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# Orthodontic Bracket Failure With and Without Primer During Six Months of Fixed Appliance Treatment

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**Orthodontic Bracket Failure With and Without Primer During Six Months of Fixed Appliance Treatment**

**ABSTRACT**

**Objective:** To compare orthodontic bracket failure rates with and without primer in patients undergoing fixed appliance treatment.

**Material and Methods**: This split-mouth randomized controlled trial was conducted on 42 participants. Diagonal quadrants were randomly assigned to either the primer (control) or non-primer (experimental) group. Allocation was concealed in opaque envelopes and revealed at the time of intervention. Both genders, aged 12-30 years, and visiting for the management of malocclusion were included. Patients with dental anomalies, caries, or restorations were excluded. The direct bonding technique was used for the placement of conventional metallic brackets. Participants were followed up for six months, with monthly visits, and bracket failure within each group was recorded. Generalized estimating equation logistic regression was used to account for clustering of multiple attachments within participants and to estimate odds ratios.

**Results**: A total of 42 participants contributing 840 orthodontic attachments were analyzed over six months. Mean age was 17.81 ± 4.09 years, and 52.4% were female. Monthly attachment failure rates were low in both groups, ranging from 3.8% to 4.3% in the primer group and 3.6% to 6.0% in the non-primer group, with no significant unadjusted differences at any month. In multivariable generalized estimating equation analysis, bonding method was not significantly associated with attachment failure (non-primer vs primer: OR = 1.24, 95% CI = 0.72–2.13; p = 0.435). Male participants (OR = 2.31, 95% CI = 1.28–4.18; p = 0.005) and those aged ≤17 years (OR = 2.18, 95% CI = 1.22–3.91; p = 0.008) had significantly higher odds of failure. Failure risk declined modestly over time (OR = 0.95, 95% CI = 0.92–0.99; p = 0.028). No significant interaction effects were observed.

**Conclusion:** Over a six-month follow-up period, omission of primer did not significantly increase orthodontic bracket failure rates. Male participants and younger patients showed a higher risk of bracket failure, irrespective of bonding method.

**Trial Registration**: This trial was retrospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12625000890437) on 15/08/2025

## INTRODUCTION

The bonding of brackets to enamel surfaces is a critical aspect of orthodontic care, as a reliable and secure bond is essential for successful treatment outcomes.[1, 2] Optimal bracket bond strength is required to withstand normal intraoral forces throughout treatment while still allowing safe debonding without enamel damage.[3-5]

Buonocore introduced composite bonding in orthodontics, replacing traditional banding methods.[6] A primer, an unfilled resin, is an important part of the bonding process making the bond stronger.[7] Literature found that primer helps increase the bond strength, ensuring that the brackets remained securely attached during treatment and can be removed later without damaging the enamel.[8, 9]

Conversely, omission of primer during bracket bonding may reduce treatment time, material cost, and technique sensitivity by eliminating one procedural step. Previous randomized clinical evidence has suggested that omission of primer may simplify the bonding procedure without significantly increasing bracket failure rates under clinical conditions.[10]

Previous studies have reported variable findings regarding the effect of primer on orthodontic bracket failure rates. While some trials observed slightly lower failure rates with primer[11], others reported minimal or no significant differences between primer and non-primer groups. Overall, failure rates ranged from approximately 3% to 15% across studies, and most did not reach statistical significance, suggesting that the routine use of primer may not consistently improve bracket retention.[9, 10]

The use of primer may also increase chairside time, procedural cost, and the risk of moisture contamination during bonding, which can adversely affect bond performance. Additionally, primer use has been associated with the release of bisphenol-A (BPA), although its clinical significance in orthodontics remains uncertain.

Although previous well-conducted randomized controlled trials generally found no significant reduction in bracket failure with primer use[9, 10], a recent meta-analysis suggested that bonding without primer may increase bracket failure rates[12]. However, that review had methodological limitations, including the inclusion of a non-randomized study with substantial statistical influence and inadequate adjustment for clustering effects inherent in split-mouth trials. These issues may have affected the reliability of the pooled estimate.

Therefore, further investigation was warranted to clarify whether omission of primer truly influences bracket failure under clinical conditions. The null hypothesis was that no difference exists in bracket failure rates between bonding performed with primer and bonding performed without primer. Accordingly, this study aimed to compare orthodontic bracket failure rates with and without primer in patients undergoing fixed appliance treatment.

