

Original Article

An evaluation of the accuracy of bracket positioning with and without loupes using 3Shape Ortho Analyzer software

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المخلص

أهداف البحث: تعد دقة وضع السناد مهمة جدا للحصول على علاج تقويم أسنان ناجح. يساعد السناد الموضوع بدقة في تعزيز نتائج العلاج. كان الهدف من هذه الدراسة هو تقييم دقة وضع السناد مع وبدون العدسات المكبرة للأسنان ومقارنتها مع وضع السناد الذي تم تحقيقه باستخدام محلل تقويمي ثلاثي الأشكال.

طرق البحث: تم إجراء تجربة منضبطة معشاة، بطريقة الفم المشطور، في قسم تقويم الأسنان، كلية طب أسنان سافيثا. تم الحصول على نماذج ممسوحة ضوئيا ثلاثية الأبعاد للسناد العلوية للمشاركين باستخدام برنامج "محلل التقويم" ذو 3 أشكال باستخدام إعدادات افتراضية. تم تخصيص الأرباع اليمنى واليسرى من القوس الحنكية لدى الأشخاص العشرة عشوانيا للربط اليدوي باستخدام العدسات المكبرة أو بدون العدسات المكبرة. تم بعد ذلك مسح القوس الحنكي المربوط يدويا بمزيد من المسح الضوئي والحصول على نماذج ثلاثية الأبعاد، ثم مقارنتها بوضع السناد الذي تم بمساعدة برنامج "محلل التقويم". في الربيعين، تمت مقارنة الانحرافات في وضع كل سناد مربوط في المناطق المختلفة في الأسنان، ثم تمت مقارنتها مع الإعداد الافتراضي. أخيرا، تم قياس أخطاء وضع السناد.

النتائج: تم إجراء اختبار تي مستقل لعينة لمقارنة متوسط الأخطاء المعيارية لتحديد موضع القوس مع العدسات المكبرة وبدون العدسات المكبرة، والتي لم تظهر أي فرق ذي دلالة إحصائية.

الاستنتاجات: لا يوجد فرق كبير في وضع الأقواس باستخدام العدسة المكبرة وبدون العدسات المكبرة. أظهرت نتائج هذه الدراسة الحالية أن وضع القوس يمكن أن يتم باستخدام العدسات المكبرة أو بدون العدسات المكبرة.

الكلمات المفتاحية: 3Shape Ortho محلل؛ النماذج الممسوحة ضوئيا ثلاثي الأبعاد؛ دقة؛ قوس تحديد المواقع؛ العدسات المكبرة للأسنان؛ إعداد الظاهري

Abstract

Objective: The accuracy of bracket positioning is very important for successful orthodontic treatment. Precisely placed brackets aid in the enhancement of treatment outcomes. The aim of the present study was to evaluate the accuracy of bracket positioning with and without dental loupes and compare this method with bracket positioning achieved using the 3Shape Ortho Analyzer.

Methods: A single blinded, split-mouth, randomized and controlled trial was conducted in the Department of Orthodontics. Three-dimensional (3D) scanned models of the maxillary arches of the subjects were obtained using 3Shape Ortho Analyzer software and virtual setups were prepared. Right and left quadrants of the maxillary arch of the 10 subjects were randomly allocated for manual bonding with loupes or without loupes. The manually bonded maxillary arch was then scanned and 3D models were obtained; these were then compared with bracket positioning achieved with the 3Shape Ortho Analyzer. In the two quadrants, deviations in the position of each bonded bracket was compared in the mesio-gingival, disto-gingival, mesio-occlusal, disto-occlusal, distal and mesial areas and then further compared with the virtual set up. Finally, bracket positioning errors were measured.

Results: An independent sample t-test was performed to compare both the area-wise and teeth-wise mean error

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in bracket positioning with loupes and without loupes which showed no statistically significant difference.

Conclusion: There was no significant difference in bracket positioning with or without loupes. The results of this current study showed that bracket positioning can be performed with loupes or without loupes.

