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Yassir, Yassir A.; McIntyre, Grant; El-Angbawi, Ahmed; Bearn, David

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Original Article

Does anchorage loss differ with 0.018-inch and 0.022-inch slot bracket systems?

Yassir A. Yassir[a]; Grant T. McIntyre[b]; Ahmed M. El-Angbawi[c]; David R. Bearn[d]

ABSTRACT

Objectives: To compare maxillary first molar anchorage loss between 0.018-inch and 0.022-inch slot fixed appliance systems.

Materials and Methods: Patients requiring bilateral maxillary premolar extractions (n = 74) within a randomized clinical trial comparing the effectiveness of 0.018-inch and 0.022-inch slot MBT bracket systems (3M-Unitek, Monrovia, Calif) were included. Three-dimensional pre- and posttreatment digital models were landmarked and measured (R700 scanner and OrthoAnalyzer software, 3Shape, Copenhagen, Denmark). Anteroposterior position of the first molars was measured using the third medial rugae point as a reference. Anchorage loss (AL) represented the subtraction of the posttreatment distance from the pretreatment distance for both anchorage loss right (ALR) and left (ALL) sides. The values were then compared using a two-way analysis of variance.

Results: There were 41 and 33 cases for the 0.018-inch and 0.022-inch bracket slot systems, respectively. The baseline characteristics were similar between groups, except for the presence or absence of anchorage devices ($P = .050$). For the total sample: 0.018-inch ALR = 3.86 mm, ALL = 3.30 mm and 0.022-inch ALR = 3.73 mm, ALL = 3.47 mm ($P = .970$). There was also no significant difference between the 0.018-inch and 0.022-inch groups when subjects with anchorage devices were excluded ($P = .383$).

Conclusions: Bracket slot size does not influence maxillary molar anchorage loss during orthodontic treatment. (*Angle Orthod.* 2019;89:605–610.)

KEY WORDS: Fixed appliances; Slot size; Anchorage loss

INTRODUCTION

Anchorage is defined as the resistance to unwanted orthodontic tooth movement.[1] It is one of the most important aspects in producing esthetic, functional, and stable occlusal results. Therefore, anchorage control and selecting appropriate mechanics should be determined at the treatment planning stage. Several intra- and extraoral adjuncts enhance anchorage control including the transpalatal, Nance, and lingual arches; headgear; or temporary anchorage devices (TADs).[1] Anchorage loss is an unfortunate consequence of leveling and aligning, overjet reduction or space closure and is usually greater in the maxillary than mandibular arch.[2] This complicates treatment, and when anchorage preparation is not adequately planned, molar distalization may be required during treatment.

Certain initial patient characteristics and treatment-related factors have been reported to influence loss of anchorage. These include growth, age, sex, malocclusion type, pretreatment upper molar angulation, crowding, and overjet. Treatment-related factors, such as extractions versus non-extraction, site of extraction, high frictional resistance appliances, type of tooth movement (bodily movement or torque), the use of intraoral or extra-oral anchorage devices and the use of heavy and uncontrolled forces can also play a role in increasing anchorage loss.[2,3]

[a] Assistant Professor, Orthodontic Department, College of Dentistry, University of Baghdad, Baghdad, Iraq; and School of Dentistry, University of Dundee, Dundee, United Kingdom.

[b] Honorary Professor, Orthodontics. School of Dentistry, University of Dundee, Dundee, United Kingdom.

[c] Honorary Lecturer, Orthodontics. School of Dentistry, University of Dundee, Dundee, United Kingdom.

[d] Professor, Orthodontics. School of Dentistry, University of Dundee, Dundee, United Kingdom.

