentially relevant to the review (Fig 1). After we reviewed the abstracts, initially 13 satisfied the inclusion criteria.[10-22] Two of these were subsequently excluded after retrieval of the full-text article because of duplicate publication of the data[20] and comparison of 2 SEPs without a control group involving conventional etch preparation.[21]

Of the final 11 articles included in the qualitative analysis, all were prospective clinical trials (Tables 1 and II). Although all of these were variously described as randomized controlled trials, the randomization procedure was considered inadequate in 5 studies. Consequently, allocation concealment was likely to have been subverted, thus increasing the risk of bias. These studies were excluded from the quantitative synthesis (Tables III and IV). Of the remaining studies, 4 were split-mouth designs,[10-12,14] and 2 were parallel-group randomized controlled trials.[16,22]

Risk of bias within studies

Of the 7 criteria used to assess risk of bias, similar results were obtained throughout for 3 criteria: completeness of data reporting, absence of selective reporting, and blinding of assessors. In particular, complete outcome data were reported in all studies without selective reporting of results (Tables III and IV; Fig 2). Additionally, blinding of assessors was considered unlikely, since the researchers themselves were involved in placing the appliances, precluding blinding. Blinding of assessors was not mentioned in any reports. Nevertheless, some authors explicitly mentioned attempts to blind the participants to the mode of bonding, although this is likely to pertain equally to all split-mouth studies.[12,15,16] Nevertheless, the binary primary outcome (bracket failure) was not easily open to manipulation, limiting the potential problems of lack of blinding.

Generation of the random sequence was considered adequate in 6 studies[10-12,15,16,22]; allocation concealment was also thought to be reliable in 5 of these studies.[7,11,13,16,17] The randomization procedure was considered inadequate or not sufficiently clear in the remaining studies. However, each of these studies was split-mouth in design, which might have negated the importance of the randomization procedure. Nevertheless, it was agreed that these trials should be omitted from the quantitative analysis.

Therefore, overall, 6 studies were deemed to be at low or unclear risk of bias and were initially considered appropriate for quantitative synthesis.[10-12,15,15,22] Early cessation was reported in 1 study because of an unacceptable number of failures with the SEP, causing a threat to validity.[12] Therefore, after further appraisal and discussion, it was decided to omit this study because of the discordant findings resulting in a premature end to the trial related to the excessive failure rates of up to 72%.

