A 3-Year Audit of the Failure Rate of First Molar Buccal Tubes among Orthodontic Patients in a Nigerian Population

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Abstract

Background: This study aimed to assess the bond failure rate of molar buccal tubes during active orthodontic treatments and the effect of age of the patient, gender, dental arches (maxillary and mandibular), and side of the arch on molar buccal tube bond failure. **Methods:** This was a retrospective study that assessed the bond failure of molar buccal tubes. Data were obtained from the case files of orthodontic patients undergoing orthodontic treatment and included subjects' age, gender, presence or absence of molar bond failure, well as the time the failure occurred. Statistical analysis was performed using IBM SPSS software version 23. **Results:** Participants comprised 96 subjects; 59 females (61.5%) and 37 males (38.5%). A total of 384 buccal tubes were bonded with a failure rate of 18%. The highest occurrence of bond failure was observed in the 1st month and the 2nd month after setup. Bond failure was observed in a higher percentage of the male population (43.2%) compared to females (37.3%). The difference in bond failure between gender was statistically insignificant. The prevalence of bond failure was significantly higher in younger patients (≤15 years, 61.7%, $P = 0.0005$). There was no significant effect of gender, time, dental arch, and side of the arch on the prevalence of bond failure. **Conclusion:** Buccal tube bond failure rate in our study was found to be 18%. Bond failure was significantly higher in the younger population compared to the adults. There was no significant effect of gender, time, or side of the arch on buccal tube bond failure.

Keywords: Bond failure, molar tubes, orthodontics

INTRODUCTION

Fixed orthodontic appliances are one of the treatment modalities used in the management of malocclusion. They require the placement of orthodontic attachments on teeth to affect their movement.[1] Bonded molar attachments were initially done by indirect bonding technique,[1] with a bond failure rate of 30%.[2] As bonding of molar attachments was associated with multiple problems and very technique sensitive,[3,4] the use of bands remained the acceptable option for molar teeth. Current literature, however, shows that in recent years, the bonding of attachments to molar teeth during fixed orthodontic treatment has almost doubled.[5] This has been attributed to better (1) understanding of the bonding protocol; (2) improvements in bond systems; and (3) improved design of molar buccal tubes.[5]

In the management of the orthodontic patient with the fixed appliance, precise positioning of the orthodontic attachment (brackets and bands) with minimal bond failure is imperative

as bond failure is associated with increased chairside time, increased treatment time, and costs of orthodontic treatment.[6] Bond failure is adduced to (a) difficulty in maintaining proper isolation of the region during bonding, (b) inadequate adaptation of the attachment base to the tooth surface, (c) masticatory forces, (d) poor etching and bonding process, and (e) variations in enamel composition of the patients.[7-14]

During the bonding process, moisture contamination of the tooth surface with saliva should be prevented. The essential

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armamentarium for achieving a dry field during the bonding procedure includes cotton rolls, dry angles, suction, and cheek retractors. The ideal bond strength of orthodontic attachments should resist masticatory forces during fixed appliance therapy yet weak enough to allow ease of debonding without causing tooth damage.[14] The majority of studies have recommended the use of 37% phosphoric acid and an etch time of 15 s and have demonstrated satisfactory bond strength for orthodontic attachments.[15,16]

Many orthodontists prefer to band teeth, especially molars, and to avoid the need to rebond these attachments in the course of orthodontic treatment. Separator placement, which precedes band placement, has been reported to induce transient bacteremia and poses a risk to patients at risk of infective endocarditis.[17] When the banding procedure is not performed with the utmost care, it can damage periodontal tissues[8] with a higher propensity to accumulate plaque as observed in banded rather than bonded teeth.

