Original Article

Comparison of periodontal status and failure rates with different retainer bonding methods and adhesives: a randomized clinical trial

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ABSTRACT

Objectives: This single-center, randomized clinical trial evaluated and compared retainer bonding among different methods and adhesives in terms of periodontal status and failure rates.

Materials and Methods: A total of 100 patients from the orthodontic department of Pamukkale University were randomly assigned to the following 4 groups: group 1, direct bonding (DB) with two-step adhesive; group 2, DB with one-step adhesive; group 3, indirect bonding (IDB) with two-step adhesive; and group 4, IDB with one-step adhesive. Eligibility criteria included good finishing results and oral hygiene, no periodontal or systemic problems, and no missing anterior teeth or restorations. Randomization was carried out using computer-generated random numbers with allocation concealment by opaque, sealed envelopes. The main outcomes were plaque index (PI), gingival index (GI), and calculus index (CI) recorded at bonding, 6 months (T1), and 12 months (T2) after bonding. A secondary outcome was failure rate. The periodontal outcome assessor was blinded. Data were analyzed using the Mann-Whitney *U*-test, Kruskal-Wallis test, and chi-square test.

Results: PI and GI increased with time in all study groups, but there were no significant differences among groups at any time point. A small amount of calculus was observed in all study groups, with the increase in CI for group 3 significantly greater at the T2-T1 time interval ($P < .05$). There were no significant differences between groups for 12-month failure rates.

Conclusions: The one-step retainer adhesive was similar in terms of periodontal status and failure rate. Therefore, a one-step adhesive can be used during bonding, regardless of technique. (*Angle Orthod.* 2023;93:57–65.)

KEY WORDS: One-step adhesive; Periodontal status; Retainer failure

INTRODUCTION

The most challenging problem that orthodontists face is the maintenance of treatment outcomes. Although there is no consensus in the literature on which type of retainer is most effective, practitioners take the patient's initial malocclusion, treatment results, oral hygiene, age, habits, and cooperation as well as their own personal experience into account.[1] However, fixed retainers should be preferred for long-term retention.[2] They can be applied with either the direct technique in which composite pads are directly placed into the mouth, or the indirect technique, as prepared on a study model.[3] The clinical advantages of the indirect bonding (IDB) technique include reduced contamination and less possibility for changes of retainer position.[4]

All surfaces of retainer adhesives are directly exposed to oral conditions and, thus, they must possess certain mechanical properties such as increased hardness and wear resistance.[5] In addition, surface roughness should be considered when conventional two-step retainer adhesive is used.[6]

Recently, the use of self-adhering composites in which the primer is integrated into the paste has attracted great clinical interest among orthodontists. Accordingly, a one-step retainer adhesive that does not require additional application after acid etching saves time and shows advantages such as malleability,

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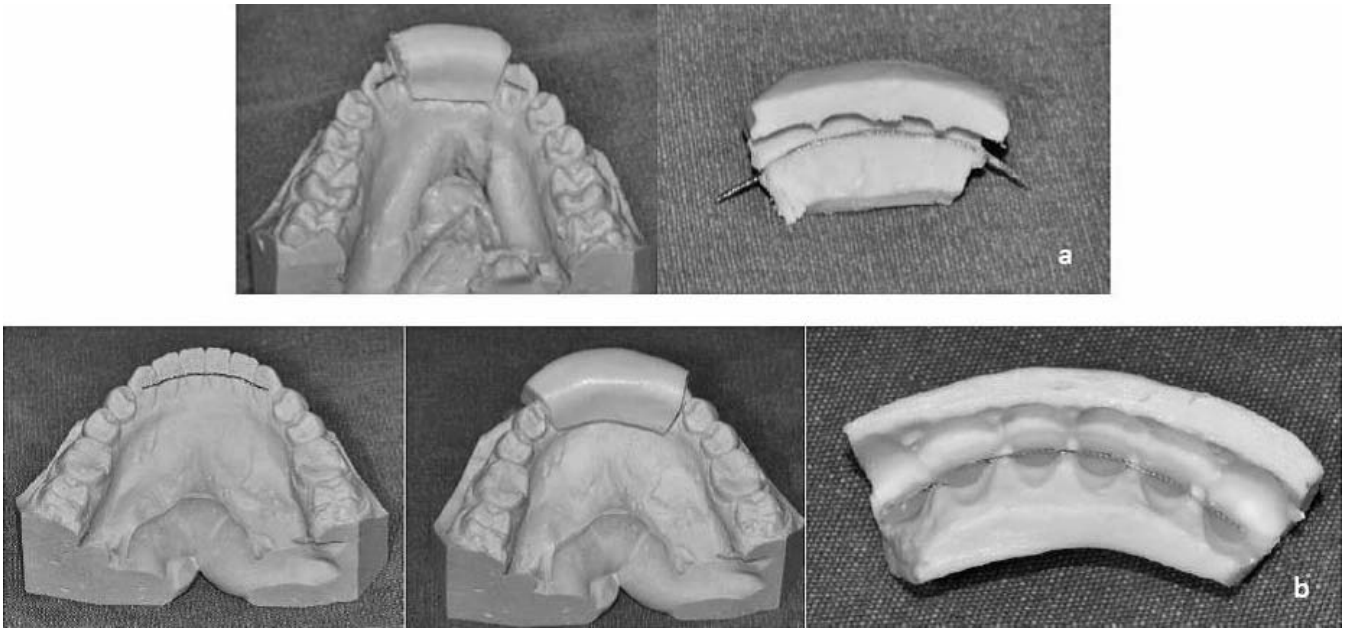