Results of individual studies, meta-analysis, and additional analyses

The failure risk of attachments was assessed in all 5 included studies. In total, 1721 brackets bonded with
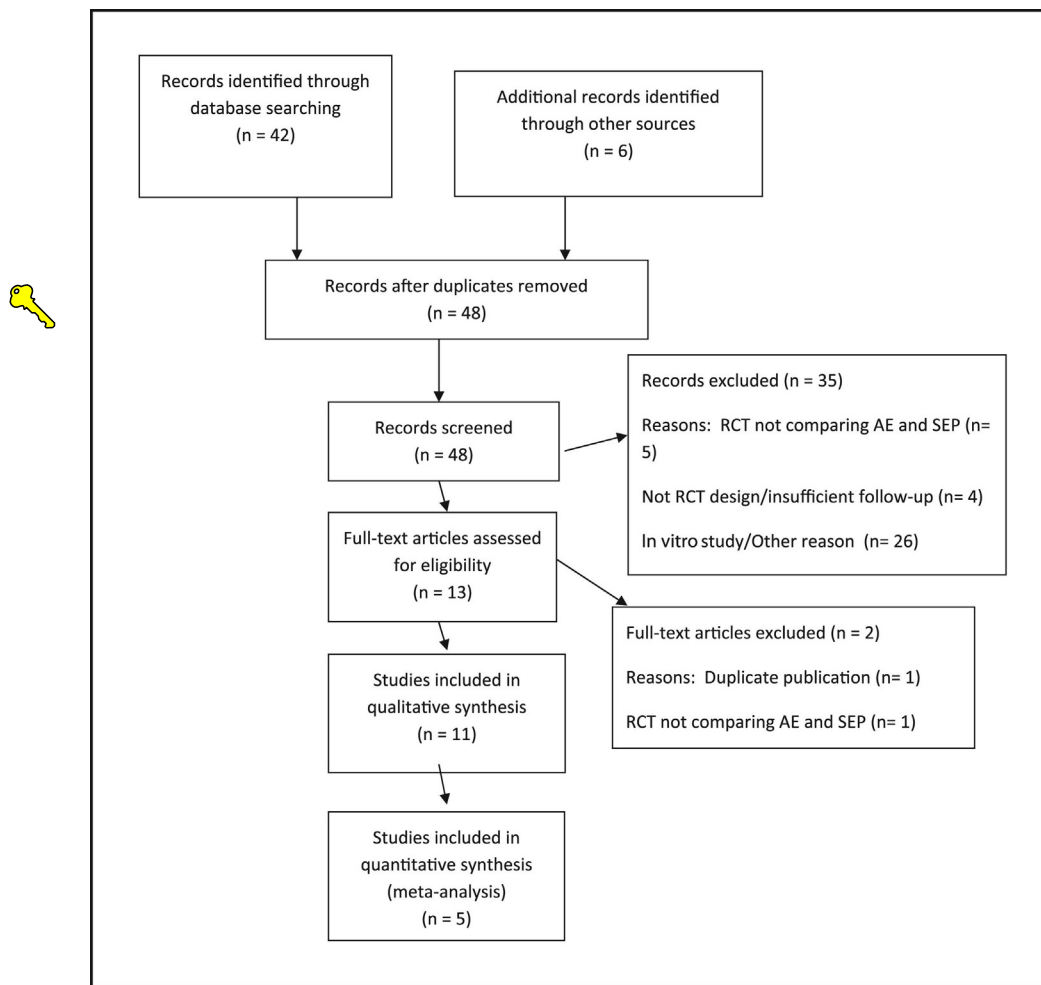
Fig 1. PRISMA diagram of article retrieval.

AE and 1723 bonded with SEP techniques were included in the quantitative synthesis (Table V). Of these, 4.5% (77 brackets) and 6.0% (104 brackets) failed with the AE and the SEP preparation techniques, respectively. The random-effects model assumes that there are different bond failure risks in different settings; the calculated estimate therefore indicates the average effect. Meta-analysis of these studies suggested higher odds of bond failures with the SEP technique, although the difference failed to reach statistical significance (Table VI; Fig 3; odds ratio, 1.35; 95% CI, 0.99-1.83). The pooled odds ratio from the random-effects model indicated that the failure risk was 35% higher in the SEP group than in the AE group. The 95% confidence interval indicates that the mean effect size can range from 1% to 83% in the SEP group compared with the AE group, verging on statistical significance ($P = 0.06$). Based on the heterogeneity of the included studies, the prediction intervals indicate that the true effect

size is likely to range from 0.82 to 2.22. The prediction interval was wider than the 95% confidence interval and includes the value 1, indicating that in certain settings no difference is expected in bond failures with the protocols. The test for homogeneity confirmed that meta-analysis of this outcome among the 5 studies was reasonable (I^2, 0.0%; chi-square, $P = 0.497$; $\tau^2 = 0.00$).

A further meta-analysis was undertaken to gauge the inclusion of the study by House et al[12] on the outcome. The results did not change significantly, with the propensity to higher failure rates with SEP remaining statistically insignificant; however, the 95% confidence interval increased (0.92-2.9). Statistically, heterogeneity also increased to an unacceptable level (I^2, 78.3%; chi-square, $P < 0.001$; Fig 4).

Little heterogeneity was observed, with confidence intervals overlapping and the effects of individual studies exclusively favoring the AE technique, with the

Table I. Design, observation period, interventions, and outcome measures of studies included in the quantitative synthesis

