Predictors of Bracket Bond Failure among Orthodontic Patients undergoing Fixed Orthodontic Treatment in Lagos, Nigeria

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ABSTRACT

Background: Bracket bond failure is a common complication of fixed orthodontic treatment and can prolong treatment duration and increase patient burden. Reported bond failure rates vary widely, and the relative contribution of patient- and treatment-related factors remains inconsistent across studies.

Objective: This audit aimed to identify predictors of bracket bond failure, with particular emphasis on age-related differences and treatment variables, including bracket system and treatment duration.

Methods: A retrospective audit was conducted of 103 patients who completed fixed appliance therapy over a three-year period. Demographic data and treatment characteristics were extracted from clinical records. Bracket failures were defined as debonding events requiring rebonding. Patients were classified into low (<2) and high (≥2) failure groups. Statistical analyses included bivariate tests and multivariable logistic regression to identify independent predictors of failure.

Results: The mean patient age was 24.7 ± 9.9 years, with adolescents comprising 30.1% of the cohort. Overall, 81.6% of patients experienced at least one bond failure, and 75.7% sustained two or more failures. The mean failure rate was 0.2 ± 0.2 per treatment month. Age category was significantly associated with failure, with adolescents experiencing proportionally more failures than adults. Gender, bracket system, and dental anomalies were not significantly associated with failure occurrence or burden. Treatment duration was not associated with overall failure occurrence; however, in multivariable analysis, longer treatment duration was a modest but significant predictor of high failure risk, with each additional month increasing the odds by 7% (OR 1.07, p = 0.028).

Conclusion: Bracket bond failure was frequent in this cohort. Age category and treatment duration were the most relevant predictors, while bracket system and gender showed no independent effects. These findings highlight the importance of patient-related factors and prolonged treatment exposure in managing bond failure risk.

Keywords: Orthodontics, Bond failure, Brackets, Fixed appliances, Orthodontic patients

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INTRODUCTION

Fixed orthodontic appliances are subject to occasional bracket debonding, which can prolong treatment duration and increase patient burden. The reported incidence of bracket failure varies widely; systematic reviews indicate a range of approximately 0.6% to 28.3%. Each debonding event may extend treatment by 0.3 to 0.6 months.[1–3] Given these consequences, identifying risk factors is essential. Previous studies have investigated both patient-related factors (such as age, sex, and compliance) and treatment-related variables (including arch, tooth, bracket type, and overbite).[1,2] For instance, Roelofs et al. reported that posterior brackets fail more frequently than anterior brackets, resulting in an average increase of 0.6 months in overall treatment time per failure.[4]

Orthodontic brackets are designed to apply corrective forces but may debond under stress. Surveys of orthodontists indicate that two to three bracket failures per case are typical, particularly among younger patients and during the initial months of treatment.[5-9] In a retrospective audit, Khan et al.[8] found that 58% of all bracket bond failures occurred in patients younger than 18 years, compared to 42% in adults. Similarly, Barbosa et al.[7] reported that adolescents are significantly more likely than adults to experience bond failure. However, some audits have found no association with age, indicating heterogeneity in findings.[6–8] Patient compliance and oral hygiene consistently correlate with bracket failure; attentive and cooperative patients experience significantly fewer debonding events.[1,7]

Orthodontic brackets are available in various systems. Clinical trials have produced mixed results regarding bracket type: one 12-month trial reported that stainless steel brackets failed more frequently than ceramic brackets (7.2% versus 1.1%).[10] Conversely, another study found that ceramic brackets had a higher hazard ratio (HR ≈ 1.62) compared to metal brackets.[11,12] Ligation style, whether self-ligating or conventional, has not demonstrated consistent effects on failure rates.[13] Bonding protocols also differ, with several studies reporting no significant difference in clinical failure rates between primers and self-etch adhesives.[3,9] Bracket location is a critical factor; multiple studies indicate that failures are more common in posterior teeth and in the mandible. For example, Khan et al.[8] observed that 55% of bond failures occurred on the lower arch, compared to 45% on the upper arch, and 61% in the posterior region, versus 39% in the anterior region.[1,8] Orthodontists also identify the lower posterior region, particularly the first molars, as the sites with the highest risk of failure.[4,5]

The objective of this audit was to evaluate the prevalence of bracket failure/debond and identify significant predictors of bracket bond failure, with particular emphasis on sociodemographic factors (e.g., age, gender) and treatment variables (e.g., bracket system, and treatment duration).

