Buccal Bone Changes With Self Ligating Brackets Versus Conventional Brackets. A Comparative Study

Thesis
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ABSTRACT

Introduction: Self ligating brackets (SLB) manufacturers claim that expansion of arches and alveolar bone building is facilitated by their bracket design. The objective of this study was to determine whether SLB brackets have a different effect on buccal bone changes compared with conventional brackets (NSLB) during orthodontic treatment. Methods: Cone beam computed tomography (CBCT) images were obtained before and after treatment of 45 patients (26 treated with conventional brackets (NSLB) and 19 with SLB). The CBCT images were compared between groups for buccal bone height and thickness at the maxillary first molars, maxillary second and first premolars using imaging software. The intermolar distance and buccolingual angulation were assessed for the maxillary first molars as potentially confounding factors. Differences for each variable measured before and after treatment were compared between the two groups. Results: Initial and final thickness and height of buccal bone were significantly different between the teeth (p <0.001). The buccal bone height (p <0.001) and thickness (p = 0.018) significantly decreased after treatment for both groups. The mean changes of buccal bone height and thickness measured were not significantly different between SLB and NSLB groups (p>0.05). The intermolar distance and molar angulation changes were not significantly different between the 2 groups (p >0.05). The change in bone height depended on the initial bone thickness where the greater the initial bone thickness, the less the decrease in bone height (p <0.01). The change in bone thickness was affected by the change
in intermolar distance where the bone thickness decreased when the intermolar distance increased (p <0.01). **Conclusions:** The buccal bone changes during orthodontic treatment regardless of which bracket type is used. Based on these data and those from RME studies, the implication is that, in the absence of other data, there is a trend that increased arch dimensions may lead to adverse bony changes depending on the patient’s initial bony status. Arch expansion and molar angulation can be similarly controlled by either type of appliance.
Dedicated to my family
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CHAPTER 1

INTRODUCTION

Self ligating brackets (SLB) have received much popularity in the past few years. Many manufacturers offer SLB indicating the increased demand of this product. They are not new in orthodontics. They were introduced in the early 20th century with the ‘Russell Lock’ edgewise attachment being described in 1935. Some early SL brackets were the Ormco Edgelok (1972), Forestadent Mobil-Lock (1980), Orec SPEED (1980), and “A” Company Activa (1986). Other designs have appeared including the Time bracket in 1994, the Damon SL bracket in 1996, the TwinLock bracket in 1998, and the Damon 2 and In-Ovation brackets in 2000. Currently, the popular SLB are Damon, Time, Speed, SmartClip, and In-Ovation R.

SLB have an inbuilt labial face, which can be opened and closed. They are promoted on the premise that elimination of ligatures reduces friction and allows for better sliding mechanics.

SLB can be dichotomized into those with a spring clip that can press against the archwire (active) and those with a passive system of ligation, in which the clip, ideally, does not press against the wire. However, the term “passive” is somewhat of a misnomer because it is passive only when teeth are ideally aligned in 3 dimensions (torque, angulation, and inout), and an undersized wire would not touch the walls of the bracket slot. Examples of active brackets are In-Ovation “R” (GAC International, Bohemia, NY), SPEED (Strite Industries, Cambridge, Ontario, Canada), and Time
(American Orthodontics, Sheboygan, Wis). Examples in the passive group are the Damon bracket (Ormco.Glendora, Calif) and the SmartClip bracket (3M Unitek, Monrovia, Calif).³

Despite the presentation of much empirical and anecdotal evidence, no documented evidence exists on the manufacturer's claims on the efficiency of self-ligating brackets in both, space closure and torque control. This is particularly intriguing because of the contradictory demands involved in the mechanotherapeutic setup for these cases, as space closure with sliding mechanics requires low friction, whereas torque control necessitates the development of frictional forces between the wire and the bracket slot walls.⁵

Various claims are made by SLB manufacturers. For example, some of these claims are increased patient comfort, better oral hygiene, increased patient cooperation, less chair time, shorter treatment time, greater patient acceptance, and expansion. Sound scientific evidence is needed before we accept manufacturers' claims about SLB. Unfortunately, the evidence for most claims is lacking.³

The Damon system claims that using biologically sensible forces which work with the body’s natural adaptive processes will create space naturally so most cases can be treated without extraction and without the need for headgear or palatal expanders.