Figure 1. Transfer trays used in the direct technique (a) and indirect technique (b).

abrasion resistance, and durability.[7] Therefore, incorporating this adhesive into the indirect technique may be beneficial in clinical practice.

In a recent systematic review and meta-analysis,[8] the results of different bonding techniques with conventional two-step retainer adhesives were considered similar in terms of failure rates despite data scarcity regarding their impact on periodontal status.[9,10] In the literature, there were no previous studies on directly or indirectly bonded retainers using one-step adhesives with respect to these parameters.

Specific Objectives and Hypothesis

The aim of this study was to evaluate potential differences between direct and IDB techniques using one- or two-step adhesive in terms of periodontal health and failure rates after a 1-year follow-up period. The null hypothesis was that lingual retainers bonded with different methods and adhesives would not differ from each other.

MATERIALS AND METHODS

Trial Design and Ethical Approval

This was a single-center, randomized clinical trial that was approved by the Ethics Committee of the Pamukkale University (02.02.2021/3).

Participants, Eligibility Criteria, and Settings

A total of 100 patients (70 females and 30 males) who completed active orthodontic treatment from August 2020 to November 2020 were included based on the following criteria: (1) good treatment outcome, (2) good oral hygiene, (3) no systemic or periodontal problems, (4) no extractions or missing anterior teeth, and (5) no restorations. Patients unwilling to wear a fixed retainer were excluded from the study. Informed consent was obtained from all patients or their parents.

Interventions

After debonding, participants were examined for periodontal health and, if appropriate, retainer bonding was confirmed. The fixed retainer, a 0.0215-inch, five-strand stainless steel wire (Pentaflex; GC Orthodontics America Inc, Alsip, Ill), was bonded with the direct or indirect method using either the primer integrated one-step (GC Ortho Connect Flow; GC Corp, Tokyo, Japan) or two-step (conventional) retainer adhesive (Transbond LR; 3M Unitek, Monrovia, Calif). All retainer wires were passively bent by the same researcher (Dr Çokakoğlu) on the study models and transferred to the mouth using a silicone tray. For the direct bonding (DB) groups, the retainer wire was embedded into the transfer tray that was prepared on the incisors by exposing the canines (Figure 1a). For the IDB groups, the transfer trays were prepared as described by Bovali et al.[11] (Figure 1b). Before clinical application, the composite pad surfaces were sandblasted with aluminum oxide particles and then cleaned with acetone to remove the residual.

During the bonding procedure, the lingual surfaces were cleaned with fluoride-free paste. The enamel surfaces were etched with 37% phosphoric acid

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(Pulpdent Corporation, Watertown, Mass) for 15 seconds, rinsed, and dried until a chalky-white appearance was obtained.