Keywords: 3Shape Ortho Analyzer; 3D scanned models; Accuracy; Bracket positioning; Dental loupes; Virtual set up

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Introduction

Effective and efficient orthodontic treatment using the pre-adjusted edgewise system is mainly based on the fact that ideal bracket placement will correct the positions of teeth in all three spatial planes.¹ The standard straight-wire appliance is designed to move teeth to their ideal location in the arch form. This can be attained by using pre-programmed brackets that have ideal tip, torque, angulation and in-out position built into each individual bracket. Accurate bracket positioning helps to avoid bracket repositioning and wire bending for a good finish, saves chair time and reduces the overall duration of treatment.^{2,3} Accurate bracket positioning makes the finishing stage easier and leads to an ideal occlusion with minimal intervention.⁴ The position of the brackets varies among different treatment philosophies. Andrews suggested the placement of brackets along the midpoint of the facial axis of the clinical crown (FACC).⁵ Later, Ricketts, and Kalange recommended that the marginal ridges can be used as a guide for the vertical positioning of brackets and bands.^{6,7} McLaughlin and Bennett used a table to decide the vertical height of each bracket based on the vertical height of the clinical crowns.⁸

Accurate bracket positioning can be achieved by various methods. Dougherty gauges are used to measure and determine the bracket distance from the incisor or occlusal edge of the teeth and to position the brackets according to the bracket positioning chart.^{4,9} Indirect bonding is another technique that can increase the accuracy of bracket positioning as all the brackets are placed in the ideal position on models and then transferred to the patient.^{10,11} These are less time consuming and more accurate but require elaborate laboratory work.^{11,12} The emergence of digital technology in indirect bonding techniques has made the fabrication of the transfer tray efficient and accurate.^{13–15}

Various studies have been conducted to evaluate the ideal bracket positioning and found that even if the brackets were ideally placed, vertical errors can occur, thus requiring improvisation in bracket positioning techniques.^{16,17} Dental loupes are one such enhancement; these can enhance visual acuity, treatment quality and also improve comfort and working posture. Loupes have become an accepted technique for qualified practitioners

and the undergraduate population.¹⁸ Many specialists in restorative and endodontic dentistry as well as tooth preparations for fixed prostheses are accustomed to use high-powered loupes and microscopes.¹⁹ The majority of those using loupes use a magnification of 2.5; this provides a field view covering 80% of the oral cavity at a working distance of 13 inches.²⁰ Farook et al. reported that discomfort, cost, wearing prescription lenses and inadequate training were the most important factors leading to the non-purchase of loupes among practitioners.²¹ Thomas et al. explored the opinions of practicing dental hygienists on loupes and found that the most highly reported perceived advantage of loupes was ergonomics.²² Back and neck pain is a common complaint among dental professionals.²³ In the survey conducted by Farook et al. this level of discomfort was reduced.²¹

Using loupes in orthodontic practice can help to accomplish more accurate bracket positioning. However, there is a paucity of literature relating to the application of dental loupes in orthodontic practice. Hence, the aim of this study was to evaluate the accuracy of bracket positioning with and without loupes and comparing this with bracket placement achieved by Ortho Analyzer software. We also investigated how loupes are beneficial in training orthodontic postgraduates in achieving accurate bracket positioning.

Materials and Methods

Study design

This split-mouth, randomized and controlled trial was conducted in our Department of Orthodontics on ten patients who were seeking fixed orthodontic treatment for correction of their malocclusion. Sample size calculation was determined by G*Power 3.1 (Franz Faul, University of Kiel, Germany) and was selected based on the mean scores obtained from Xue et al. (2019).¹ These authors measured the mean errors caused by bracket positioning with a guided bonding device when compared with a virtual setup obtained using the 3Shape Ortho Analyzer. The mean and standard deviations of the mesio-distal, buccolingual and vertical errors of the incisor (0.013 ± 0.079 , 0.123 ± 0.064 , 0.088 ± 0.041) were used for sample size calculation with an alpha error of 0.05, power of 0.95, and an allocation ratio of 1. Subjects who had a full complement of permanent dentition with no labial or proximal decay or restorations with only minimal crowding (Little's index < 3 mm) which did not obstruct the full visibility of the labial surface were included in this study. Patients who required any extractions and any alterations to the labial tooth morphology, including teeth with developmental defects and fractures, were excluded from the study.