Study	Method	Observation period	Participants	Interventions	Outcome
Aljubouri et al (2004)[10]	Split-mouth RCT	6 and 12 months	51 participants: 16 male, 35 female 32 <15 years, 19 >15 years	389 brackets bonded with SEP, 388 bonded with AE (353 paired per group)	Bond failure risk Bonding time
Manning et al (2006)[11]	Parallel-group RCT	6 and 12 months; overall treatment	34 participants, 17 per group: 11 male, 23 female. Ages, 11-16 years	299 brackets bonded with SEP and 298 with AE	Bond failure risk
House et al (2006)[12]	Split-mouth RCT	1, 6, and 12 months	30 participants: only 20 were analyzed because trial stopped prematurely	339 brackets bonded with Ideal 1 SEP and AE	Bond failure risk
Murfitt et al (2006)[15]	Split-mouth RCT	12 months	39 participants: 13 male, 26 female. Mean age, 14.4 (SD, 2.5) years	661 brackets bonded overall with SEP (331) and AE (330)	Bond failure risk
Banks and Thiruvenkatachari (2008)[16]	Parallel-group RCT	Overall treatment	60 participants, 30 per group: 23 male, 37 female. Ages, 11-18 years	30 participants (438 brackets) with TransBond Plus SEP; 30 participants (433 brackets) with AE	Bond failure risk
Cal-Neto et al (2009)[22]	Parallel-group RCT	12 months	28 participants, 14 per group: Mean age, 14.92 years; 11 male, 17 female	276 brackets bonded with SEP and 272 brackets with AE	Bond failure risk

RCT, Randomized controlled trial.

Table II. Design, observation period, interventions, and outcome measures of studies excluded from the quantitative synthesis

Study	Method	Observation periods	Participants	Interventions	Outcome
Pandis et al (2006)[13]	Split-mouth RCT	12 months	62 participants: 23 male, 39 female. Mean age, 14 years	610 brackets bonded with TransBond Plus SEP, 610 bonded with AE and OrthoSolo primer	Bond failure risk
Pandis et al (2006)[14]	Split-mouth RCT	15 months	62 participants: 23 male, 39 female. Mean age, 13.7 years	221 molar tubes bonded with TransBond Plus SEP, 223 molar tubes bonded with AE and OrthoSolo primer	Bond failure risk
Reis et al (2008)[17]	Split-mouth RCT	18 months	30 participants: 15 male, 15 female. Ages, 12-18 years	283 brackets bonded with SEP and 283 with AE	Bond failure risk
Elekdag-Turk et al (2008)[18]	Split-mouth RCT	6 and 12 months	39 participants: 23 male, 39 female. Mean age, 15.58 years	344 brackets bonded with SEP and 344 with AE	Bond failure risk
Ghiz et al (2009)[19]	Split-mouth RCT	18 to 24 months	25 participants. No demographics given	236 brackets bonded with SEP and 233 brackets with AE	Demineralization

RCT, Randomized controlled trial.

exception of the study of Aljubouri et al,[10] who reported a lower risk of failure with SEP. Sensitivity analysis investigating the influence of this study on the overall meta-analysis resulted in estimates favoring AE further (Fig 5). Statistical analysis of publication bias was not indicated, since fewer than 10 studies were included in the quantitative synthesis.

Time taken to place individual attachments with either technique was considered in 2 investigations. Similar results were obtained in both studies, with Aljubouri

Table III. Risk of bias of studies included in the quantitative synthesis, including the study by House et al[12]

Trial	Random sequence generation	Allocation concealment	Blinding participants and personnel	Blinding assessor	Free of incomplete outcome data	Free of selective reporting	Free of other threats to validity
Aljubouri et al (2004)[10]	Low	Low	Unclear	Unclear	Low	Low	Low
Manning et al (2006)[11]	Low	Unclear	Unclear	Unclear	Low	Low	Low
House et al (2006)[12]	Low	Low	Low	Unclear	Low	Low	High
Murfitt et al (2006)[16]	Low	Low	Low	Unclear	Low	Low	Low
Banks and Thirvenkatachari (2008)[16]	Low	Low	Low	Unclear	Low	Low	Low
Cal-Neto et al (2009)[22]	Low	Low	Unclear	Unclear	Low	Low	Low