Unarguably, direct bonding saves chair time as the separator placement, prior band selection, and fitting are not required. Current literature recommends the bonding of all teeth except when there are severe anchorage needs.[9] Despite reported advantages of direct bonding to molar teeth which include patient comfort, less damage to periodontal tissues, and reduced chairside time, its acceptance in fixed orthodontic treatment remains low.[9]

Studies[10,13,14] have been done on the bond failure rate of brackets and tubes in orthodontic patients; however, most of them focused on the bond failure rate of brackets. A recent researcher however investigated bond failure rates of both orthodontic brackets and molar tubes 10 bandings versus bonding of molars,[8,11,12] but not there is still limited study on the survival rate of molar buccal tubes, especially in different orthodontic populations, hence the need for this study. The essence of this study was to assess the bond failure rate of molar buccal tubes during active orthodontic treatments and the time of bond failure and also determine the effect of the age of the patient, gender, dental arches (maxillary and mandibular), and side of the arch on molar buccal tube bond failure.

METHODS

Ethical approval was obtained from the health research review board before the commencement of the study. Data for the study were obtained from the case files of orthodontic patients undergoing orthodontic treatment at a private orthodontic center in Lagos, Nigeria. Study subjects included patients undergoing fixed orthodontic treatment and who had been in the treatment for longer than 6 months. Inclusion criteria also included subjects who had buccal tube attachments on all four first permanent molars. Data obtained included patients' age at the time of commencement of the treatment, gender, and date of commencement of the orthodontic treatment. Information on the failure of buccal tubes bonded on either the upper left (UL), upper right (UR), lower left (LL), or lower right was

also document as well as the time (duration into treatment) the bond failure occurred. Bond failure was assessed for a period of 6 months from the time of initial setup.

Bonding procedure

All subjects had been bonded by a single operator under similar conditions. The teeth bonded were etched using 37% phosphoric acid for 20 s, rinsed thoroughly, and dried until a frosty white surface was obtained. The teeth surfaces were primed using OrthoSolo universal bond enhancer (Ormco). Light bond adhesive paste (Reliance) was applied onto the bonding surface of the buccal tubes (Pwortho, 3B Ortho) and attached to the buccal surfaces of the first molars. The excess adhesives (splash) beside the buccal tubes were removed, and curing was done using LED curing light (Henry Schein) for 30 s. Moisture control measures were in place at the time of bonding in the form of dry angles (dri-angles dhp.inc the USA) and use of suction and cheek/lip retractor optiview (Ormco) to eliminate moisture contamination. Patients were given postoperative dietary instructions. They were advised to refrain from a very hard/coarse diet such as popcorn, bone, and nuts, as these could lead to attachment failure. They were similarly advised to avoid sugary substances as these increased the chances of developing caries and white spot lesions. Subjects were reviewed every 4 weeks for their orthodontic treatment. Bond failure was said to have occurred when one or more molar buccal tubes were detached from the buccal surface of the tooth in the subject; irrespective of its attachment to the archwire. Bond failure on the first permanent molars only was assessed. Once attachment failure had occurred on a tooth, subsequent bond failures were not recorded.

Eligibility for the study included subjects bonded with fixed orthodontic appliances (brackets and bondable buccal tubes) at least 6 months before the study. Subjects with a band as the means of attachment to the molars were not included in the study.

Statistical analysis was performed using Statistical Package for Social Sciences version 23 (IBM Statistics, Armonk NY, USA). Simple descriptive statistics were used to summarize the data. The findings were presented in frequency tables and cross-tabulations to examine the relationship between variables. Test of association was evaluated using the Chi-square test and Fisher's exact statistics. $P < 0.05$ was considered significant for all statistical analysis.

RESULTS

A total of 96 subjects comprising 59 females (61.5%) and 37 males (38.5%) with an age range of 9–60 years and a mean age of 21.88 ± 12.22 years participated in the study [Table 1].

A total of 384 molar buccal tubes were bonded on all the first permanent molars on all four quadrants of the participants. Buccal tube bond failure occurred in 38 out of the 96 subjects undergoing orthodontic treatment, with a higher bond rate observed in the males. A total of 69 buccal tubes were debonded in the 96 subjects surveyed. Where *n* (384) is the total number of bonded buccal tubes, the failure rate is 18%.