MATERIALS AND METHODS

A cross-sectional, descriptive, retrospective study was conducted on all patients who completed fixed-appliance therapy at a private dental clinic in Lagos, Nigeria, over a 3-year period. (October 2023 to November 2025). Information was obtained from the case files of the study participants. Information obtained included demographic data (age, sex) and treatment variables (malocclusion type, bracket system, treatment duration, among others), which were recorded. Bracket failures, defined as events requiring rebonding, were tabulated by frequency. Statistical analyses included survival association statistics and logistic regression models to assess predictors, consistent with approaches used in previous studies. Failure was categorised into High (>2) and Low (≤2) failure groups. Statistical significance set at $P<0.05$.

RESULTS

A total of 103 patients were included, with a mean age of 24.7 ± 9.9 years, indicating a predominantly young adult population. Approximately one third were adolescents under 18 years (30.1%), while 69.9% were adults. The age distribution among the 18–24, 25–34, and ≥35 year groups was relatively even (27.2%, 25.2%, and 17.5%, respectively), suggesting broad representation across early and mid-adult age ranges. Females comprised 71.8% of the sample and males 28.2%, reflecting a marked female predominance in treatment uptake (Table 1). The mean treatment duration was 30.3 ± 8.6 months, indicating that most cases involved prolonged active

orthodontic therapy. Consistent with this, the majority of patients (79.6%) were treated for more than 24 months, while only 2.9% completed treatment within 12 months and 17.5% within 13–24 months. Patients attended a mean of 23.4 ± 11.0 appointments, reflecting substantial follow-up requirements over the course of treatment. Conventional brackets were used in most cases (75.7%), with self-ligating systems used less frequently (24.3%). Dental anomalies were uncommon, being recorded in only 5.8% of patients, indicating that most treatments were not complicated by developmental dental abnormalities (Table 2). Bracket failures were common in this cohort. Overall, 81.6% of patients experienced at least one bracket debond during treatment, confirming that bond failure was a frequent clinical event. The mean total number of bracket failures per patient was 5.8 ± 5.2, with a mean failure rate of 0.2 ± 0.2 per treatment month, suggesting that failures accumulated gradually over time rather than occurring in rapid succession. Using the predefined cut-off, 75.7% of patients were classified into the high-failure group (≥ 2 failures), while 24.3% were classified as low-failure (< 2 failures), demonstrating that most patients experienced multiple failures rather than isolated events (Table 3). The distribution of failures was right-skewed, with most patients experiencing between 3 and 6 failures and a small number exhibiting very high counts (up to 35 failures), indicating substantial inter-individual variability in failure burden (Figure 1).

When bond failure occurrence was examined in relation to sociodemographic factors, no statistically significant difference was observed in mean age between patients with and without failures (25.5 ± 10.0 versus 21.3 ± 9.0 years, p = 0.214). Similarly, age group was not significantly associated with failure occurrence when analysed across four age bands (p = 0.104). However, age category showed a significant association, with adolescents demonstrating a higher proportion of bond failures compared with adults (p = 0.018). Gender was not significantly associated with bond failure occurrence (p = 0.446), indicating similar failure patterns among males and females (Table 4). Treatment duration category was not significantly associated with the presence of bond failure (p = 0.141), with failures occurring across short, medium, and long treatments. Bracket system type similarly showed no significant association with bond failure occurrence (p = 0.554), and all patients with documented dental anomalies experienced at least one failure, although this association was not statistically significant (p = 0.590) (Table 5).