Corresponding author: Dr Yassir A. Yassir, Orthodontic Department, College of Dentistry, University of Baghdad, Baghdad, Iraq
(e-mail: yassirkyassir@gmail.com)

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Anchorage loss has been investigated with different orthodontic fixed appliance systems. In their retrospective study, Geron et al.[3] found that anchorage loss was significantly greater with labial edgewise appliances compared with lingual edgewise appliances. Although various studies have concluded that no significant differences exist between conventional and self-ligating bracket systems for anchorage loss,[4–9] Rajesh et al.[10] found that anchorage loss was significantly greater with Roth than MBT appliances. No study to date has investigated the difference in anchorage loss between 0.018-inch and 0.022-inch bracket slot systems, which may vary due to the differences in play (friction between the bracket slot and archwire) and critical contact angle (angle of contact between archwire and bracket slot wall). Therefore, this study aimed to determine if slot size had an effect on anchorage loss of the maxillary first molar. The null hypothesis was that there is no statistically significant difference between the 0.018-inch and 0.022-inch slot bracket systems in terms of maxillary first molar anchorage loss on completion of orthodontic treatment.

MATERIALS AND METHODS

This study included all 74 orthodontic patients with bilateral maxillary premolar extractions from the cohort of a published randomized clinical trial that compared the effectiveness of treatment with the 0.018-inch and 0.022-inch slot MBT bracket systems (3M-Unitek, Monrovia, Calif).[11–13] The cases were collected from the Orthodontic Clinics at the trial centre (Dundee Dental Hospital and School and Perth Royal Infirmary) and represented either moderate or severe crowding or an increased overjet. In total, there were 41 patients treated with the 0.018-inch slot and 33 patients treated with 0.022-inch slot MBT brackets. Participants were excluded if they had unilateral extractions or extraction of teeth other than premolars (eg, first molars), hypodontia, or defects such as bubbles or broken teeth on the study models. The study was undertaken in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). Ethical approval was obtained from the East of Scotland NHS Ethics Service (REC Reference: 09/S1401/56) with research and development approval obtained from NHS Tayside.

The treatment protocols were standardized for both appliance groups so that the only differences were bracket slot size and the relevant archwires. The following archwire sequences were specified throughout the trial. For the 0.018-inch slot bracket group: 0.016-inch superelastic nickel-titanium, 0.016×0.022-inch superelastic nickel-titanium, and 0.016×0.022-inch stainless steel archwires and for the 0.022-inch slot bracket group: 0.016-inch superelastic nickel-titanium, 0.019×0.025-inch superelastic nickel-titanium, and 0.019×0.025-inch stainless steel archwires. Extractions were carried out immediately before appliance placement.

Three-dimensional (3D) digital dental models were obtained pre- and posttreatment (R700, 3Shape, Copenhagen, Denmark) and OrthoAnalyzer software 1.0 (3Shape, Copenhagen, Denmark) was used to identify the landmarks and calculate the measurements. The anteroposterior molar positional change was evaluated according to the method described by Ziegler and Ingervall[14] and used by other studies.[3,10,15] The following landmarks were identified:

1. Anterior Raphe Point: the most detectable anterior point of the midpalatal raphe.
2. Posterior Raphe Point: the most detectable posterior point of the midpalatal raphe.
3. Right Rugae Point: the most medial point of the right third rugae.
4. Left Rugae Point: the most medial point of the left third rugae.
5. Right Molar Mesial Point: the mesial contact point of the right first permanent molar.
6. Left Molar Mesial Point: the mesial contact point of the left first permanent molar.

In order to calculate the linear measurement of molar positional change, a horizontal plane using the occlusal plane of the maxillary first molars was created. The midpalatal raphe was identified as a median reference line, from the anterior to posterior raphe points. To determine the anteroposterior position of the first molars, a perpendicular line was projected from the mesial contact point of the first molar to the median reference line bilaterally. The distance from this line to the third medial rugae point was measured in millimeters (Figure 1). Anchorage loss (AL) represented the value of subtracting posttreatment distance from the pretreatment distance for both the anchorage loss right (ALR) and left (ALL) sides. These values were then compared between the 0.018-inch and 0.022-inch groups. The investigator (Y.A.Y.) was blinded to allocation group and was trained and calibrated in using the OrthoAnalyzer software by both the manufacturer and an orthodontic technician experienced in the use of digital models. A random sample of 25 models was remeasured 4 weeks later by the investigator to calculate intraexaminer reliability, and these were also measured by an orthodontic technician for the calculation of interexaminer reliability.