In group 1, DB with conventional adhesive, Transbond XT Primer (3M Unitek) was applied on acid-etched surfaces and then slightly air thinned. After the wire was transferred using a silicone tray, the canines were first bonded with conventional adhesive (Transbond LR), the tray was removed, and the wire was bonded to the incisors using the same adhesive. The polymerization time was determined as 12 seconds for each tooth.[11] In group 2, DB with one-step adhesive, after etching, no primer was applied, and the retainer wire was bonded in the same manner using a one-step adhesive.

In group 3, IDB with conventional adhesive, components A and B of the chemically cured resin (Maximum Cure; Reliance Orthodontics Products Inc, Itasca, Ill) were applied to composite pads and acid-etched surfaces, respectively. The transfer tray was subsequently placed in the mouth and lightly pressed for 90 seconds. Before tray removal, the tray was left for 5 minutes in accordance with the manufacturer's instructions. In group 4, IDB was performed using the same steps as with a one-step adhesive. Indirect procedures were completed after the removal of transfer trays. Any irregularities on the lingual surfaces were checked using a probe and removed.

Standard retainers and oral hygiene instructions were provided to all patients. They were asked to brush their teeth according to the modified Bass method and use dental floss (Superfloss; Oral B, Cincinnati, Ohio). They were also asked to visit the clinic every 6 months for the assessment of periodontal status and immediately in case of retainer failure. Periodontal measurements, including plaque index (PI),[12] gingival index (GI),[13] and calculus index (CI),[14] were recorded at the bonding session (T0) and 6 months (T1) and 12 months (T2) after bonding. Scoring was performed by a periodontist (Dr Kızıldağ) on the mesiolingual, lingual, and distolingual aspects of mandibular anterior teeth. All periodontal measurements were performed using acrylic stents to ensure reproducible placement of the periodontal probe (15 UNC Colour-Coded Probe; Hu-Friedy, Chicago, Ill). A retainer with at least one composite pad detachment was considered to be a failure. When there was no wire breakage or deformation, the tooth surfaces were cleaned, and bonding was completed using a direct technique.

Outcomes

The primary outcome was to evaluate whether the one-step adhesive demonstrated similar periodontal outcomes to conventional adhesives, irrespective of the bonding technique. The secondary outcome was the failure rate of retainers bonded with either the direct or indirect technique using the conventional or one-step adhesive during a 1-year follow-up period.

Sample Size Calculation

The sample size was calculated using G*Power software (version 3.1.9.7; Franz Faul, Kiel University, Kiel, Germany). The effect size was calculated as 0.402 based on the GI values of a previous study[10] with a sample size of 76 providing at least 80% power (actual power = 0.8234006) at an $\alpha = 0.05$ significance level (critical f = 2.731; noncentrality parameter $\lambda = 12.160$) to detect significant differences. A total of 100 patients were included in this study because of the possibility of dropout.

Randomization

Randomization was performed using an online randomization program. Allocation concealment was achieved with numbered opaque, sealed envelopes that were prepared before trial commencement. Envelopes with the names of an equal number of retainer groups were selected by the patients, and baseline information was written on the outer surface of the envelopes before opening. The operator responsible for the bonding process also performed the randomization, allocation concealment, and implementation.

Blinding

Blinding was possible during the assessment of the periodontal status. This was because the study groups did not differ from each other clinically. In addition, the person performing the data entry and the statistician were blinded to the study groups.

Statistical Analysis

The data were analyzed using SPSS (version 25; IBM Corp. Armonk, N.Y.). Data normality was assessed using the Shapiro-Wilk test. Time-dependent changes in periodontal parameters were analyzed using the Friedman and Wilcoxon tests to evaluate differences within the groups. The Kruskal-Wallis and Mann-Whitney *U*-tests were used to compare periodontal parameters among and between the groups. The failure rates were evaluated using the chi-square test. Statistical significance was set at $P < .05$.

RESULTS

Participant Flow

A total of 100 patients (70 females and 30 males) with a mean age of 17.37 ± 2.71 years were randomly allocated to four study groups, as shown in Figure 2.