They also claim that posttreatment CT image shows transverse arch development and normal alveolar bone on lingual and buccal surfaces. Low friction and low force are purported to be good for physiologically rebuilding the alveolar bone.⁶

On the other hand, excessive expansion can force the teeth through the cortical plate.⁷ This can ultimately cause bone dehiscence, and gingival recession.⁸
The three-dimensional capability of cone-beam computed tomography (CBCT) technology makes it possible to assess alveolar bone loss for posterior teeth where buccal bone defects can be detected and quantified.

**REVIEW OF THE LITERATURE**

**Self ligating brackets (SLB) versus conventional brackets (NSLB)**

Various researchers have conducted studies to investigate the differences between SLB and NSLB.

**Frictional resistance:**

Several investigators found that SLB had lower frictional resistance than conventional brackets. Kusy and Whitley divided resistance to sliding into 3 components: (1) friction, static or kinetic due to contact of the wire with bracket surfaces; (2) binding, created when the tooth tips or the wire flexes so that there is contact between the wire and the corners of the bracket (3) notching, when permanent deformation of the wire occurs at the wire-bracket corner interface. This often occurs under clinical conditions. Tooth movement stops when a notched wire catches on the bracket corner and resumes only when the notch is released.

Burrow in 2009 pointed out that the clinical advantage of reduced resistance to sliding should be a reduction in the amount of time to align the teeth and close the spaces. Several clinical studies found no evidence to support the claim of reduced treatment time with self-ligating
He concluded that a binding and releasing phenomenon, not frictional resistance, is the major determinant of how well bracketed teeth move along an archwire and that is about the same with conventional and self-ligating brackets.

**Treatment duration:**

Several investigators assessed the treatment efficiency of SLB. Damon\(^2\) in 1998 stated that the self-ligating bracket design allowed for rapid leveling because teeth drifted along the path of least resistance with little or no friction between the bracket and slot of the wire. Thus, this system was capable of increasing the appointment intervals, and possibly reducing the overall treatment time.

Harradine\(^2\) in 2001 found that SLB cases required an average of four fewer months and four fewer visits to be treated to an equivalent level of occlusal regularity as measured by the PAR scores. Eberting et al\(^2\) in 2001 found an average reduction in treatment time of 6 months (from 31 to 25) and 7 visits (from 28 to 21) for SLB patients compared with conventional ligation patients.

On the other hand, several clinical studies found no evidence to support the claim of reduced treatment time with self-ligating brackets. Miles\(^2\) in 2005 concluded that SLB were no more effective in reducing irregularity than NSLB. Miles et al\(^2\) in 2006 found that SLB were no better during initial alignment than a conventional bracket. Also in 2007, Miles\(^1\) compared the rate of en-masse space closure and found that there was no significant difference in the rate of en-masse space closure between SLB and NSLB. Scott et al\(^2\) in 2008 concluded that SLB were no more efficient than NSLB during tooth alignment. Hamilton et al\(^3\) in 2008 conducted a study to determine if self-
ligating brackets are more efficient. They concluded that SLB appear to offer no measurable advantages in orthodontic treatment time, number of treatment visits and time spent in initial alignment over NSLB. Fleming et al\textsuperscript{31} in 2009 concluded that efficiency of alignment in the mandibular arch in nonextraction patients is independent of bracket type.

**Torque control:**

Pandis et al\textsuperscript{5} in 2006 found that self-ligating brackets were equally efficient in delivering torque to maxillary incisors relative to conventional brackets in extraction and non-extraction cases.

Badawi et al\textsuperscript{32} examined the torque expression of 2 active self-ligating brackets (In-Ovation, GAC, Bohemia, NY; Speed, Strite Industries, Cambridge, Ontario, Canada) and 2 passive self-ligating brackets (Damon2, Ormco, Orange, Calif; Smart Clip, 3M Unitek, Monrovia, Calif) using a bracket/wire assembly torsion device. They concluded that active self-ligating brackets were more effective in torque expression than passive self-ligating brackets.

Morina et al\textsuperscript{33} in 2008 examined the torque expression of active and passive self-ligating brackets compared with metallic, ceramic, and polycarbonate edgewise brackets. Six types of orthodontic brackets were included in the study: the self-ligating Speed and Damon2, the stainless steel (SS), Ultratrimm and Discovery, the ceramic bracket, Fascination 2, and the polycarbonate bracket, Brilliant. All brackets had a 0.022-inch slot size and were torqued with 0.019 x 0.025-inch SS archwires. The ceramic bracket (Fascination 2) presented the highest torquing moment and, together with a SS bracket, the lowest torque loss (4.6 degrees). Self-ligating, polycarbonate, and
selective metallic brackets demonstrated almost a 7-fold decreased moment developed during insertion and a 100 per cent increase in loss.