Table 1: Sociodemographic variables of the study population

Variables	Frequency (*n*=96; 100%), *n* (%)
Gender	
Female	59 (61.5)
Male	37 (38.5)
Age (years)	
≤15	47 (49.0)
16-20	14 (14.6)
21-30	12 (12.5)
31-40	14 (14.6)
>40	9 (9.4)

An assessment of the bond failure between gender showed a higher percentage of the male population when compared to the females. Table 2 shows that out of the 37 males who participated in the study, bond failure occurred in 16 (43.2%) of them, whereas 37.3% of the female population had a bond failure. The difference was, however, statistically insignificant. Further evaluation on the prevalence of bond failure, where *n* = 384 showed a slightly higher prevalence of bond failure in females compared to the males. A prevalence of 18% (69 out of the 384 buccal tubes bonded) was observed with no significant statistical difference (*P* = 0.485) [Table 3].

The relationship between age and bond failure rate revealed a significant increase in the failure rate in the younger age group [Tables 2 and 3]. Bond failure was observed to decrease with increasing age.

A higher bond failure rate was observed on the right side compared to the left. The highest rate of buccal tube bond failure was observed in the mandibular right molar, with a total of 22 buccal tubes lost during the observation period (5.7%), followed by the maxillary right molar (4.4%), maxillary left molar (4.2%), and left mandibular molar (3.6%). Comparisons showed no statistically significant difference in the rate of buccal tube bond failure in the four quadrants (UR, UL, lower right, and LL) (*P* = 0.518) [Table 4]. There was also no significant difference in the bond failure between the dental arches, although a slightly higher prevalence was observed in the mandible [Table 4].

Table 5 shows the time the bond failure of the buccal tubes occurred. The highest prevalence of bond failure was observed in the 1st month and 2nd month after setup was done; with the mandibular right molar demonstrating the highest bond failure rate at this time. A decline in the failure rate was observed in most quadrants as treatment progressed, showing an inverse relationship between buccal tube bond failure and treatment time. There was no statistically significant difference in the rate of buccal tube failure with treatment time (*P* = 0.339).

Discussion

Minimal bond failure rates of orthodontic attachments are essential in orthodontic treatment. The pattern and frequency of bond failure vary with age and gender of the patient, the tooth type, and the location of the arch.[18] Studies have reported varied bond failure rates of molar tubes ranging from 6% to 33.8%.[4,6,12,13,19,20]

This study observed a bond failure rate of 18.0% of 384 buccal tubes bonded in the study population. This is higher than some reports from the previous researchers[6,19,20] but comparable with a study conducted among a similar orthodontic population in Southwest Nigeria[13] albeit assessing bond failure of brackets. As a result of the reported increase of bond failure in posterior teeth, many orthodontists use bands on molar teeth, instead of buccal tubes. The results of this study showed comparable bond failure rates in the buccal tubes and brackets with a previous study.[13] In our environment, our diet comprises predominantly hard and coarse foods;[13] thus, dietary changes that exclude hard foods are recommended for the patients for the duration of the treatment.[13] Adherence to this dietary counsel over a long period may be difficult and may be contributory to the relatively high bonding failure reported in this population.[21] The variations in materials and methods observed in the different studies[6,13,19-22] make comparisons difficult.

Buttressing this point may be the wide disparity in the prevalence reports by two similar studies by Jung[19] and Roelofs *et al.*[20] The former study was conducted among South Koreans with a bond failure rate of buccal tubes of 11.6%. Methodology showed the use of Transbond XT and 3M Unitek adhesives and curing done using Plasma arc light.[19] A significantly lower prevalence of 2.6% was reported by Roelofs *et al*. despite using similar adhesives. They, however, premedicated the participants with 0.25% atropine and used OrthoSolo primer. This variation in methodology may be contributory to the lower prevalence observed in this study.