Virtual bracket placement

Intraoral scanning of the maxillary arches of the patients who fulfilled the inclusion criteria was performed using an

i500 (Medit Corp., Seoul, Korea) intraoral scanner to obtain 3D models. The files were then imported to the Ortho Analyzer (3Shape, Copenhagen, Denmark) planning software for virtual bracket placement. The long axis of all teeth were set using the software. The height of the clinical crowns was measured and the bracket positioning chart was used to determine the height of bracket placement for each tooth.⁸ Gemini metal brackets (3M Unitek, China) with MBT prescription and a 0.022 inch slot were selected from the software's bracket library using the bracket placement tool. The virtual brackets were placed along the long axis of the clinical crowns at a predetermined height based on the bracket positioning chart from second premolar to second premolar in the maxillary arch. Virtual bracket placement was performed for all subjects before bonding by the same operator who performed bonding on the patients. The virtual bracket placement for all subjects was supervised and final positions were verified by an experienced orthodontist. This virtual bracket placement served as reference positions for comparing the position of the brackets that were placed on the patients later.

In vivo bracket placement

The study was only performed on the maxillary arch as accurate bracket positioning is more critical for upper anterior aesthetics.^{24,25} Right and left quadrants of the maxillary arches of the patients were randomly allocated for bonding into group A or group B protocols using a computer-generated randomization chart. The odd numbers were allocated into group A and even numbers were allocated into group B. In group A, the brackets were directly bonded with the operator viewing through the loupes on the right side and without using loupes on the left side of the maxillary arch, and vice versa in Group B. The bracket bonding was performed by the same operator in all

ten subjects to avoid inter-operator errors; this operator had 3 months of experience using the dental loupes. The sequence of direct bonding of the brackets was from the upper right quadrant to the upper left quadrant in all subjects. The most common loupe magnification power for routine dental procedures is between 2.0 and 3.5, irrespective of the lens system employed.²⁶ Therefore, in this study, the Gemini metal brackets were placed while viewing through the loupes (Magni Vision) with a magnification of 2.5 \times for one quadrant; the opposite quadrant was bonded with naked eye without using loupes. The brackets in both quadrants were placed along the long axis of the clinical crown at a height predetermined by the bracket positioning chart customized for each patient during the virtual placement of brackets. Bracket positioning gauges were used for placing the brackets at the predetermined height. Once brackets were placed and light curing was complete, the maxillary arch was scanned intraorally using the i500 scanner.

Measurements

The following measurements were taken for all teeth bonded in the maxillary arch for both the virtual bracket placement model and the post bracket placement scanned models (Figure 1).

1. Vertical distance from the mesio-gingival wing of bracket to the gingival margin.
2. Vertical distance from the disto-gingival wing of bracket to the gingival margin.
3. Vertical distance from the mesio-occlusal wing of bracket to the incisal edge.
4. Vertical distance from the disto-occlusal wing of bracket to the incisal edge.
5. Horizontal distance from the distal border of the bracket base along the slot to the distal edge of the tooth.