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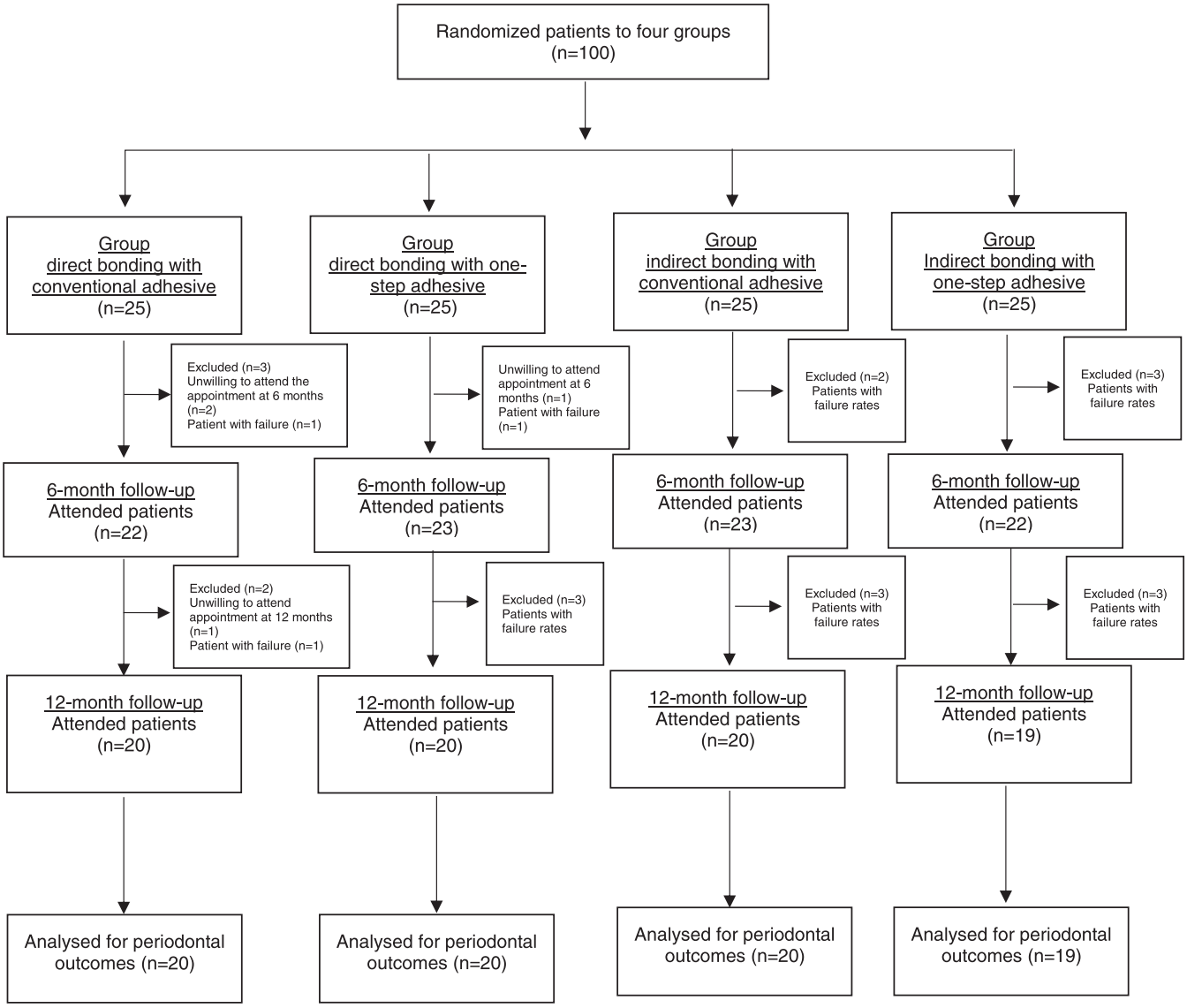

Figure 2. Study flowchart.

The mean observation period was 12.10 ± 0.09 months. Four patients did not attend recall at either 6 or 12 months. Among the DB groups, three patients in whom retainers bonded with conventional adhesive and one patient with one-step adhesive did not attend either the 6-month or the 12-month follow-up sessions and were considered as dropouts. There were no dropouts in the IDB groups. Patients with retainer failure were excluded before the analysis of periodontal outcomes, as the obtained data would have affected periodontal results because of rebonding with the direct technique. Therefore, the final analysis was performed on 20 patients in the DB group. For the IDB groups, the final analysis was carried out for 20 and 19 patients who used conventional and one-step adhesive, respectively.