## MATERIAL AND METHODS

### Trial design, sampling technique and registration

This split-mouth randomized controlled trial was conducted at the Orthodontic Department, Bacha Khan Dental College, Mardan, from August 5, 2024 to October 20, 2025, using consecutive non-probability sampling and is reported according to the CONSORT guidelines. The study protocol, including study design, eligibility criteria, intervention procedures, follow-up schedule, and the primary outcome (bracket failure rate), was finalized before participant recruitment and data collection began. No changes were made to the primary outcome, intervention methods, or planned follow-up after study initiation. This trial was retrospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12625000890437) on 15/08/2025.

### Sample size

The sample size was estimated based on the primary outcome of attachment failure rate between primer and non-primer bonding methods. Previous clinical studies comparing orthodontic bracket bonding with and without primer have reported failure rates ranging from approximately 3% to 10%. Assuming an expected absolute difference of 5% in failure rates between groups, with a two-sided alpha level of 0.05 and 80% statistical power, approximately 434 attachments per group were required to detect this difference. Because the present study used a split-mouth design in which

multiple attachments were contributed by each participant, observations were clustered within individuals. To ensure an adequate number of evaluable attachments and to allow for potential dropouts or incomplete follow-up, 42 participants were recruited, each contributing approximately 20 bonded attachments, resulting in a total planned sample of 840 attachments equally distributed between primer and non-primer conditions. As attachment-level outcomes within the same participant are correlated, the primary inferential analyses accounted for within-participant clustering using generalized estimating equation (GEE) models.

**Ethical approval and informed consent**

Ethical approval was obtained from the Research and Ethics Committee, Bacha Khan Medical Complex and Bacha Khan Medical College, Mardan, Pakistan (Reference No. 30/RCBKMC). The full research protocol was explained to the patients and to the parents of those under 16 years of age, with written consent for treatment. All study procedures adhered to the Declaration of Helsinki.

**Eligibility criteria**

Patients visiting for orthodontic treatment, aged between 12 and 30 years, of both genders, requiring fixed appliances in both arches for dental malocclusion (Angle Class I, II, and III), and Pakistani nationals (verified through their national identity card), were included. Patients with dental anomalies such as enamel fluorosis, caries or restorations on the facial enamel surface, or poor oral hygiene were excluded. Additionally, patients with extreme overbite or overjet, presence of crossbites, or other occlusal irregularities that could complicate bonding procedures or increase risk of bond failure were excluded to ensure uniformity in bracket placement and reduce confounding factors affecting bracket failure.

**Randomization and allocation concealment**

Forty-two participants were enrolled by a single operator, and randomization was performed using Microsoft Excel 2010. Each participant's two diagonal quadrants (i.e., upper right and lower left or vice versa) were randomly assigned to either the primer group (control group) or the non-primer group (experimental group). The allocation was done by entering participant numbers into one column in Microsoft Excel 2010, generating random numbers in an adjacent column using the function (=RAND), and sorting them in ascending order. The first assigned diagonal quadrants were allocated

to the primer group, while the contralateral diagonal quadrants were assigned to the non-primer group. To ensure allocation concealment**,** group assignments were sealed in opaque envelopes and revealed only at the time of intervention. Due to the nature of the intervention, only the participants were blinded to the allocation.

**Bonding procedure**

The appliances were placed by trained clinicians with more than two years of orthodontic bonding experience. The participants were divided into two groups: Group I received primer during bonding, while Group II received the non-primer bonding protocol according to the assigned allocation. All attachments were 0.022-inch metal Roth or MBT prescription (Transbond™ XT, 3M Unitek, Monrovia, California, USA). The bracket bonding procedure in Group I involved several steps. First, oral prophylaxis was performed using a scaling and polishing without the use of pumice. The bonding surface of the teeth was dried with an air syringe, followed by isolation using a cheek retractor and cotton roll. Continuous saliva control with suction was used where required. Bonding was performed in a dry field, and teeth were bonded sequentially in small segments to minimize moisture contamination. If any contamination from saliva or moisture was observed during the procedure, the enamel surface was re-dried before proceeding. The enamel surface was etched for 30 seconds with 37% phosphoric acid(3M Unitek, Monrovia, California, USA). After a thorough wash with water and drying using an air syringe, the enamel exhibited a frosted white appearance. A thin layer of primer (Transbond™ XT, 3M Unitek, Monrovia, California, USA) was painted on enamel surface. The brackets were firmly positioned, and any flash was removed with a dental explorer. Light curing was performed for 20 seconds using LED light (Elipar™, 3M ESPE, St. Paul, Minnesota, USA). Bonding was done on one side at a time to ensure effective moisture control. The bracket bonding procedure in Group II followed the same steps as in Group I, except that primer was not applied to the enamel surface.