Table IV. Risk of bias of studies excluded from the quantitative synthesis

Trial	Random sequence generation	Allocation concealment	Blinding participants and personnel	Blinding assessor	Free of incomplete outcome data	Free of selective reporting	Free of other threats to validity
Pandis et al (2006)[13]	High	High	Unclear	Unclear	Low	Low	Low
Pandis et al (2006)[14]	High	High	Unclear	Unclear	Low	Low	Low
Reis et al (2008)[17]	High	High	Unclear	Unclear	Low	Low	Low
Elekdag-Turk et al (2008)[18]	High	High	Unclear	Unclear	Low	Low	Low
Ghiz et al (2009)[19]	High	High	Unclear	Unclear	Low	Low	Low

et al[10] highlighting a reduction in bonding time of 24.9 seconds (95% CI, 22.1-27.7) per attachment. Banks and Thiruvenkatachari[16] highlighted a mean reduction of 22.2 seconds (95% CI, 21.1-23.3) per tooth with Transbond Plus. Quantitative analysis of these studies showed a pooled mean reduction of 23.2 seconds per tooth (95% CI, 20.7-25.8) with the 1-step approach (Fig 6), a statistically significant finding (P <0.001). The elevated statistical heterogeneity (I^2, 68.2%; chi-square, $P = 0.08$; $\tau^2 = 2.48$) should be interpreted with caution, because it is related to the lack of studies and the artificially narrow confidence intervals, since large numbers of teeth artificially inflate the precision of the estimates. The high I^2 value indicates that, although the observed variance is real, estimates lie in a narrow range.[7]

Risk of bias across studies

Tests for publication bias were not undertaken as no more than 6 studies were included in an individual meta-analysis.

DISCUSSION

Summary of evidence

Relative to other systematic reviews in orthodontics, this review identified many studies with a potentially low risk of bias, permitting meta-analysis. Five studies were included in the meta-analyses; however, of these, only 1 study dealt with the duration of treatment in its entirety.[16] Scrutiny of the total duration of treatment has been advocated in previous reviews to ascertain the influence of long-term alterations in bond strength and to provide a more complete assessment of the performance of bonding materials.[23] Therefore, additional studies encompassing a complete course of treatment would be desirable to produce more robust conclusions from future research.

The impact of bias on the outcome of systematic reviews is well documented.[24] The preponderance of split-mouth research in our review complicated the risk of bias assessment, since we were unable to identify specific guidelines relating to the handling of these

Fig 2. Risk of bias summary outlining judgment of risk of bias items for studies included in the quantitative synthesis, including the study by House et al.[12]

reports. Although it might be reasonable to assume that robust random allocation can be less important in split-mouth research, inherent bias might prompt different handling of the appliances; for example, a decision could be made to use 1 technique in a less crowded quadrant or to partially ligate a tooth to prevent attachment failure if there is a preference for a particular bonding technique. Therefore, we thought that it was reasonable to conclude that the omission of robust random allocation procedures would lead to an unacceptable risk of bias.

Split-mouth studies offer the advantages of concurrent experimental and control assignment, limiting sample-size requirements and increasing precision, and avoiding period effects obviating the need for a "washout period" that can be necessary with analogous crossover designs. For the bonding time outcome, we were able to calculate standard errors from the information given to adjust for the matching within patients in the split-mouth studies. However, due to insufficient information, it was not possible to account for the matching effects within patients for bond failure estimation. Reporting the details of the 2×2 table for matched pairs within patients permits calculation of the desired estimates, confidence intervals, and variance or correlation between pairs, by using either the Mantel-Haenszel or conditional likelihood approaches.[25] The calculation of the correlation can be used to appropriately adjust the standard errors to account for matching.

A separate and opposite problem in split-mouth research stems from the nesting of teeth in patients and quadrants, producing clustering effects. Clustering of outcome measurements can be managed by applying specific statistical methods accounting for the correlated data, in which either a summary outcome measurement is calculated for each cluster followed by simple statistical tests or by using complex hierarchical regression models for correlated data such as generalized estimating equations or random effects.[26-28] Incorrect treatment of clustered observations as independent might result in smaller standard errors and consequently artificially small P values, increasing the chance of false-positive results. Of the 3 split-mouth studies included in the quantitative synthesis, 2 incorporated or discussed statistical adjustments to mitigate this problem.[10,15] Meta-analysis of clustered designs would ideally require knowledge of a measure of the correlation of the data, such as the intracluster correlation coefficient or the coefficient of variation between clusters. This would be used to appropriately adjust the sample size of the constituent studies. This measure was not reported in these studies and would have necessitated the availability of the entire data sets for separate intracluster correlation coefficient or coefficient of variation values to be calculated for each trial. Acquisition of the complete data sets was not attempted; depending on the within-cluster correlation, this might have artificially altered the results toward the null. Nevertheless, it is important that further studies account for this problem at the outset to facilitate recruitment of a sufficient sample to confer the desired level of power. Additionally, it is important that intracluster correlation coefficient values are reported to allow future investigators to perform sample-size calculations and adjustments of standard errors for the purposes of meta-analyses.[29]