Table 1. Sociodemographic Characteristics (N=103)

Variable	N = 103[1]
Age (years)	24.7 ± 9.9
Age Group	
<18	31 (30.1%)
18-24	28 (27.2%)
25-34	26 (25.2%)
≥35	18 (17.5%)
Age Category	
Adult	72 (69.9%)
Adolescent	31 (30.1%)
Gender	
Female	74 (71.8%)
Male	29 (28.2%)

[1] Mean ± SD; n (%)

Table 2. Orthodontic Treatment Factors

Variable	N = 103[1]
Treatment Duration (months)	30.3 ± 8.6
Duration Category	
Short (≤12mo)	3.0 (2.9%)
Medium (13-24mo)	18.0 (17.5%)
Long (>24mo)	82.0 (79.6%)
Number of Appointments	23.4 ± 11.0

Bracket System	
Conventional	78.0 (75.7%)
Self ligating	25.0 (24.3%)
Dental Anomaly Present	6.0 (5.8%)

[1] Mean ± SD; n (%)

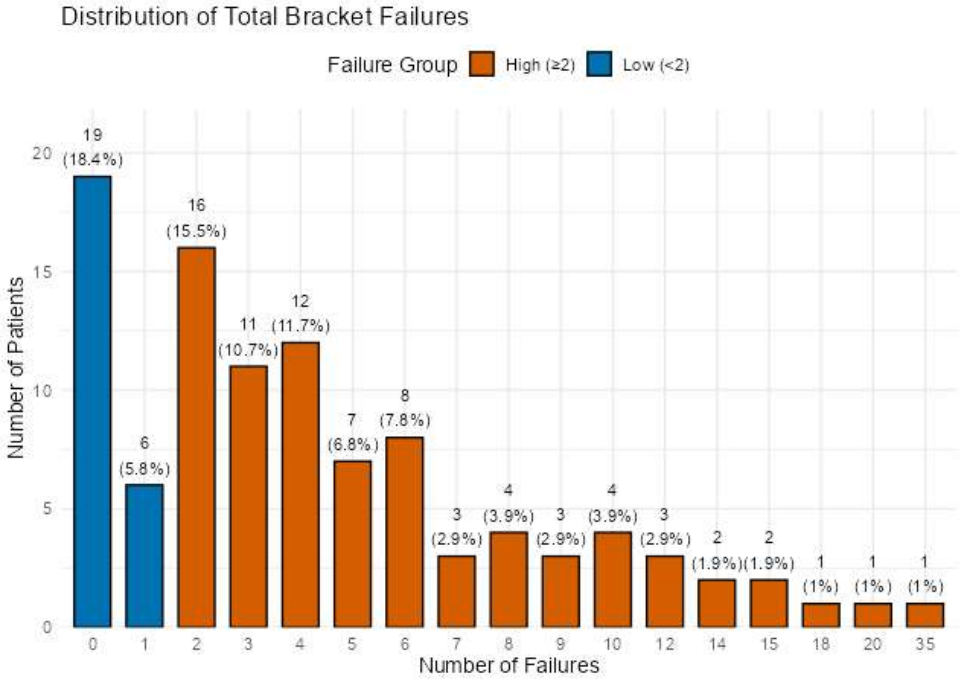

Figure 1: Distribution of Bracket Failure Amounts

Table 3. Clinical Findings and Bracket Failure Summary

Variable	N = 103[1]
Total Bracket Failures	5.8 ± 5.2
Failure Rate (per month)	0.2 ± 0.2
Bond Failure Occurrence	84 (81.6%)
Failure Group Classification	
Low (<2)	25 (24.3%)
High (≥2)	78 (75.7%)

[1] n (%); Mean ± SD

Table 4. Association of Sociodemographic Characteristics with Bond Failure

Variable	Overall N = 103[1]	Yes N = 84[1]	No N = 19[1]	Test Statistic
Age	24.7 ± 9.9	25.5 ± 10.0	21.3 ± 9.0	T -Test, p = 0.214
Age Group				Fisher's Exact, p = 0.104
<18	31 (100.0%)	21 (67.7%)	10 (32.3%)	
18-24	28 (100.0%)	26 (92.9%)	2 (7.1%)	
25-34	26 (100.0%)	22 (84.6%)	4 (15.4%)	
≥35	18 (100.0%)	15 (83.3%)	3 (16.7%)	
Age Category				**χ^2 = 5.62, p = 0.018**
Adult	72 (100.0%)	63 (87.5%)	9 (12.5%)	