Baseline Data

There were no statistically significant differences between the groups in terms of baseline characteristics, including age, sex, malocclusion, amount of crowding, and treatment plan with or without extraction ($P > .05$; Table 1).

Periodontal Parameters

Periodontal parameters increased over time in all study groups, as shown in Table 2. Intragroup evaluation showed that the baseline PI, GI, and CI scores were significantly lower than those of T1 and T2 ($P < .05$). The PI scores of T1 were significantly lower than those of T2 in both bonding groups when a one-step adhesive was used ($P < .05$). In addition, in DB

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Table 1. Baseline Characteristics of Study Groups

	Group 1, DB + Conventional (n = 20)	Group 2, DB + One Step (n = 20)	Group 3, IDB + Conventional (n = 20)	Group 4, IDB + One Step (n = 19)	*P* Value[a]
Age, y, median (IQR)[b]	17 (15–19)	18 (16.25–20)	18 (16–21)	17 (13.25–19.25)	.125
Sex, n (%)					
Female	14 (25.45)	17 (30.9)	13 (23.6)	11 (20)	.312
Male	6 (25.0)	3 (12.5)	7 (29.2)	8 (33.3)	
Malocclusion, n (%)					
Class I	13 (65)	12 (60)	11 (55)	7 (37)	.054
Class II	6 (30)	6 (30)	8 (40)	8 (42)	
Class III	1 (5)	2 (10)	1 (5)	4 (21)	
Mandibular crowding, mm, median (IQR)	1.55 (0.975–4.975)	1.65 (0.75–2.75)	2.5 (0.3–4.7)	1.1 (0.65–5.0)	.232
Treatment plan, n (%)					
Nonextraction	18 (90)	17 (85)	15 (75)	15 (79)	.390
Extraction	2 (10)	3 (15)	5 (25)	4 (21)	

[a] *P* value for comparison of groups by Kruskal-Wallis test or differences in proportions by chi-square test.
[b] IQR indicates interquartile range.

with one-step adhesive, the GI score of T1 was significantly lower than that of T2 ($P < .05$). For CI scores, IDB with conventional adhesives at T1 was significantly lower than that at T2 ($P < .05$). However, no significant differences were observed among the groups at any of the evaluation times ($P > .05$).

A comparison of the median differences is presented in Table 3. The increases were not significantly different among the groups, with one exception. In IDB with conventional adhesive, the increase of CI score was significantly greater compared with the other groups during the T2-T1 time interval ($P < .05$).

Failure Rates

In 17 of the 96 (18%) patients, at least one failure was observed during the 12-month follow-up period (Table 4). The overall number of detachments in each group at the three time intervals is shown in Figure 3. If failure was observed in the first 6 months, it was not observed in the same patient in the second 6 months of the study. The lowest failure rate (4.17%) was observed for DB with conventional adhesive. The highest failure rate (6.67%) was observed for IDB using the same adhesive. However, no significant differences were observed among the groups ($P > .05$).

In terms of tooth type, the highest failure rate was 15.38% for the right central incisor bonded with the indirect technique using conventional adhesive during the T0-T1 time interval. However, no significant differences were found between incisors and canines ($P > .05$; Table 5). All bonding failures were observed at the adhesive-enamel interface. No detachment was found between the composite and wire, and no wire breakage was observed in the study groups.

Table 2. Comparison of Periodontal Measurements Among Groups and Times[a]