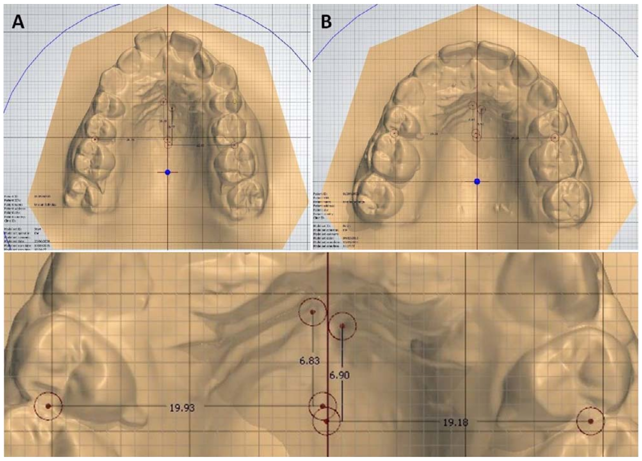

Figure 1. Anteroposterior first permanent molar distance to the medial end of the third palatal rugae. (A) Pretreatment. (B) Posttreatment.

Statistical Analysis

The data were inspected and analyzed using the Statistical Package for Social Sciences for Windows, version 22.0 (SPSS Inc, Chicago, Ill). The following statistical analyses were used:

- Descriptive statistics, including number, mean, and standard deviation.
- Reliability: the intraclass correlation coefficient (ICC) was used to test interexaminer and intraexaminer reliability of the AL measurements for 25 patients.
- Inferential statistics: a two-way analysis of variance (ANOVA) compared the two appliance groups ($P <$ .05).

RESULTS

The ICC values of 0.98 for interexaminer reliability and 0.97 for intraexaminer reliability indicated high levels of agreement and near-perfect reproducibility of the measurements.

The descriptive statistics for right and left anchorage loss (mm) in each group and for the total sample are presented in Table 1 and Figure 2.

Table 1. Descriptive Statistics for Anchorage Loss (mm)

Side	Group	N	Minimum	Maximum	Mean	Standard Deviation
Left side	0.018-inch	41	0.02	7.85	3.30	2.03
	0.022-inch	33	−1.75	6.66	3.47	1.69
	Total	74	−1.75	7.85	3.38	1.87
Right side	0.018-inch	41	−0.34	8.60	3.86	2.15
	0.022-inch	33	0.64	10.01	3.73	1.87
	Total	74	−0.34	10.01	3.80	2.02

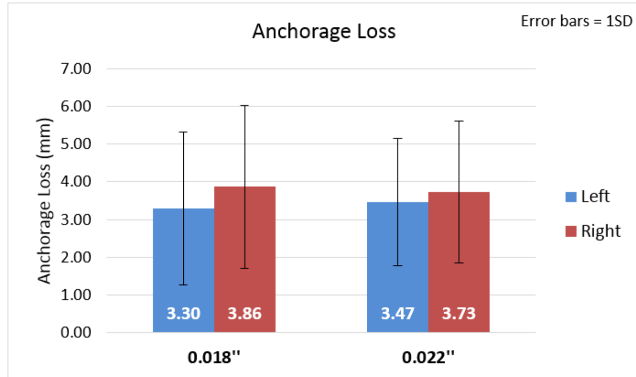

Figure 2. Mean anchorage loss (mm) for each group.

Comparison Between 0.018-inch and 0.022-inch Groups

No statistically significant difference was found between the two appliance groups where F (1, 72) = 0.001 and $P = .970$ (Table 2). Similarly, there was no statistically significant difference for the interaction between group and side, nor for the effect of left-right sides ($P > .05$).

Normality was not an issue due to the large sample size allowing the central limit theorem to be invoked.[16] Homogeneity was tested using Levene's test, and no problems were observed. The data were also inspected for outliers, and the two cases with studentized residuals exceeding three standard deviations were not considered problematic. The data were inspected for overly influential cases using Cook's value and none were found to exceed the threshold of 1.