Adolescent	31 (100.0%)	21 (67.7%)	10 (32.3%)	
Gender				$\chi^2 = 0.58$, p = 0.446
Female	74 (100.0%)	59 (79.7%)	15 (20.3%)	
Male	29 (100.0%)	25 (86.2%)	4 (13.8%)	

Table 5. Association of Treatment Factors with Bond Failure

Variable	Overall N = 103[1]	Yes N = 84[1]	No N = 19[1]	Test Statistic
Treatment Duration				Fisher's Exact, p = 0.141
Short (≤12mo)	3 (100.0%)	1 (33.3%)	2 (66.7%)	
Medium (13-24mo)	18 (100.0%)	15 (83.3%)	3 (16.7%)	
Long (>24mo)	82 (100.0%)	68 (82.9%)	14 (17.1%)	
Bracket System				Fisher's Exact, = 0.554
Conventional	78 (100.0%)	62 (79.5%)	16 (20.5%)	
Self ligating	25 (100.0%)	22 (88.0%)	3 (12.0%)	
Dental Anomaly	6 (100.0%)	6 (100.0%)	0 (0.0%)	Fisher's Exact, = 0.590

Comparison between low- and high-failure groups revealed no statistically significant differences in age, age category, gender, bracket system, or presence of dental anomalies (all p > 0.9). However, treatment duration differed significantly between groups, with the high-failure group exhibiting a longer mean treatment duration (31.0 ± 8.0 months) compared with the low-failure group (17.0 ± 9.5 months, p = 0.005). The number of appointments was slightly higher in the high-failure group, although this difference was not statistically significant (p = 0.3) (Table 6). These patterns are visually supported by boxplots, which show greater dispersion and higher central values for treatment duration among patients with higher failure counts, while appointment counts largely overlapped between groups (Figure 2). When patients were reclassified using the predefined failure-group threshold (<2 versus ≥2 failures), age category again demonstrated a significant association, with adolescents more frequently represented in the low-failure group compared with adults (p = 0.025). Treatment duration category was also significantly associated with failure-group classification (p = 0.039), with patients undergoing longer treatments more likely to fall into the high-failure group. Continuous treatment duration and number of appointments did not differ significantly between groups (both p > 0.05), indicating that categorical rather than continuous duration measures better discriminated failure burden (Table 7). In multivariable logistic regression examining predictors of any bond failure, none of the included variables reached statistical significance. Age, gender, bracket system, and treatment duration all showed odds ratios close to unity, suggesting limited independent predictive value for failure occurrence (Table 8). In contrast, logistic regression modelling for high failure risk (≥ 2 failures) identified treatment duration as the only statistically significant predictor. Each additional month of treatment was associated with a modest increase in the odds of high failure risk (OR 1.07, 95% CI 1.01–1.14, p = 0.028). Age, gender, bracket system, and number of appointments were not independently associated with high-failure status (Table 9).

Table 6. Comparison by Failure Group

Variable	Overall N = 103[1]	Low N = 5[1]	High N = 98[1]	p-value[2]
Age (years)	24.7 ± 9.9	30.4 ± 11.0	24.4 ± 9.8	0.2
Age Category				>0.9
Adult	72.0 (69.9%)	4.0 (80.0%)	68.0 (69.4%)	
Adolescent	31.0 (30.1%)	1.0 (20.0%)	30.0 (30.6%)	
Gender				>0.9
Female	74.0 (71.8%)	4.0 (80.0%)	70.0 (71.4%)	
Male	29.0 (28.2%)	1.0 (20.0%)	28.0 (28.6%)	
Bracket System				>0.9
Conventional	78.0 (75.7%)	4.0 (80.0%)	74.0 (75.5%)	
Self ligating	25.0 (24.3%)	1.0 (20.0%)	24.0 (24.5%)	
Dental Anomaly	6.0 (6.0%)	0.0 (0.0%)	6.0 (6.3%)	>0.9
Treatment Duration (months)	30.3 ± 8.6	17.0 ± 9.5	31.0 ± 8.0	**0.005**

Number of Appointments	21.9 ± 7.0	20.0 ± 11.0	22.0 ± 6.8	0.3

[1] Mean ± SD; n (%)