Table V. Bond failure risk and time taken to place attachments reported in the included studies

Study	Intervention (number of attachments)	Bond failures (%) AE	Bond failures (%) SEP	Time (s) AE	Time (s) SEP
Aljubouri et al (2004)[10]	SEP (389), AE (388): 353 paired per group reducing to 312 at 12 months	11 (3.1)	6 (1.6)	Mean, 106.6 Mean difference, 24.9 (95% CI, 22.1-27.7)	Mean, 81.7
Manning et al (2006)[11]	SEP (299), AE (298)	22 (7.4)	21 (7)		
House et al (2006)[12]	Ideal 1 SEP (339), AE (339)	25 (14.8)	123 (72.4)		
Murfitt et al (2006)[15]	SEP (331), AE (330)	13 (3.9)	37 (11.2)		
Banks and Thiruvenkatachari (2008)[16]	SEP 30 participants (438), AE 30 participants (433)	15 (3.5)	21 (4.8)	97.7 (SD, 9.1; 95% CI, 94.3-101.2)	75.5 (SD, 6.7; 95% CI, 72.9-78.5)
Cal-Neto et al (2009)[22]	SEP (276), AE (272)	13 (4.8)	19 (6.9)		

Table VI. Summary of findings (SoF) table according to GRADE. Number of bonded brackets (participants), effect estimates, quality of the evidence, and expected bond failures per 1000 brackets bonded with SEP and AE

SEP compared with AE for orthodontic patients

Patient or population: orthodontic patients
  Settings: various
  Intervention: SEP
  Comparison: AE

Outcomes	Illustrative comparative risks (95% CI) Assumed risk AE	Illustrative comparative risks (95% CI) Corresponding risk SEP	Relative effect (95% CI)	Number of participants (studies)	Quality of the evidence (GRADE)
Bond failures	45 per 1000	59 per 1000 (44-79)	OR 1.35 (0.99-1.83)	3445 (5 studies)	⊕⊕⊕⊕ High

High quality (indicated by ⊕): further research is unlikely to change our confidence in the estimate of effect. *Moderate quality*: further research is likely to have an important impact on our confidence in the estimate of effect and might change the estimate. *Low quality*: further research is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate. *Very low quality*: we are uncertain about the estimate. The corresponding risk (and its 95% CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).
GRADE, Working group grades of evidence; *OR*, odds ratio.

The randomized controlled trial by House et al[12] presented a further dilemma. This trial was initially adjudged to have low or unclear risk of bias and was well reported. However, because of the excessive number of failures in the SEP arm, the premature end of the trial, and the use of a different bonding material, it was regarded to be at significant odds with all the other studies. The closest failure risk to the 72.4% reported for Ideal-1 in that study was just 11.2%.[15] The particular system investigated was also in its infancy, having been subject to concurrent in-vitro investigation by the same research group.[30] It was, therefore, agreed to omit this trial from the quantitative analysis to prevent skewing the results. Even with the inclusion of this study, the direction of the results remained the same; however, the degree of statistical heterogeneity increased significantly, making amalgamation of the data questionable.