**Outcome measurement**

Demographics like age and gender were recorded. Patients were seen every four weeks over a period of six months to evaluate bond failure. Bracket failure was defined as any clinically observed bracket detachment or loss of bond requiring rebonding during follow-up visits. Failures were analyzed at the attachment level. Rebonded

brackets continued to be monitored after rebonding, and repeated failures of the same attachment occurring during different follow-up visits were recorded as separate failure episodes. The tooth and arch in which brackets were failed were recorded. A proforma was filled out by a single examiner at each appointment to gather the necessary data. To control for bias and confounders, randomization was applied, inclusion/exclusion criteria were strictly followed, and regression analysis was performed.

**Blinding**

Due to the nature of the intervention, the operators performing bracket bonding could not be blinded to group allocation. Participants were unaware of whether primer was applied to the allocated quadrants. Bracket failure outcomes were assessed during follow-up visits by a single examiner who was not involved in the bonding procedure and was blinded to group allocation where feasible.

**Statistical analysis**

Statistical analyses were performed using R software (version 4.3.2). Because outcomes were collected at the attachment level, with multiple attachments contributed by each participant, generalized estimating equation (GEE) logistic regression models with logit link were used to account for within-participant clustering. Participant ID was specified as the clustering variable using an exchangeable working correlation structure. Attachment failure (yes/no) was the dependent variable. Robust (sandwich) standard errors were used to account for potential misspecification of the working correlation matrix. An exchangeable correlation structure was selected because observations within the same participant were assumed to have similar correlation. Model convergence and diagnostic assessments were evaluated to confirm model adequacy. Bonding method (primer vs non-primer) was the primary independent variable and models were adjusted for age group, sex, dental arch, side, and follow-up month. Interaction terms between bonding method and sex, and between bonding method and age group, were additionally evaluated. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). A two-sided p-value $<0.05$ was considered statistically significant.

## RESULTS

Sixty patients were assessed for eligibility. Eighteen patients were excluded because they did not meet the inclusion criteria, including missing teeth in the bonding area, caries on the facial surface, or excessive overjet. The remaining 42 participants were randomized and allocated to the split-mouth intervention. Each participant received both bonding protocols according to the randomized allocation, resulting in 420 attachments in the primer protocol and 420 attachments in the non-primer protocol. No participants were lost to follow-up or discontinued treatment during the six-month observation period. All 42 participants and all 840 attachments were included in the final analysis (**Fig. 1**).

A total of 42 participants contributing 840 orthodontic attachments were analyzed over a six-month follow-up period. Mean age was 17.81 ± 4.09 years, and 52.4% of participants were female. Monthly attachment failure rates were low in both groups throughout follow-up. **(Table 1**) In the primer group, failure rates ranged from 3.8% to 4.3%, whereas corresponding rates in the non-primer group ranged from 3.6% to 6.0%. No significant unadjusted differences were observed between groups at any month (**Table 2**).

In multivariable generalized estimating equation analysis accounting for clustering of attachments within participants, bonding method was not significantly associated with attachment failure (non-primer vs primer: OR= 1.24, 95% CI= 0.72–2.13; p=0.435). Male participants had significantly greater odds of failure than females (OR 2.31, 95% CI= 1.28–4.18; p=0.005), while participants aged 17 years or younger had higher odds of failure than older participants (OR= 2.18, 95% CI= 1.22–3.91; p=0.008). No significant associations were observed for dental arch or side. Failure risk declined modestly with increasing follow-up month (OR= 0.95, 95% CI = 0.92–0.99; p=0.028). No significant interaction effects were found between bonding method and sex or age group **(Table 3)**.