[2] **Wilcoxon rank sum test; Fisher's exact test**

Table 7. Comparison of Variables by Failure Group Classification

Variable	Overall N = 103[1]	Low (<2) N = 25[1]	High (≥2) N = 78[1]	Test Statistic, p-value
Age (years)	24.7 ± 9.9	21.3 ± 9.0	25.5 ± 10.0	T-test, p = 0.082
Age Group				Fisher's Exact, p = 0.167
<18	31 (100.0%)	12 (38.7%)	19 (61.3%)	
18-24	28 (100.0%)	4 (14.3%)	24 (85.7%)	
25-34	26 (100.0%)	5 (19.2%)	21 (80.8%)	
≥35	18 (100.0%)	4 (22.2%)	14 (77.8%)	
Age Category				χ^2 = 5.03, p = 0.025
Adult	72 (100.0%)	13 (18.1%)	59 (81.9%)	
Adolescent	31 (100.0%)	12 (38.7%)	19 (61.3%)	
Gender				χ^2 = 0.00, p = 0.984
Female	74 (100.0%)	18 (24.3%)	56 (75.7%)	
Male	29 (100.0%)	7 (24.1%)	22 (75.9%)	
Bracket System				χ^2 = 1.23, p = 0.268
Conventional	78 (100.0%)	21 (26.9%)	57 (73.1%)	
Self ligating	25 (100.0%)	4 (16.0%)	21 (84.0%)	
Dental Anomaly	6 (100.0%)	0 (0.0%)	6 (100.0%)	Fisher's Exact, p = 0.332
Treatment Duration (months)	30.3 ± 8.6	28.1 ± 9.7	30.8 ± 8.3	T-test, p = 0.490
Treatment Duration				Fisher's Exact, p = 0.039
Short (≤12mo)	3 (100.0%)	2 (66.7%)	1 (33.3%)	
Medium (13-24mo)	18 (100.0%)	7 (38.9%)	11 (61.1%)	
Long (>24mo)	82 (100.0%)	16 (19.5%)	66 (80.5%)	
Number of Appointments	23.4 ± 11.0	23.3 ± 16.8	23.4 ± 9.3	T-test, p = 0.087

[1] Mean ± SD; n (%)

Table 8. Logistic Regression for Bond Failure

Characteristic	OR	95% CI	p-value
Age (per year)	1.05	0.99, 1.12	0.105
Gender			
Female	—	—	
Male	1.57	0.49, 6.20	0.475
Bracket System			
Conventional	—	—	
Self-ligating	1.59	0.44, 7.53	0.511
Treatment Duration (months)	1.03	0.97, 1.10	0.297

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

Table 9. Logistic Regression for High Failure Risk (≥2 failures)

Characteristic	OR	95% CI	p-value
Age (per year)	1.04	0.99, 1.10	0.130
Gender			
Female	—	—	
Male	0.98	0.34, 3.01	0.967
Bracket System			
Conventional	—	—	
Self ligating	1.47	0.45, 5.75	0.545

Treatment Duration (months)	1.07	1.01, 1.14	**0.028**
Number of Appointments	0.99	0.94, 1.03	0.552