The reported association between bond failure and gender varies among studies. We found no significant effect of gender on bond failure, although there was a slightly higher male incidence of bond failure. This agrees with the findings of a previous researcher[20] but in contrast with others who reported a much higher prevalence in males[13,21] and others in females.[23,24]

The younger patients (≤15) demonstrated a much higher bond buccal tube failure than older patients (*P* = 0.0005). This is similar to other studies that reported a higher bond failure in the younger population.[4,13,19,21] This finding might be attributed to a decreased level of motivation and adherence to dietary and oral hygiene instructions and self-motivation in children while undergoing orthodontic treatment when compared to adults.[14,23] This age maturity may also be contributory to the progressive decline in the buccal tube loss as treatment progressed that was seen in this study. This may influence the preference of the use of bands in the younger orthodontic population but may not be necessary for older patients who may have existing periodontal conditions which may be worsened by band placement.

Table 2: Buccal tube bond failure with age and gender of patients

	Bond failure (*n*=38), *n* (%)	No bond failure (*n*=58), *n* (%)	Total (*n*=96), *n* (%)	*P*
Gender				
Female	22 (37.3)	37 (62.7)	59 (61.5)	χ^2=0.337, *P*=0.561
Male	16 (43.2)	21 (56.8)	37 (38.5)	
Age (years)				
≤15	29 (61.7)	18 (38.3)	47 (49.0)	*P*=0.001*
16-20	2 (14.3)	12 (85.7)	14 (14.6)	
21-30	1 (8.3)	11 (91.7)	12 (12.5)	
31-40	3 (21.4)	11 (78.6)	14 (14.6)	
>40	3 (33.3)	6 (66.7)	9 (9.4	
Total	38 (39.6)	58 (60.4)	96 (100)	

*Fisher's exact

Table 3: Prevalence of bond failure

	Bond failure, *n* (%)	No bond failure, *n* (%)	Total, *n* (%)	χ^2	*P*
Total (prevalence)	69 (18)	315 (82)	384 (100)		
Gender					
Female	38 (55.1)	198 (62.9)	236 (100)	1.448	0.485
Male	31 (44.9)	117 (37.1)	148 (100)		
Total	69 (100)	315 (100)	384 (100)		
Age (years)					
≤15	57 (82.6)	131 (41.6)	188 (49)	39.801	0.0005*
16-20	2 (2.9)	54 (17.1)	56 (14.5)		
21-30	1 (1.4)	47 (14.9)	48 (12.5)		
31-40	5 (7.3)	51 (16.2)	56 (14.6)		
>40	4 (5.8)	32 (10.2)	36 (9.4)		
Total	69 (100)	315 (100)	384 (100)		

*Fisher's exact *P* value

Table 4: Rate of failure in the maxillary and mandibular arches

Bond failure	Right maxillary, *n* (%)	Left maxillary, *n* (%)	Right mandibular, *n* (%)	Left mandibular, *n* (%)
Yes	17 (17.7)	16 (16.7)	22 (22.9)	14 (14.6)
No	79 (82.3)	80 (83.3)	74 (77.1)	82 (85.4)
Total	96 (100.0)	96 (100.0)	96 (100.0)	96 (100.0)

χ^2=1.393, *P*=0.498

Table 5: Time of buccal bondable time bond failure

Time in months	Upper right, *n* (%)	Upper left, *n* (%)	Lower right, *n* (%)	Lower left, *n* (%)	Total, *n* (%)
Time	UR 17 (17.7)	UL 16 (16.7)	LR 22 (22.9)	LL 14 (14.6)	
1	3 (17.6)	3 (18.8)	8 (36.4)	8 (57.1)	22 (31.9)
2	5 (29.4)	6 (37.5)	5 (22.7)	2 (14.3)	18 (26.1)
3	3 (17.6)	4 (25.0)	1 (4.5)	1 (7.1)	9 (13.0)
4	3 (17.6)	2 (12.5)	5 (22.7)	1 (7.1)	11 (15.9)
5	2 (11.8)	-	-	1 (7.1)	3 (4.3)
6	1 (5.9)	1 (6.3)	3 (13.6)	1 (7.1)	6 (8.7)
Total	17 (100)	16 (100)	22 (100)	14 (100)	