## DISCUSSION

The present split-mouth randomized controlled trial compared orthodontic bracket failure rates with and without primer over a six-month follow-up period. The

findings demonstrated no statistically significant difference in bracket failure between the two bonding protocols, and the null hypothesis was therefore not rejected. These results suggest that omission of primer did not adversely affect short-term bracket survival under the clinical conditions of the present study.

The split-mouth design represented an important methodological strength, as each participant served as their own control.[13] This approach minimizes inter-individual variability and reduces the influence of patient-related confounding factors such as enamel quality, oral hygiene habits, dietary patterns, masticatory forces, and treatment compliance. As a result, differences observed between groups are more likely to reflect the intervention itself rather than variation between participants.

Another strength of the present trial was the complete follow-up of all randomized participants, with no dropouts or treatment discontinuations during the study period. This minimized the risk of attrition bias and strengthened the internal validity of the findings. In addition, monthly follow-up visits allowed regular monitoring of bracket performance and timely recording of failure events under routine clinical conditions.

Our results showed low failure rates in both groups throughout follow-up. Mean monthly failure rates were 4.1% in the primer group and 5.0% in the non-primer group. In adjusted generalized estimating equation analysis, attachment failure was the dependent outcome*, while* bonding method and other covariates were entered as independent variables. Bonding method was not significantly associated with attachment failure (OR = 1.24, 95% CI: 0.72–2.13; p = 0.435). Although the point estimate numerically favored primer use, the confidence interval crossed unity and did not demonstrate a statistically significant benefit. Therefore, routine primer application may not be essential for achieving acceptable short-term bracket retention in all patients. Although the differences between groups were not statistically significant, the non-primer group demonstrated consistently higher numerical failure rates during most follow-up months. Even small increases in bracket failure may increase emergency visits, rebonding procedures, and chairside workload in busy orthodontic practices. Therefore, clinicians should balance procedural simplification against the possibility of slightly greater maintenance requirements when selecting a bonding protocol.

The present findings are consistent with several previous randomized clinical trials. Bazargani et al.[10] reported failure rates of 3.1% with primer and 5.5% without primer, with no statistically significant difference between groups. Nandhra et al.[9] also

observed numerically higher failure rates in the non-primer group, although the difference did not reach significance. Romano et al.[14], in a six-month clinical trial, similarly found no significant difference in bracket failure between bonding protocols. Similar findings were also reported in Arab patients with bimaxillary protrusion. [11] Collectively, these studies support the view that omission of primer may not substantially compromise clinical bonding success.

Multivariable analysis further demonstrated that male participants and patients aged 17 years or younger had significantly higher odds of bracket failure. Notably, male participants exhibited more than twice the odds of attachment failure compared with females after adjustment for age, arch, side, bonding method, and follow-up duration. This finding is clinically relevant because it suggests that patient-related factors may influence bracket survival independently of the bonding protocol. Possible explanations include greater masticatory forces, consumption of harder foods, and differences in compliance with dietary restrictions and appliance-care instructions. Similar findings were reported by Bazargani et al. [10], who observed significantly higher bracket failure rates among boys than girls in their randomized controlled trial. In contrast, Nandhra et al. [9] found no significant association between sex and bracket failure. These discrepancies may reflect differences in study populations, age distribution, follow-up duration, bonding protocols, and definitions of failure. Younger patients also demonstrated a significantly higher risk of failure in the present study, which is consistent with previous reports suggesting that younger individuals may be more prone to bracket failure because of behavioral and compliance-related factors. However, as these variables were not directly measured, the underlying mechanisms remain speculative and should be interpreted cautiously.

Previous literature has reported inconsistent findings regarding the effect of age and sex on bracket failure. Bazargani et al.[10] similarly found higher failure rates among younger patients and males, whereas Nandhra et al.[9] found no significant differences according to age or sex. Barbosa et al.[15] reported a significant association between age and bonding failure. These discrepancies may be related to differences in study design, sample characteristics, follow-up duration, operator technique, and definitions of failure.

Although the present study did not evaluate the Adhesive Remnant Index (ARI) or the precise site of bond failure, several factors may contribute to bracket detachment in clinical practice. Bond failure may occur at the enamel–adhesive interface, within the

adhesive itself (cohesive failure), or at the bracket–adhesive interface. The mechanism of failure may be influenced by factors such as masticatory forces, dietary habits, moisture contamination during bonding, enamel surface characteristics, and bracket base design. However, the randomized split-mouth design of the present study allowed each participant to serve as their own control, thereby minimizing the influence of many patient-related confounding factors, including oral hygiene practices, dietary habits, enamel characteristics, masticatory patterns, and treatment compliance. Because the current study was designed to evaluate overall clinical bracket failure rates rather than failure mode characteristics, the exact mechanism and location of failure could not be determined. Future studies incorporating failure-mode analysis and ARI assessment would provide additional insight into the biological and mechanical mechanisms underlying bracket detachment.