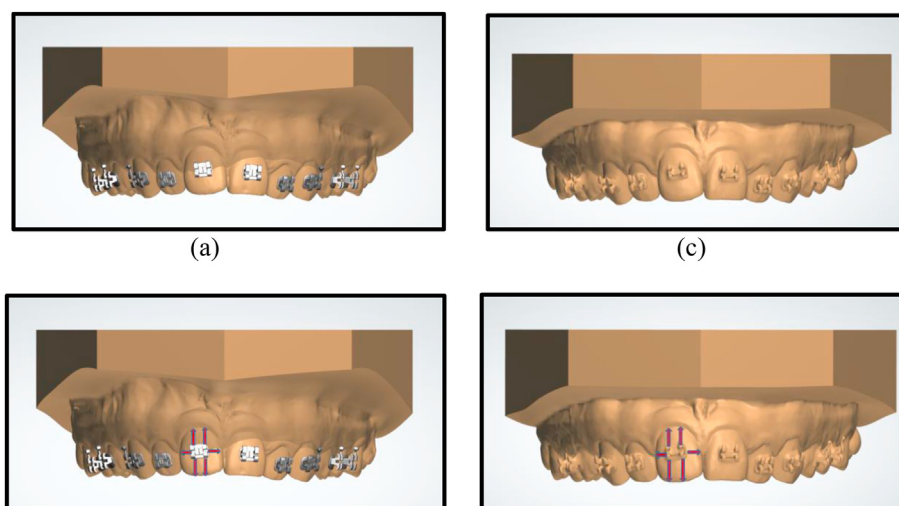


Figure 1: (a) The virtual set up with bracket positioning, (b) the measurements taken, (c) the 3D model obtained after bonding the brackets in the patient's mouth with loupes and without loupes and (d) the measurements taken. Measurements: mesio-gingival, disto-gingival, mesio-occlusal, disto-occlusal, distal and mesial areas.

6. Horizontal distance from the mesial border of the bracket base along the slot to the mesial edge of the tooth.

The above measurements were taken from each tooth, separately recorded and tabulated for both the virtual bracket placement on the pre-treatment model and the post-bracket placement scanned models (Figure 1). The difference in the measurements taken on the post bracket placement scan when compared with the virtual bracket placement on the pre-treatment scan was considered as bracket placement error. These errors were calculated separately for all teeth bonded with and without loupes for all patients.

Statistical analysis

The data obtained was stratified into individual tooth-wise errors and area-wise errors. Descriptive statistics were performed and a separate independent sample t-test was performed to compare the mean errors of bracket positioning with loupes and without loupes based on individual tooth-wise and area-wise parameters using IBM SPSS version 23.0 keeping the level of significance at $p < 0.05$.

Results

Table 1 shows the area-wise mean, standard deviation and standard errors of bracket positioning with loupes and without loupes. There was no statistical significance in the area-wise mean error in bracket positioning with loupes and without loupes ($p > 0.05$).

Table 2 shows the individual tooth-wise mean and standard errors of bracket positioning with loupes and without loupes. There was no statistical significance in the tooth-wise mean error in bracket positioning with loupes and without loupes ($p > 0.05$). Table 3 shows the overall mean standard errors of bracket positioning with loupes and without loupes. Overall, the difference in the mean error for bracket positioning with and without loupes did not show any statistical significance ($p = 0.054$). The overall mean difference in the error between the two groups was 0.086 mm; this is clinically insignificant (Table 3).

Table 2: Individual tooth-wise mean deviation of bracket positioning with and without loupes.

Tooth-wise group	Mean	Std. deviation	Std. error mean	Sig. (2-tailed)
15 With loupes	4.46	2.35	1.05	0.17
Without loupes	2.63	1.39	0.62	0.18
14 With loupes	3.26	3.02	1.35	0.69
Without loupes	2.62	1.80	0.80	0.69
13 With loupes	2.68	1.47	0.66	0.92
Without loupes	2.59	1.13	0.50	0.92
12 With loupes	3.48	1.68	0.75	0.30
Without loupes	2.29	1.78	0.79	0.30
11 With loupes	2.50	0.93	0.42	0.89
Without loupes	2.44	0.76	0.34	0.89
21 With loupes	2.71	1.19	0.53	0.70
Without loupes	2.97	0.83	0.37	0.71
22 With loupes	3.17	2.29	1.02	0.90
Without loupes	3.33	1.76	0.79	0.90
23 With loupes	2.89	1.40	0.62	0.86
Without loupes	2.70	1.80	0.80	0.86
24 With loupes	4.16	1.47	0.65	0.07
Without loupes	2.02	1.80	0.81	0.08
25 With loupes	3.87	2.76	1.24	0.77
Without loupes	3.38	2.36	1.05	0.77

Table 3: Independent t tests comparing the mean errors of bracket positioning with and without loupes.

Groups	Mean (error)	Std. deviation	Std. error mean	p value
With loupes	0.35	0.25	0.03	0.05
Without loupes	0.26	0.23	0.03	

Discussion

This was a prospective study designed to identify if there were any significant differences in the accuracy of orthodontic bracket positioning when performed with loupes and without loupes. There was no statistically significant difference in bracket positioning with loupes and without loupes in

Table 1: Table depicts the area-wise mean deviation of bracket positioning with and without loupes.