	Group 1, DB + Conventional	Group 2, DB + One Step	Group 3, IDB + Conventional	Group 4, IDB + One Step	*P* Value[b]
PI score					
T0	0 (0-0.11)[A]	0 (0-0.11)[A]	0 (0-0.11)[A]	0 (0-0.22)[A]	.999
T1	0.56 (0.39-0.94)[B]	0.69 (0.36-0.82)[B]	0.66 (0.38-0.94)[B]	0.55 (0.28-0.83)[B]	.570
T2	0.66 (0.33-1.06)[B,C]	0.99 (0.52-1.00)[C]	0.72 (0.39-1.00)[B,C]	0.89 (0.55-1.00)[C]	.970
P value[c]	.001*	.001*	.001*	.001*	
GI score					
T0	0 (0-0.33)[D]	0 (0-0.30)[D]	0 (0-0.22)[D]	0 (0-0.22)[D]	.975
T1	0.72 (0.40-1.00)[E]	0.63 (0.36-0.86)[E]	0.50 (0.33-1.11)[E]	0.46 (0.33-1.17)[E]	.827
T2	1.00 (0.55-1.11)[E,F]	1.08 (0.94-1.36)[F]	0.66 (0.39-1.61)[E,F]	0.94 (0.44-1.44)[E,F]	.439
P value[c]	.001*	.001*	.001*	.001*	
CI score					
T0	0 (0-0)[G]	0 (0-0)[G]	0 (0-0)[G]	0 (0-0)[G]	.999
T1	0.33 (0.06-0.44)[H]	0.22 (0.03-0.44)[H]	0.17 (0.06-0.61)[H]	0.11 (0-0.33)[H]	.106
T2	0.33 (0.22-0.61)[H,I]	0.33 (0-0.63)[H,I]	0.33 (0.06-1.28)[I]	0.22 (0-0.33)[H,I]	.635
P value[c]	.001*	.001*	.001*	.001*	

[a] Data are provided as median (IQR). No difference is indicated with the same uppercase letter between groups and times in each group.
[b] Kruskal-Wallis test.
[c] Friedman test.
* $P < .05$.

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Table 3. Median Differences in Periodontal Parameters Among Groups During Different Time Intervals[a]

Time Interval	Group 1, DB + Conventional	Group 2, DB + One Step	Group 3, IDB + Conventional	Group 4, IDB + One Step	*P* Value[b]
PI score					
T1-T0	0.55 (0.33-0.83)	0.61 (0.13-0.78)	0.61 (0.36-0.89)	0.39 (0.06-0.83)	.578
T2-T1	0.08 (0.07-0.39)	0.28 (0.01-0.54)	0.06 (0.05-0.47)	0.34 (0.06-0.56)	.533
T2-T0	0.62 (0.22-1.00)	0.83 (0.41-1.00)	0.71 (0.33-1.00)	0.89 (0.44-1.00)	.980
GI score					
T1-T0	0.55 (0.39-1.00)	0.53 (0.23-0.82)	0.45 (0.24-0.97)	0.39 (0.06-1.17)	.883
T2-T1	0.20 (0.04-0.71)	0.32 (0.03-0.90)	0.12 (0.03-0.42)	0.28 (0.06-0.55)	.370
T2-T0	0.77 (0.33-1.11)	1.03 (0.75-1.19)	0.66 (0.28-1.58)	0.72 (0.33-1.44)	.614
CI score					
T1-T0	0.33 (0.22-0.61)	0.22 (0.03-0.44)	0.11 (0.05-0.78)	0.11 (0-0.33)	.106
T2-T1	0.06 (0.05-0.28)[A]	0.03 (0.03-0.16)[A]	0.16 (0.03-0.55)[B]	0.02 (0-0.22)[A]	.007*
T2-T0	0.33 (0.06-0.44)	0.33 (0.03-0.63)	0.33 (0.03-1.30)	0.22 (0-0.33)	.635

[a] Data are provided as median difference (IQR). No difference between groups is indicated with the same uppercase letter based on a pairwise comparison with the Mann-Whitney *U*-test.
[b] *P* value for comparison of groups by the Kruskal-Wallis test.
* $P < .05$.

DISCUSSION

Although there is a lack of evidence on the selection of the optimal protocol and materials for retainer bonding,[15] 0.0215-inch, five-strand stainless steel bonded to all anterior teeth was recommended as the gold standard.[16] Therefore, this type of retainer wire was used to evaluate whether the one-step adhesive had an influence on periodontal status compared with the conventional adhesive when bonded with either direct or indirect techniques. In addition, failure rates were assessed between different bonding techniques and adhesives.