Although the mandibular arch showed numerically higher failure rates than the maxillary arch in the present study, this difference was not statistically significant. Similar trends have been described in previous studies. Greater difficulty in moisture control, increased functional loading during mastication, and occlusal contacts in the lower arch may partially explain this pattern. Nevertheless, the absence of statistical significance indicates that arch location alone may not be a major determinant of failure risk. Similar trends have been observed in previous randomized clinical trials examining bracket failure rates with and without the use of primer, which also reported greater failures in the mandible than the maxilla, but without statistically significant differences.[3, 9, 11, 14]



From a practical perspective, omission of primer may offer several advantages, including reduced chairside time, lower material costs, and elimination of one procedural step. Simplification of the bonding protocol may be particularly useful in high-volume clinical settings or in patients where shorter chairside procedures are desirable.[9] However, operator experience, moisture control, enamel condition, and patient compliance should still be considered when selecting the most appropriate bonding approach. The present study also contributes to an important evidence gap in orthodontic bonding. Although previous clinical trials have investigated primer omission, the available evidence remains limited and has produced inconsistent findings. By using a randomized split-mouth design and accounting for clustering of multiple attachments within participants, the present study provides a methodologically

robust evaluation of primer omission under routine clinical conditions. The findings suggest that, in appropriately selected patients, a simplified bonding protocol without primer may achieve clinically comparable short-term outcomes while reducing procedural complexity. These results may assist clinicians in making evidence-based decisions regarding bonding protocols and resource utilization in daily orthodontic practice.

A recent meta-analysis concluded that bonding without primer was associated with a significantly higher bond failure rate.[12] However, that review included a limited number of studies, incorporated a non-randomized trial with substantial statistical influence, and did not fully account for clustering effects inherent in split-mouth designs. These methodological limitations may have influenced the pooled estimate. Consequently, the findings of that review should be interpreted with caution.

This study had several strengths. First, randomization helped control for both known and unknown confounding factors. Second, the split-mouth design allowed each participant to serve as their own control, thereby minimizing inter-individual variability and reducing the influence of factors such as occlusal interferences, masticatory forces, dental anatomy, oral hygiene practices, and malocclusion characteristics. Third, complete follow-up of all participants reduced the risk of attrition bias. Fourth, standardized bonding procedures and regular monthly assessments improved the consistency and reliability of outcome measurement. Fifth, the use of generalized estimating equation analysis appropriately accounted for clustering of multiple attachments within the same participant, thereby strengthening the validity of the statistical findings.

This study also had several limitations. First, the six-month follow-up period may not reflect long-term bracket survival throughout the full course of orthodontic treatment. Second, the single-center setting and modest sample size may limit the generalizability of the findings. Third, the Adhesive Remnant Index (ARI) or site of bond failure was not assessed; therefore, the present study could not differentiate whether failures occurred at the enamel-adhesive, cohesive, or bracket-adhesive interface. Fourth, although the study protocol and primary outcomes were finalized before participant recruitment, retrospective trial registration may still reduce methodological transparency and carries a potential risk of selective reporting bias. Fifth, although the split-mouth design minimized inter-individual variability, side-related behavioral factors such as

preferential chewing habits may still have influenced bracket failure independently of the bonding protocol. Lastly, although some clinicians consider a bracket failure rate below 5% to be clinically acceptable, the non-primer group showed numerically higher monthly failure rates than the primer group during most follow-up visits.

## Conclusion

Within the limitations of this split-mouth randomized controlled trial, omission of primer was not associated with a statistically significant increase in orthodontic bracket failure during the six-month follow-up period. Comparable bracket failure rates were observed between primer and non-primer bonding protocols. Male participants and those aged 17 years or younger demonstrated a significantly higher overall risk of bracket failure, independent of bonding method. These findings suggest that omission of primer may be a clinically acceptable bonding approach in selected patients. Further multicenter randomized trials with longer follow-up are warranted to confirm these findings and evaluate long-term clinical outcomes.