In order to ensure that there were no significant differences between the groups, the baseline variables (age, sex, type of malocclusion, and presence or absence of anchorage device) were compared between the groups using an independent samples *t*-test for continuous variables and χ^2 with Fisher's exact tests for categorical variables. There was only a significant difference in the presence or absence of anchorage devices ($P = .050$). Therefore, a new set of data excluding cases with anchorage devices was created (Table 2). This included 23 participants in the

Table 2. Two-way Analysis of Variance Test for Anchorage Loss Between Groups

Category	Source	Degrees of Freedom	F	P
All selected cases (N = 74)	Side	1	3.382	.070
	Side* Group	1	0.459	.500
	Group	1	0.001	.970
Cases without anchorage devices (N = 49)	Side	1	3.268	.077
	Side* Group	1	0.119	.732
	Group	1	0.777	.383

* Significance level <.05

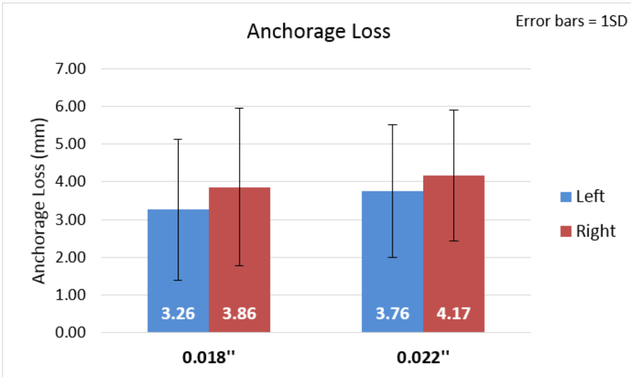

Figure 3. Mean anchorage loss (mm) for each group (patients without anchorage devices).

0.018-inch group and 26 participants in the 0.022-inch group (Figure 3). The mean anchorage loss value for the 0.022-inch group was nonsignificantly higher than the 0.018-inch group in this subset: $F(1, 47) = 0.777$, $P = .383$.

DISCUSSION

As there was no significant difference between the groups for anchorage loss, the null hypothesis was supported. Although anchorage loss between different bracket prescriptions[10] and between conventional and self-ligating brackets[4–8] has been investigated, this is the first study to investigate the effect of bracket slot size on anchorage loss.

The sample included therapeutic extraction of bilateral maxillary first or second premolars for the relief of moderate or severe anterior crowding or to correct an increased overjet. Almost all the studies that have evaluated anchorage loss have used samples with bilateral premolar extractions to assess the mesial displacement of the first molars. Unlike other studies using bilateral first premolar extractions,[4–8,10,14,15,17,18] both bilateral first or bilateral second premolar extraction cases were selected in this study to increase the generalizability of the results. This was not expected to introduce confounding as there would be a nonsignificant difference in the amount of anchorage loss between participants with first or second premolar extractions (assessed from cephalometric radiographs or dental models) as reported by Geron et al.[3] Moreover, Xu et al.[19] and Sandler[20] adopted different extraction patterns in their studies.

The medial ends of the third palatal rugae were selected as reference points as they have been used by previous studies for measuring tooth movement and maxillary first molar anchorage loss.[3,10,14,15] Although the medial ends are least affected by extractions and subsequent tooth movement,[21–31] the stability of the medial rugal points has been questioned by Simmons et al.[32] whilst Deepak et al.[31] noted that palatal expansion followed by extractions has the greatest impact on their stability. Nonetheless, excellent intra- and interexaminer reliability was found, and the medial rugal landmarks are less likely to be affected by orthodontic changes than those on the lateral aspects.

Different techniques have been used for measuring anchorage loss;[3,5,7,8,10,14,15,17,18,20,33] however, the use of 3D digital models overcame the drawbacks with other techniques, such as ionizing radiation, difficulty in visualizing landmarks, and magnification and superimposition errors. Moreover, the current technique was cheaper and less time consuming than the superimposition of 3D scanned models as geometric superimposition software was not required. Anchorage loss was measured separately for the right and left sides and was in agreement with Sandler,[20] who suggested separate measurements of the right and left molars for the assessment of the precise biomechanical effect of appliances on the position of the molar teeth rather than averaging both sides, which results in regression to the mean.