Periodontal Parameters

Periodontal status in the presence of fixed retainers is mainly influenced by patient-related factors.[17] Therefore, plaque deposits, calculus, or inflammation increased because of decreased patient motivation during follow-up, consistent with previous findings.[9,10] In addition, application-related factors might have an impact. Ramoğlu et al.[6] stated that accelerated aging corresponding to a 1-year clinical duration increased the surface roughness of conventional adhesives. Plaque accumulation could be influenced in the same manner as in the present study. In addition, intragroup evaluations revealed the following assumptions: first, the one-step adhesive would be more resistant to intraoral degradation because of its different composition, and second, a smoother transition between the composite pads and acid-etched surfaces would occur because of its lower viscosity.

The viscosity of the IDB resin makes it difficult to manipulate, and a thick layer cannot be reduced by applying an air stream. Although the excess resin was removed from gingival embrasures, remnant adhesives could act as an irregular surface predisposed to plaque accumulation.[9] Supporting this, IDB with conventional adhesive demonstrated a pronounced increase in CI during the second 6-month period. Considering the ability of patients to remove plaque before assessment, other periodontal findings were not significantly different except the results of the CI. In addition, it should be considered that patients were not monitored in terms of standard oral hygiene. Nevertheless, no pronounced calculus formation or gingival inflammation was observed at the end of the follow-up, confirming the improved periodontal results demonstrated in clinical trials.[17]

Failure Rates

Some studies have investigated whether bonding techniques could affect the failure rates when conventional adhesives were used.[10,11,18,19] Concerning the adhesive material, only one study concluded that a highly filled orthodontic composite exhibited lower failure rates than a flowable composite.[20] Although

Table 4. Comparison of Bond Failures Among Groups

Group	No. of Patients	Failure	Percentage	*P* Value[a]	No. of Teeth Bonded	No. of Detached Teeth/ Frequency of Bond Failure, %	*P* Value[a]
DB + Conventional	22	2	9	.459	126	5/3.97	.446
DB + One Step	24	4	17		144	6/4.17	
IDB + Conventional	25	5	20		150	10/6.67	
IDB + One Step	25	6	24		150	7/4.67	

[a] Chi-square test.

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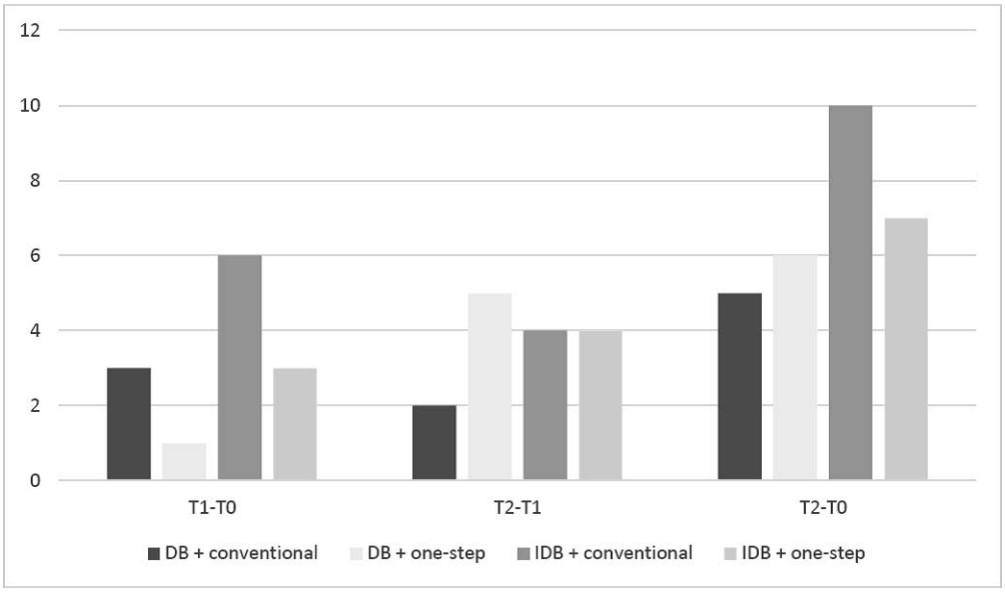

Figure 3. Overall detachments observed in the study groups.

the one-step adhesive had a lower filler level than the conventional adhesive, no significant differences were observed during this study.