The higher failure rate with SEPs was partially offset by a reduction in chair-side time with this technique. The magnitude of the time savings was relatively small (23.2 seconds on average). This difference translates to a reduction of 8 minutes overall during placement of a dual-arch appliance. The time saving encountered with SEPs is counterbalanced by the increased likelihood
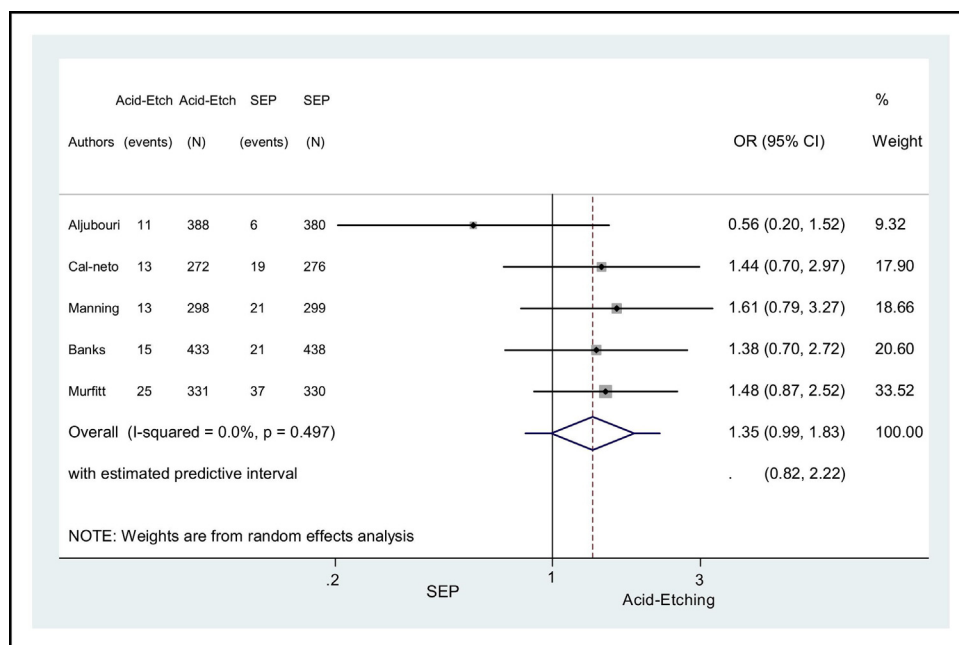
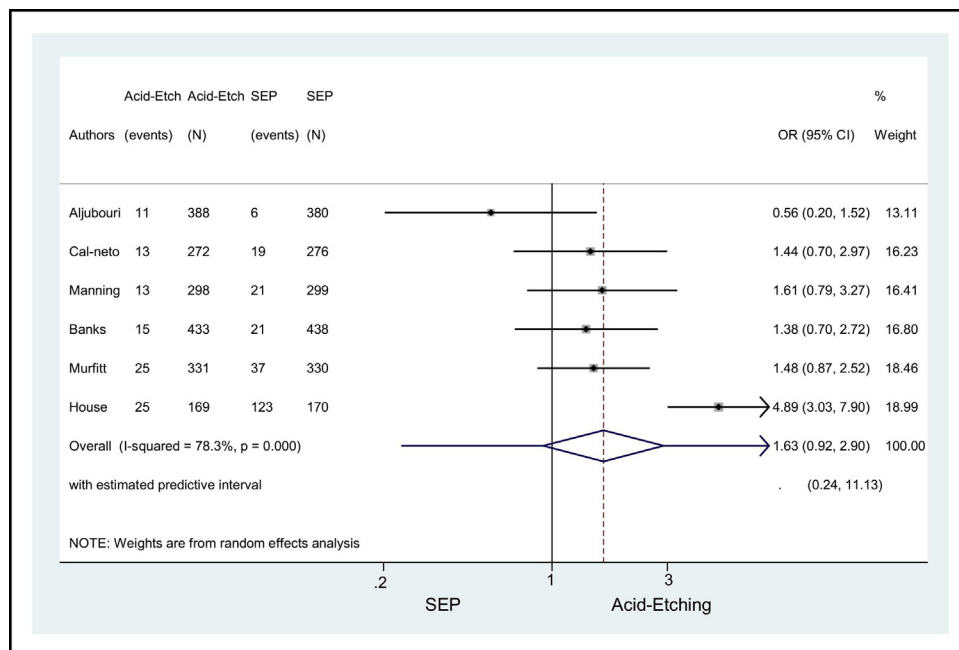**Fig 3.** Random-effects meta-analysis of bracket failure with SEP and AE.