χ^2=16.662, Fisher's exact *P*=0.339

We also found a lower bond failure in the maxillary arch compared to the mandibular arch. This is in agreement with a study carried out among patients undergoing orthodontic treatment in Nigeria[13,21] but contrasts with other studies carried out in other parts of the world,[15,18] which reported a greater failure rate in the maxilla. However, some authors, on the other hand, reported no significant difference between bond failure in the maxilla and mandible.[25-27]

The increased failure rate observed in the mandible in this study may be due to failure to achieve a dry field during bonding,[18] as well as masticatory forces.

The report on the bond failure pattern on the side of the jaw is equivocal.[11,13,16,21] In our study, the right side of the jaw demonstrated a higher bond failure compared to the left with the lower right showing the highest bond failure rate of 5.7. Masticatory habits of the patient could be related to bond failure. The side of the jaw that the patient uses more can affect the side where bond failure occurs. Masticatory preference has been found with probable origins in the dominant hemisphere of the brain.[24] Therefore, right-sided individuals (more common) are more likely to chew on the right side of the jaw, with consequent higher bond failure.

Evaluating the time of bond failure, we observed that 58% occurred in the first two months of observation. This agrees with earlier studies reporting high bond failure in the early stages of treatment.[13,19,20] Bond failure occurring at the early period of treatment may be adduced to the initial adaptation to the orthodontic appliance, poor bonding technique, and moisture contamination.[14,16,19,20]

Observation periods vary among different studies and would influence the findings of various researchers. In our study, an observation period of 6 months was chosen because reports reveal that 82% of attachment failures occur during that period.[22,23]

CONCLUSION

Buccal tube bond failure rate in our study was found to be 18%. Bond failure was significantly higher in the younger population compared to the adults. There was no significant effect of gender on the buccal tube bond failure. Buccal tubes placed on the right mandibular molar had the highest failure rate, though not statistically significant.

Based on the findings of this study, we, therefore, recommend frequent use of buccal tubes in orthodontic treatment, especially in adults. The younger patient should be adequately motivated before the treatment commences and educated on the need to adhere to postoperative instructions.