Mean anchorage loss in both appliance groups ranged from 3.30 mm to 3.86 mm and, after excluding cases with anchorage devices, it ranged from 3.26 mm to 4.17 mm for the 0.018-inch and 0.022-inch slot bracket systems, respectively. This was slightly less than that found by Alhadlaq et al.[34] when using a transpalatal arch with continuous arch mechanics (4.5 mm measured cephalometrically). However, anchorage loss was greater than reported by Lee and Kim[35] for both their TADs and conventional anchorage reinforcement (headgear) groups, which could explain the reduced anchorage loss in that study. Similarly, Thiruvenkatachari et al.[17] found no anchorage loss with, and a mean of 1.6 mm anchorage loss without, TADs in the maxillary arch. Treatment with conventional bracket systems has shown mean anchorage loss ranging from 0.59 to 5.33 mm as reported in studies comparing conventional and self-ligating brackets.[4–8] All the aforementioned studies used different methods for measuring anchorage loss which could explain the heterogeneity in results. Rajesh et al.[10] used the same method in this study to compare Roth and MBT brackets. For the MBT appliance, they found the amount of anchorage losses for the right and left sides were 1.8 and 2.10 mm, respectively. This was approximately half the values in the present study and could be because anchorage loss was measured only for the leveling and alignment stage. In this study, anchorage loss was measured at the completion of treatment, including anchorage loss during leveling and aligning, overjet reduction and space closure. Therefore, it is likely that 50% of anchorage loss occurs during leveling and alignment and the remainder during the later stages of treatment. The results of this study are therefore more generalizable than limiting the assessment to any particular treatment stage, which would have required additional study models.

Comparison of Anchorage Loss

The 0.022-inch slot brackets showed 0.17 mm greater anchorage loss for the left side, while the 0.018-inch slot brackets showed 0.13 mm greater anchorage loss for the right side. These amounts were neither statistically significantly different nor of clinical importance. Excluding the influence of anchorage devices revealed that the 0.022-inch slot group experienced greater anchorage loss for the left and right sides (0.5 mm and 0.31 mm, respectively) but again this did not reach statistical significance. This trend may have been due to the effect of greater play and increased critical contact angle between the archwire and bracket during the working stages of treatment of 9.5° and 1.25°, respectively with 0.022-inch slot brackets (0.019 × 0.025-inch stainless steel archwire) compared with 7.8° and 0.83°, respectively for the 0.018-inch slot brackets (0.016 × 0.022-inch stainless steel archwire).[36,37] This was not statistically significant potentially because the study was powered to assess a difference in treatment time and not anchorage loss.

In both the 0.018-inch and 0.022-inch groups, there was a variation in AL between the right and left sides (albeit nonsignificant), in agreement with Rajesh et al.[10] and Sandler.[20] This may have been due to occlusal variation, which might retard the movement of one side compared with the other.

The aforementioned findings mean that the contribution of bracket slot size to anchorage loss is weak. Anchorage loss is likely to be influenced by other factors. This may include bracket prescription, as Rajesh et al.[10] found greater anchorage loss with Roth brackets (right: 2.9 mm, left: 3.10 mm) compared with MBT brackets (right: 1.80 mm, left: 2.10 mm). This was attributed to the increased tip in the anterior segment for the Roth prescription compared with the MBT prescription. Furthermore, anchorage loss does not differ between conventional and self-ligating brackets,[4–8] which was confirmed by a systematic review and meta-analysis.[9] It can, therefore, be concluded from the aforementioned that the influence of bracket tip may be greater than the differences due to slot size or ligation method.

Limitations of the Study

The severity of crowding was not stratified, but as cases were randomly allocated, any bias would have been equalized between groups. Similarly, any confounding resulting from the requirement to close residual space in the finishing stages of treatment would also be equally split between groups. Although the technique used in this study for measuring anchorage loss was novel, it was a two-dimensional measurement of 3D subjects. which may have introduced a small amount of error. None of these would have influenced the results.

CONCLUSION

- Bracket slot size has no significant influence on the maxillary molar anchorage loss during orthodontic treatment.

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