Fig 4. Random-effects meta-analysis of bracket failure with SEP and AE including the study of House et al.[12]

of failure of attachments with this system, with unscheduled replacement of each additional attachment on an emergency basis likely to necessitate a 5 to 10 minute appointment. Practitioners should also consider price differences between individual agents in conjunction with the implications of each agent on chair-side time when assessing the economic advantages of 1- or 2-step systems.
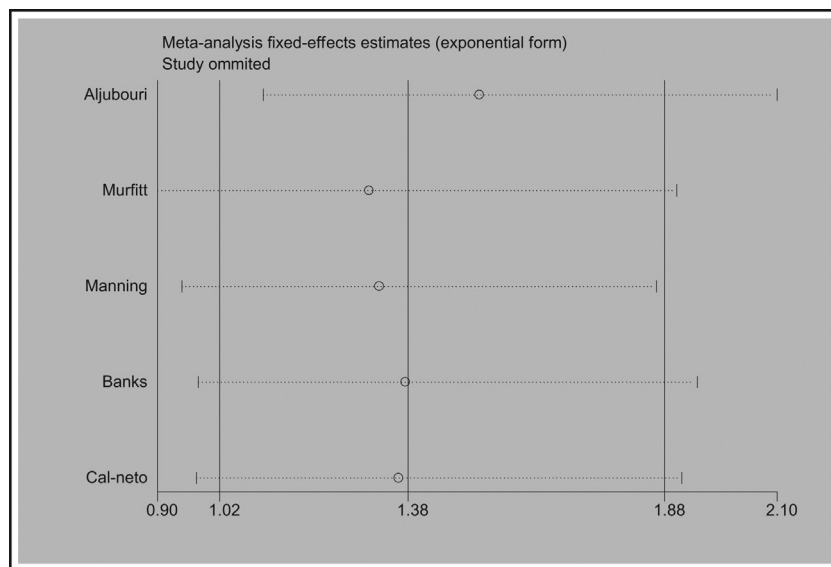
Fig 5. Sensitivity analysis to investigate the influence of individual studies on the overall meta-analysis estimate. The graph shows the pooled estimate (*open circle*) and its confidence interval (*dotted horizontal line with vertical breaks*) as trials were sequentially excluded from the meta-analysis. For example, the first open circle and the dotted range at the top of the graph indicate the pooled estimate after the exclusion of the study of Aljubouri et al.[10]
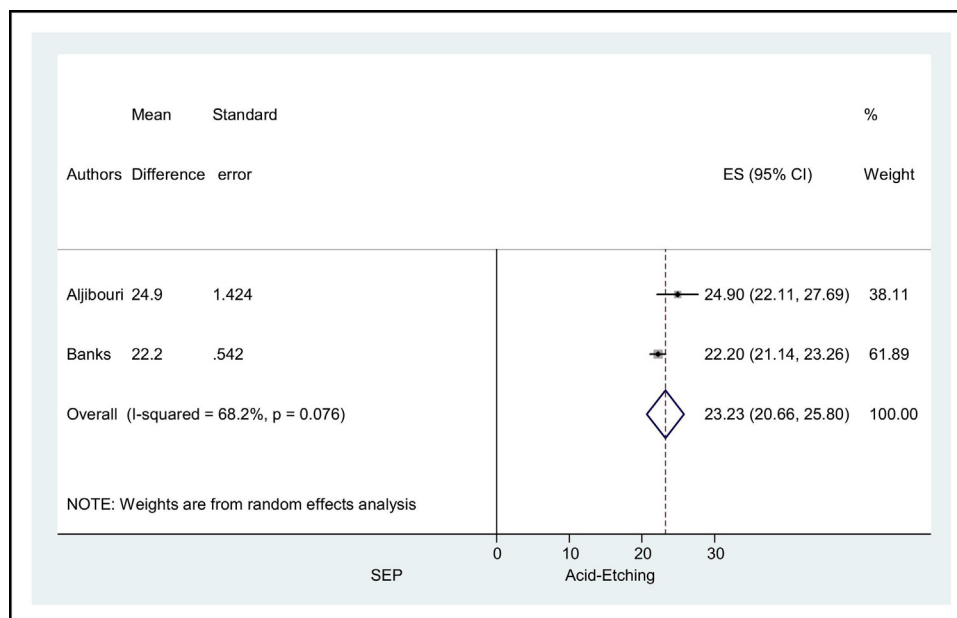

Fig 6. Random-effects meta-analysis of required time to bond with SEP and AE.