Further research is needed to compare the bond failure of buccal tubes with brackets and bands and to also determine the effect of the buccal tube compared with the band on oral health.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Silverman E, Cohen M. The twenty-minute full strapup. J Clin Orthod 1976;10:764-8.
2. Zachrisson BJ. A posttreatment evaluation of direct bonding in orthodontics. Am J Orthod 1977;71:173-89.
3. Geiger AM, Gorelick J, Gwinnett AJ. Bond failure rates of facial and lingual attachments. J Clin Orthod 1983;17:165-9.
4. Millett DT, Hallgren A, Fornell AC, Robertson M. Bonded molar tubes: A retrospective evaluation of clinical performance. Am J Orthod Dentofacial Orthop 1999;115:667-74.
5. Keim RG, Gottlieb EL, Nelson AH, Vogels DS 3rd. 2008 JCO study of orthodontic diagnosis and treatment procedures, part 1: Results and trends. J Clin Orthod 2008;42:625-40.
6. Linklater RA, Gordon PH. Bond failure patterns *in vivo*. Am J Orthod Dentofacial Orthop 2003;123:534-9.
7. Mandall NA, Hickman J, Macfarlane TV, Mattick RC, Millett DT, Worthington HV. Adhesives for fixed orthodontic brackets. Cochrane Database Syst Rev 2018;4:CD002282.
8. Boyd RL, Baumrind S. Periodontal considerations in the use of bonds or bands on molars in adolescents and adults. Angle Orthod 1992;62:117-26.
9. Trevisi H. Individualized bracket positioning system. Orthodontic treatment with SmartClip self Ligating appliance system; Concepts and biomechanics. Rio de Janeiro: Elsevier; 2007.p. 71-123.
10. Knoll M, Gwinnett AJ, Wolff MS. Shear strength of brackets bonded to anterior and posterior teeth. Am J Orthod 1986;89:476-9.
11. Pandis N, Christensen L, Eliades T. Long-term clinical failure rate of molar tubes bonded with a self-etching primer. Angle Orthod 2005;75:1000-2.
12. Nazir M, Walsh T, Mandall NA, Matthew S, Fox D. Banding versus bonding of first permanent molars: A multi-centre randomized controlled trial. J Orthod 2011;38:81-9.
13. Aikins EA, Ututu C. An audit of bonding failure among orthodontic patients in a tertiary hospital in south South Nigeria. Int J Orthod Rehabil 2017;8:91-5.
14. Sukhia HR, Sukhia RH. Bracket debonding and breakage prevalence in orthontic patients. Pak oral Dent J 2011;31:73-7.
15. Manning N, Chadwick SM, Plunkett D, Macfarlane TV. A randomized clinical trial comparing 'one-step' and 'two-step' orthodontic bonding systems. J Orthod 2006;33:276-83.
16. Murfitt PG, Quick AN, Swain MV, Herbison GP. A randomised clinical trial to investigate bond failure rates using a self-etching primer. Eur J Orthod 2006;28:444-9.
17. Umeh OD, Sanu OO, Utomi IL, Nwaokorie FO. Prevalence and intensity of bacteraemia following orthodontic procedures. Int Orthod 2016;14:80-94.
18. Rasool G, Raza HA, Afzal F, Ijaz W, Shah SS. Frequency of bracket breakage and bond failure in patients, undergoing fixed orthodontic treatment at Khyber College of Dentistry, Peshawar. Pak Oral Dent J 2013;33:299-302.
19. Jung MH. Survival analysis of brackets and tubes: A twelve-month assessment. Angle Orthod 2014;84:1034-40.
20. Roelofs T, Merkens N, Roelofs J, Bronkhorst E, Breuning H. A retrospective survey of the causes of bracket- and tube-bonding failures. Angle Orthod 2017;87:111-7.
21. Moninuola AE, Costa OO, Isiekwe MC. A review of orthodontic bond failure using a chemical cure adhesive. Odontostomatol Trop 2010;33:35-40.
22. Wienke A, Ripatti S, Palmgren J, Yashin A. A bivariate survival model with compound Poisson frailty. Stat Med 2010;29:275-83.
23. Therneau TM, Grambsch P, Pankratz VS. Penalized survival models and frailty. J Comput Graph Stat 2003;12:156-75.
24. Khamnei S, Sadat-Ebrahimi SR, Salarilak S, Savadi Oskoee S, Houshyar Y, Shakouri SK, *et al*. Manifestation of hemispheric laterality in chewing side preference and handedness. Bioimpacts 2019;9:189-93.
25. Pandis N, Polychronopoulou A, Eliades T. Failure rate of self-ligating and edgewise brackets bonded with conventional acid etching and a self-etching primer: A prospective *in vivo* study. Angle Orthod 2006;76:119-22.
26. Ozer M, Bayram M, Dincyurek C, Tokalak F. Clinical bond failure rates of adhesive precoated self-ligating brackets using a self-etching primer. Angle Orthod 2014;84:155-60.
27. Romano FL, Valério RA, Gomes-Silva JM, Ferreira JT, Faria G, Borsatto MC. Clinical evaluation of the failure rate of metallic brackets bonded with orthodontic composites. Braz Dent J 2012;23:399-402.