Abbreviations: CI = Confidence Interval, OR = Odds Ratio

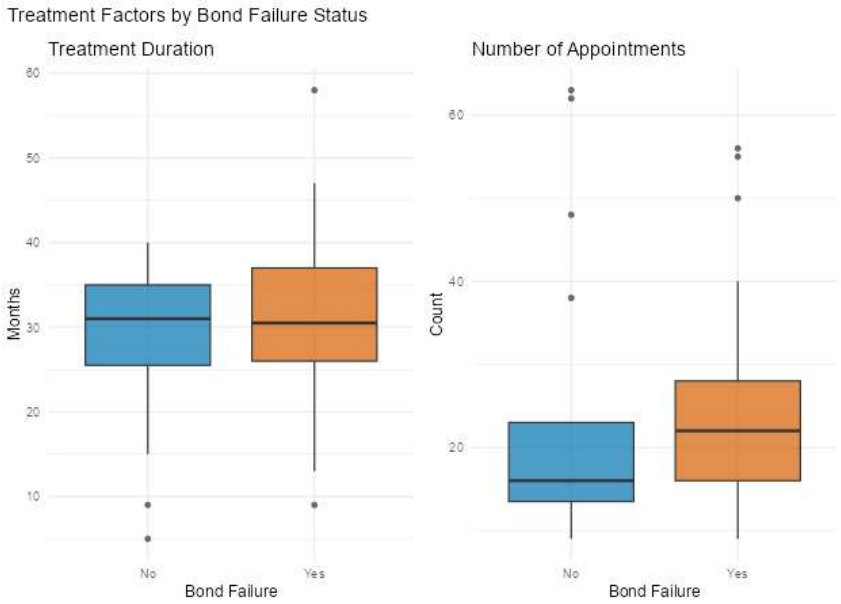

Figure 2: Distribution of Treatment Factors by Failure Group

DISCUSSION

The current study evaluated the prevalence of bracket bond failure among orthodontic patients who completed their fixed orthodontic treatment in Lagos, Nigeria over a 3- year duration. It also evaluated the effect of sociodemographic and clinical factors on bracket bond failure rate. The evaluation of bond failure of attachments in fixed orthodontic therapy has become pertinent because it has been associated with delayed treatment time, prolonged chairside time, and increased patient burden and treatment cost.[1-3]

The overall bond failure rate in this study high with a majority of patients (81.6%) experienced at least one bond failure over the course of their treatment, and approximately three-quarters (75.7%) sustained two or more failures. A study done amongst a similar demographic on the failure rate of buccal tubes revealed much lower bond failure rates at 18%.[9] The findings of this audit are consistent with published patterns: younger age is generally associated with a higher incidence of bracket debonding, while adult cases tend to exhibit fewer failures. Most studies report that adolescent patients have two to three times higher failure rates than adults, likely due to differences in compliance and occlusal factors.[7,8] Gender effects in this study were minimal ($p > 0.9$); although some cohorts have reported slightly higher failure rates in males, many audits have found no significant sex difference.[1,2,6,7,11] Age category showed a significant association with bond failure occurrence and failure-group classification, with adolescents experiencing proportionally more failures than adults. The literature largely concurs that adolescents experience higher debond rates. For example, one clinic series reported that 58% of failures occurred in patients under 18 years, compared to 42% in adults.[8] Similarly, Vasconcelos-Barbosa's audit found a failure rate of 25.4% in younger patients versus 12.3% in older patients.[7] In contrast, some analyses, such as a Kathmandu audit, found no age effect.[6] Generally, patient maturity and compliance covary with age, and low compliance, often observed in teenagers, significantly increases debond risk. Overall, age group and associated compliance are more consistent predictors of failure than gender. Strategies to improve cooperation, such as reminders, have been tested, although one trial found no effect on failure rate.[1,7,8,12]

Hamilton et al.[13] determined that 80.2% of patients treated with active self-ligating brackets experienced bond failures, compared to 53.0% of patients treated with conventional brackets ($p < 0.001$). In contrast, the present audit did not observe a significant association between bracket type and failure rate ($p > 0.9$), which aligns with the majority of trends reported in recent literature.[14–18]

Most studies do not find that a longer planned duration predicts failure. Özaydin et al.[1] (4.4% failure rate) found no association between treatment length and debonding. Stasinopoulos[3] similarly noted each failure extended treatment by 0.3–0.6 months, but did not identify long cases as inherently riskier. Notably, Urala et al.[19] observed that patients who debonded had significantly longer actual treatment (and each extra month modestly increased failure odds by 7%). Similarly, when high failure burden (≥ 2 failures) was examined in our cohort, treatment duration emerged as a statistically significant but modest predictor, with each additional month of treatment increasing the odds of high failure risk by approximately 7% Thus, while prolonged active treatment provides more time for failures, our data align with most reports that treatment plan length is a risk factor.

CONCLUSION

In summary, this audit confirms that bracket bond failure is multifactorial. Key predictors include patient age (with younger patients at higher risk) and bracket location (posterior and lower regions). At the same time, treatment-related factors such as duration demonstrated less consistent effects. The impact of bracket material and design varies across studies. These findings identify areas for targeted interventions to minimize bracket failures.

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