Limitations

It is accepted that bond failure can be influenced by a range of factors including demographics, operator experience, tooth location, tooth surface preparation, handling of attachments, and tooth surface both before and after placement. A confounding effect of these variables was not demonstrated in 1 study.[16] Manning et al,[11] however, demonstrated

a higher failure risk in the maxillary arch, whereas Cal-Neto et al[22] highlighted greater failures of premolar than anterior attachments. Murfitt et al[15] reported increased risk of failure in male patients. The robust application of selection criteria, randomization procedures, and allocation concealment will reduce the impact of these potential confounders on the results. When a significant imbalance is noted, multivariate statistical models can be used to offset these differences. The premium on cleaning teeth before bonding with SEPs has previously been demonstrated.[31] Enamel preparation was carried out in all included studies with pumice slurry[11,12,15,16,22] or prophylaxis paste,[10] eliminating tooth surface preparation before bonding procedures as a significant confounder in this research.

Differences in archwire sequences might also have a bearing on bracket failures. Although use of identical archwire sequences throughout treatment is both impractical and unlikely to be sanctioned by ethical review committees, standardized archwire sequences would ideally be used during this type of research to limit confounding effects. Different initial aligning wires (either 0.014-in nickel-titanium or stainless steel) were used in 1 study based on the degree of initial crowding.[15] Use of similar archwire sequences over a 12-month period was alluded to by Aljubouri et al[10]; similar sequences were also used by Banks and Thiruvenkatachari,[16] whereas in the trial by Cal-Neto et al,[22] 0.014-in nickel-titanium wires were used for initial aligning in each patient.

We had hoped to analyze the effect of bonding modality on the risk of decalcification during treatment. However, only 1 study considering this eventuality was identified.[19] This study lacked information on randomization and allocation concealment and also failed to account for clustering. Although information on confounders—in particular, plaque accumulation—was obtained, the statistical analysis did not account for the interaction of these variables. Therefore, it was unclear whether enamel preparation techniques have a demonstrable effect on demineralization of enamel. Further research on this aspect of enamel preparation techniques would be welcome.

CONCLUSIONS

On the basis of this review, we concluded the following.

1. Weak but statistically insignificant evidence suggests that the odds of attachment failures differ between SEP and AE orthodontic bonding techniques over a minimum period of 12 months.

2. Use of 1-step bonding techniques is likely to result in a modest time saving compared with 2-stage techniques.
3. Additional high-quality randomized controlled trials investigating the overall course of treatment are required to analyze the effect of bonding modality on demineralization around fixed appliances.
4. In the absence of clear evidence to favor either system, the choice of bonding modality remains at the discretion of each operator.

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APPENDIX

MEDLINE SEARCH STRATEGY VIA OVID

1. RANDOMIZED CONTROLLED TRIAL.pt. (311155)
2. CONTROLLED CLINICAL TRIAL.pt. (82831)
3. RANDOMIZED CONTROLLED TRIALS.sh. (0)
4. RANDOM ALLOCATION.sh. (72051)
5. DOUBLE BLIND METHOD.sh. (111370)
6. SINGLE BLIND METHOD.sh. (15222)
7. or/1-6 (459019)
8. (ANIMALS not HUMANS).sh. (3533433)
9. 7 not 8 (420281)
10. CLINICAL TRIAL.pt. (464598)
11. exp Clinical Trial/ (647582)
12. (clin$ adj25 trial$).ti,ab. (192365)
13. ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).ti,ab. (112153)
14. PLACEBOS.sh. (29877)
15. placebo$.ti,ab. (130730)
16. random$.ti,ab. (524593)
17. RESEARCH DESIGN.sh. (63258)
18. or/10-17 (1113684)
19. 18 not 8 (1027643)
20. 19 not 9 (622360)
21. 9 or 20 (1042641)
22. exp ORTHODONTICS/ (39565)
23. orthod$.mp. (43453)
24. 22 or 23 (49508)
25. (self-etch$ or self-etching$ or SEP$ or self-adhesive$ or single component$).mp. (743767)
26. (primer$ or bonding agent$).mp. (146371)
27. 25 and 24 and 26 (342)
28. 27 and 21 (154)