According to the results, the number of overall failures was nearly similar during the first and second 6 months after bonding. In contrast, failures were more frequently observed during the first 6 months in previous studies.[18,21,22] The lowest rate was found in DB with conventional adhesive, and the rates of others were also within the range of previous studies, although the observation periods were different.[10,11,19]

From a clinical standpoint, retainers bonded using the indirect technique demonstrated higher failure rates. This can be explained by the partially polymer-

Table 5. Distribution of Failures Per Tooth and Comparison Among Groups for the Different Time Intervals[a]

Time Interval	Group 1, DB + Conventional	Group 2, DB + One Step	Group 3, IDB + Conventional	Group 4, IDB + One Step	*P* Value[b]
LR-1					
T1-T0	1 (7.69)	0 (0)	2 (15.38)	0 (0)	.316
T2-T1	0 (0)	1 (6.66)	0 (0)	0 (0)	.394
T2-T0	1 (3.57)	1 (3.57)	2 (7.14)	0 (0)	.597
LR-2					
T1-T0	0 (0)	0 (0)	1 (7.69)	0 (0)	.424
T2-T1	1 (6.66)	0 (0)	0 (0)	0 (0)	.362
T2-T0	1 (3.57)	0 (0)	1 (3.57)	0 (0)	.570
LR-3					
T1-T0	0 (0)	1 (7.69)	1 (7.69)	1 (7.69)	.803
T2-T1	1 (6.66)	0 (0)	1 (6.66)	1 (6.66)	.785
T2-T0	1 (3.57)	1 (3.57)	2 (7.14)	2 (7.14)	.877
LL-1					
T1-T0	1 (7.69)	0 (0)	0 (0)	1 (7.69)	.529
T2-T1	0 (0)	1 (6.66)	1 (6.66)	1 (6.66)	.803
T2-T0	1 (3.57)	1 (3.57)	1 (3.57)	2 (7.14)	.862
LL-2					
T1-T0	1 (7.69)	0 (0)	1 (7.69)	0 (0)	.570
T2-T1	0 (0)	1 (6.66)	1 (6.66)	0 (0)	.593
T2-T0	1 (3.57)	1 (3.57)	2 (7.14)	0 (0)	.597
LL-3					
T1-T0	0 (0)	0 (0)	1 (7.69)	1 (7.69)	.426
T2-T1	0 (0)	2 (13.66)	1 (6.66)	2 (13.33)	.496
T2-T0	0 (0)	2 (7.14)	2 (7.14)	3 (10.71)	.389

[a] Data are provided as number (percentage). Failure rate (percentage) is calculated as number of failures/total number of failures in each time interval.

[b] Chi-square test. LR, Lower right; LL, Lower left.

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ized resin. Consistent with previous findings, tooth-related factors were considered the main reason for most detachments that occurred in the right central incisor.[10,11,18] However, it should be noted that it was difficult to completely compare the results with other studies because of the different adhesives, wire dimensions or materials, and observation times.[23]

All bond failures occurred at the enamel-adhesive interface, depending on the incomplete preparation of enamel surfaces, moisture contamination, or polymerization shrinkage.[10,11,19] Based on these findings, it was observed that the phosphate monomer of the one-step adhesive provided a strong bond on the wires, resulting in no detachment between the wire-composite interface.

Limitations

Because of the lack of previous data on one-step adhesives, periodontal and failure outcomes were discussed in a limited manner. Standardization of the thickness and size of the composite pads, which might influence plaque formation and bonding failure, was impossible. In this context, it was clinically observed that the one-step adhesive had the advantage of reducing the bulky structure owing to its lower filler level. However, this finding should be confirmed in future studies. Considering the limitations of this study, the null hypothesis was not rejected. Retainers bonded by direct or indirect techniques using either one-step or conventional adhesives showed similar results in terms of periodontal health and failure rates after a 1-year follow-up period.

Generalizability

The generalizability of the findings might be limited because this study was conducted in a single center, and the success of retainer bonding also depends on patient-related factors.

CONCLUSIONS

- Mild gingivitis and a small amount of calculus were present in all groups.
- IDB with conventional adhesive demonstrated a pronounced calculus increase during the second 6-month period.
- No significant differences were found in the failure rates between different bonding methods and adhesives.

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