Group	Mean	Std. deviation	Std. error mean	p value	
Mesio-gingival	With loupes	0.49	0.46	0.65	0.79
	Without loupes	0.46	0.41	0.58	0.79
Disto-gingival	With loupes	0.53	0.47	0.07	0.34
	Without loupes	0.45	0.43	0.06	0.34
Mesio-occlusal	With loupes	0.75	0.67	0.09	0.06
	Without loupes	0.53	0.50	0.07	0.06
Disto-occlusal	With loupes	0.72	0.64	0.09	0.28
	Without loupes	0.58	0.49	0.07	0.28
Distal	With loupes	0.42	0.29	0.04	0.69
	Without loupes	0.39	0.34	0.05	0.69
Mesial	With loupes	0.39	0.35	0.05	0.05
	Without loupes	0.27	0.26	0.03	0.05

any areas of the teeth or in any particular tooth. The difference in the mean error for bracket positioning with and without loupes did not show any statistical significance. Hence, the use of loupes does not provide a significant advantage over brackets positioned with naked eye.

The overall accuracy of bracket positioning without loupes was very similar to control values, thus indicating good accuracy in direct bonding. Using loupes for bonding brackets did not seem to improve the bonding accuracy nor did it worsen it significantly as the mean difference between bracket positioning with and without loupes was not significant. Hence, the use of loupes did not seem to improve the accuracy of direct bonding.

While using loupes, we focus only on a small area; however, for accurate bracket positioning, various other factors, such as root morphology, root angulation, gingival contour also need to be considered; this is not easily achieved while wearing loupes. In other fields of dentistry, loupes are beneficial as they help the operator to focus on a specified restricted field of vision such as tooth preparations, root canal treatment and restorations.²⁷ As the magnification increases, the depth of field decreases to the point where only a small part of the object can be focused on accurately; everything around this area is not visible. Even slight movements of the operator or the patient might result in a loss of focus in the working field and require time to refocus on the area, making it more difficult to use in orthodontic bonding procedures. Even though we did not measure the time taken for bonding with and without loupes as a parameter, we observed that in general, bonding takes more time with loupes. For this reason, we recommend the use of four-handed dentistry while bonding with loupes to reduce the time taken for reorientation.

In a survey conducted by Hayes et al. on the experience and opinion of dental hygienists on the introduction of loupes to their dental practice; 91.7% of respondents felt that the identification of calculus was better with loupes and at least half of the hygienists felt that loupes improved their ergonomic posture and helped to improve the assessment of periodontal probing depth. In this study, the authors study felt that a longer adjustment period and the limited depth of vision were some of the drawbacks of using loupes.²⁸

Valachi and Valachi suggested the need for good posture while performing dental procedures as bad posture can contribute to the onset of back and neck pain.^{29,30} Many dentists of various age groups and from across the world are known to experience chronic back and neck pain.³¹ Two surveys conducted in the USA concluded that ergonomics was one of the major advantages of using loupes.^{32,33} Also, a survey on the use of magnification loupes in dental hygiene programs found that almost all participants suggested ergonomics as an advantage of wearing loupes.³² This was one of the advantages which we too observed in our study. When using new equipment, a period of learning and adaptation is always required.³⁴ Previous research on the use of loupes in dental hygiene programs suggests that undergraduate students might benefit from the early use of loupes prior to developing bad postural habits.³⁵ However, there is a significant paucity of literature relating to the application of dental loupes in orthodontic practice; therefore, it was impossible to compare our results directly with the literature. In this study, one operator performed all

of the bonding procedures; this could potentially be one limitation of this study. The use of multiple operators could have avoided any operator bias, if present. Furthermore, the use of multiple operators could have enabled us to estimate the comfort and ergonomics while using loupes; this could have given us more insight into the use of loupes for direct bonding. Further studies should be performed with various magnifications and commercial brands to assess for variations.

Conclusion

Our analysis concluded that loupes do not significantly improve or worsen the accuracy of bracket positioning in direct bonding.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical clearance was obtained from Saveetha University on 17/05/2021; the ethical approval number is SRB/SDC/ORTHO-1902/21/008.

Authors contributions

Both authors checked the article for plagiarism. ASK contributed to the design of the study. The study was performed by AAT and the data and the results were checked and verified by ASK. The manuscript was written by AAT. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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