**Declaration**

**Abbreviations**

BPA – Bisphenol-A

n – Sample size

OR – Odds ratio

P – Proportion

RCT – Randomized controlled trial

SD – Standard deviation

**Consent for publication**

Not applicable. This study does not contain any individual person's data in any form (including images or videos).

**Availability of data and materials**

Data of current study are available from the corresponding author on reasonable request. However, for privacy reasons, no individual data allowing identification of participants (e.g., videos) can be provided.



**Competing Interests**

The authors declare that they have no financial, personal, or professional conflicts of interest that could have influenced the work reported in this manuscript. No support or funding was received from any organization that could be perceived to influence the findings, and there are no affiliations or relationships that may be viewed as potential competing interests.

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**Trial registration**

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**Authors' contributions**

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**Ferdous Bukhary** - (Conceptualization [equal], (Data curation [equal], Investigation [equal], Methodology [equal], Writing—review & editing [equal]), final approval

**Mohammed Mohsen Al Jearah -** (Conceptualization [equal], (Data entry [equal], Writing—review & editing [equal]), final approval

**Waqas Naseem** - (Conceptualization [equal], (Data analysis [equal], Writing—review & editing [equal]), final approval

**Muhammad Abdullah Kamran -** (Conceptualization [equal], literature review [equal], Methodology [equal], Writing—review & editing [equal]), final approval

**Ali Alqerban -** (Conceptualization [equal], data interpretation [equal], Writing—review & editing [equal]), final approval

**Shehroz Khan**- (Conceptualization [equal], (Data analysis [equal], Writing—review & editing [equal]), final approval

**Asif Rehman** - (data entry [equal], data curation[equal], literature review [equal], Methodology [equal], Writing—review & editing [equal]), final approval



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**Figures legends**

Fig 1. Flow chart for selecting participants

**Tables legends**

Table 1. Baseline Characteristics of Included Participants

Table 2. Descriptive Comparison of Attachment Failure Rates Over Six Months

Table 3. Multivariable GEE Logistic Regression for Attachment Failure

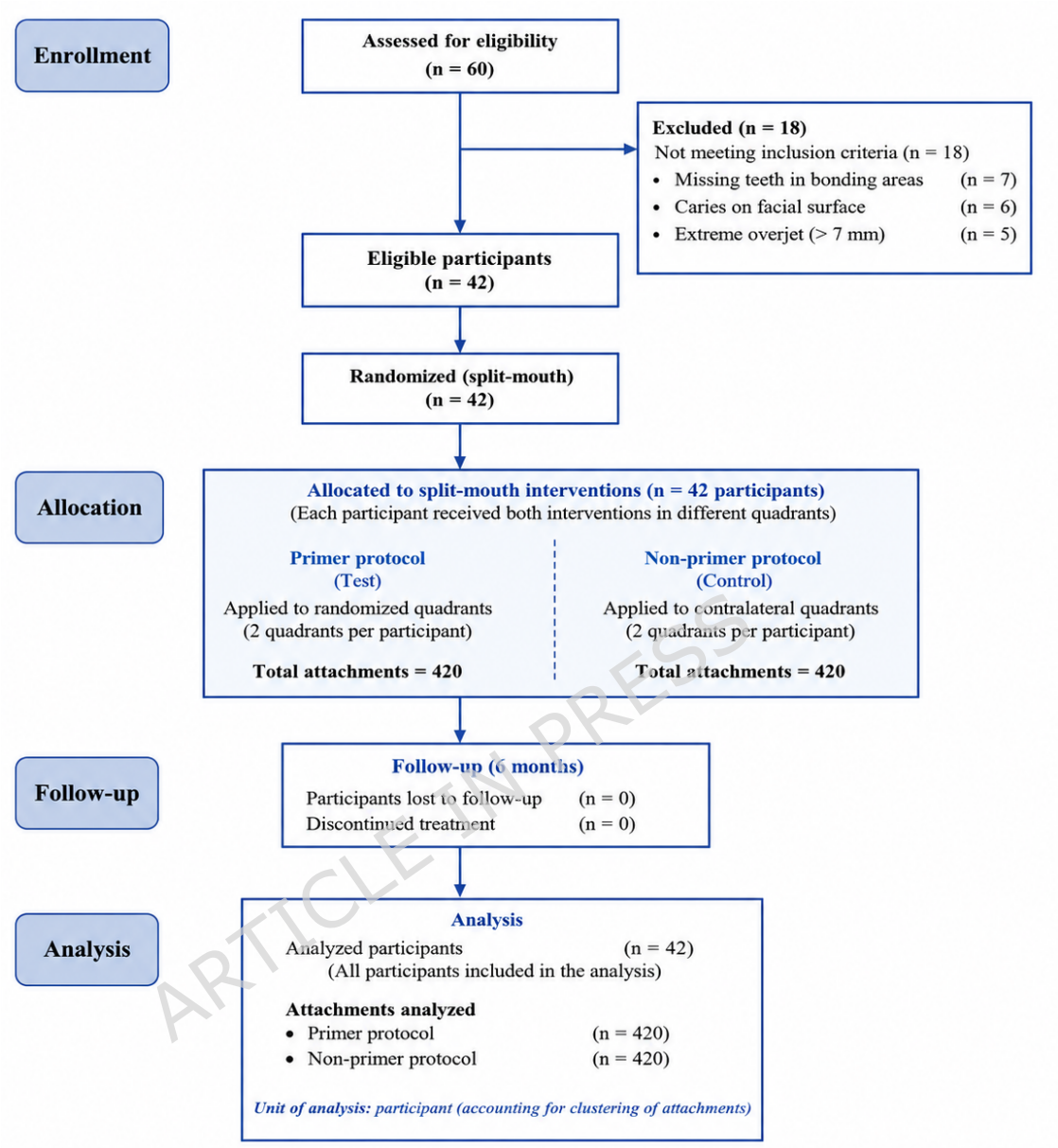


Fig 1. Flow chart for selecting participants

Table 1. Baseline Characteristics of Included Participants

| Variable | Total (n = 42) |
|---|---|
| Age (years), mean ± SD | 17.81 ± 4.09 |
| Age group ≤17 years, n (%) | 22 (52.4) |
| Age group ≥18 years, n (%) | 20 (47.6) |
| Male, n (%) | 20 (47.6) |
| Female, n (%) | 22 (52.4) |
| Total attachments analyzed | 840 |
| Attachments per participant, median (IQR) | 20 (20–20) |
| Primer attachments, n (%) | 420 (50.0) |
| Non-primer attachments, n (%) | 420 (50.0) |

Table 2. Descriptive Comparison of Attachment Failure Rates Over Six Months

| **Month** | **Primer Failures n/N (%)** | **Non-primer Failures n/N (%)** | **Unadjusted p-value*** |
|---|---|---|---|
| 1st | 17/420 (4.0) | 25/420 (6.0) | 0.25 |
| 2nd | 18/420 (4.3) | 23/420 (5.5) | 0.47 |
| 3rd | 17/420 (4.0) | 18/420 (4.3) | 0.87 |
| 4th | 18/420 (4.3) | 24/420 (5.7) | 0.40 |
| 5th | 17/420 (4.0) | 21/420 (5.0) | 0.53 |
| 6th | 16/420 (3.8) | 15/420 (3.6) | 0.89 |
| Mean monthly failures | 17.2/420 (4.1) | 21.0/420 (5.0) | — |

*Chi-square test*

Table 3. Multivariable GEE Logistic Regression for Attachment Failure

| Variable | Adjusted OR | 95% CI | p-value |
|---|---|---|---|
| Non-primer vs Primer | 1.24 | 0.72–2.13 | 0.435 |
| Male vs Female | 2.31 | 1.28–4.18 | 0.005 |
| Age ≤17 vs ≥18 years | 2.18 | 1.22–3.91 | 0.008 |
| Mandible vs Maxilla | 1.49 | 0.86–2.60 | 0.158 |
| Right vs Left | 1.37 | 0.76–2.48 | 0.289 |
| Month (per additional month) | 0.95 | 0.92–0.99 | 0.028 |
| Non-primer × Male | 1.09 | 0.59–2.02 | 0.781 |
| Non-primer × Age ≤17 | 1.16 | 0.64–2.11 | 0.623 |

**Outcome:** Attachment failure (yes/no); **Cluster variable:** Participant ID; **Reference categories:** Primer, Female, Age ≥18 years, Maxilla, Left side