**Transverse dimensions:**

Tecco et al\textsuperscript{34} in 2009 evaluated the transverse dimensions of the maxillary arch induced by fixed self-ligating and traditional straight-wire appliances during orthodontic therapy. Forty consecutive patients (age range 14 to 30 years) with normal or low mandibular plane angle, normal overbite, and mild crowding were included. The traditional appliance was composed of Victory Series MBT brackets (3M Unitek), and the self-ligating appliance of Damon-3MX brackets (Ormco). Intercanine, first and second interpremolar, and intermolar widths in the maxilla were recorded before treatment (T0) and 12 months later (T1). They found in both groups, a significant increase was recorded for all transverse measurements from T0 to T1, but no significant difference was observed between groups. They concluded that within 12 months of treatment, both appliances increased maxillary dentoalveolar widths.

Other researchers investigated the mandibular dental arch changes. Mandibular arch alignment resulted in transverse expansion and incisor proclination irrespective of the appliance system used. However a statistically greater increase in intermolar width in the group treated with the self-ligating appliance, the difference was only 0.91 mm by Fleming et al\textsuperscript{35}; 1.3 mm by Pandis et al\textsuperscript{36} and 0.77 mm by Jiang and Fu\textsuperscript{37}. On the other hand, Scott et al\textsuperscript{29} found no significant difference for either bracket system where their patients had premolar extractions.
**Periodontal condition:**

Pandis et al\(^3^8\) in 2008 investigated the periodontal condition of the mandibular anterior dentition in patients with conventional and self-ligating brackets to explore whether the use of self-ligating brackets is associated with better values for periodontal indices because of the lack of elastomeric modules and concomitantly, reduced availability of retentive sites for microbial colonization and plaque accumulation. They concluded that the self-ligating brackets do not have an advantage over conventional brackets with respect to the periodontal status of the mandibular anterior teeth.

Pellegrini et al\(^3^9\) in 2009 examined plaque retention by self-ligating vs elastomeric orthodontic brackets. They concluded that self-ligating appliances promote reduced retention of oral bacteria.

Pandis et al\(^4^0\) in 2010 investigated the salivary Streptococcus mutans levels in patients with conventional and self-ligating brackets. No difference was found in the oral hygiene indices between the two groups. The levels of S. mutans in whole saliva of orthodontically treated patients were not significantly different between conventional and self-ligating brackets.

**Systematic reviews:**

Fleming and Johal\(^4^1\) in 2010 conducted a systematic review to evaluate the clinical differences (alleviation of irregularity using Little’s irregularity index, rate of orthodontic space closure, dimensional changes during orthodontic alignment, plaque retention, extent of root resorption developing during treatment, and attachment debond rate) in relation to the use of self-
ligating brackets in orthodontics. They concluded that at this stage there is insufficient high-quality evidence to support the use of self-ligating fixed orthodontic appliances over conventional appliance systems or vice versa.

Ehsani et al\textsuperscript{42} in 2009 conducted a systematic review on frictional resistance in self-ligating orthodontic brackets and conventionally ligated brackets in vitro. They concluded that compared with conventional brackets, self-ligating brackets produce lower friction when coupled with small round archwires in the absence of tipping and/or torque in an ideally aligned arch. Sufficient evidence was not found to claim that with large rectangular wires, in the presence of tipping and/or torque and in arches with considerable malocclusion, self-ligating brackets produce lower friction compared with conventional brackets.

**Rapid maxillary expansion studies and buccal bone**

The effect of rapid maxillary expansion on buccal bone has been investigated utilizing computed tomography.

Ballanti et al\textsuperscript{43} in 2009 investigated by low-dose computed tomography (CT) protocol the dental and periodontal effects of rapid maxillary expansion (RME). Their sample comprised 17 subjects (7 males and 10 females), with a mean age of 11.2 years. Each patient underwent expansion of 7 mm. Multislice CT scans were taken before rapid palatal expansion (T0), at the end of the active expansion phase (T1), and after a retention period of 6 months (T2). All interdental transverse measurements were significantly increased at both T1 and T2 with respect to T0. In the evaluation of T0-T1 changes, a significant reduction in buccal alveolar bone thickness of maxillary molars with
the greatest amount of bone resorption being 0.4mm. In the evaluation of changes between the end of active expansion (T1) and the end of retention (T2), and of overall T0-T2 changes, periodontal measurements were significant on the lingual aspects, but not on the buccal side.

Rungcharassaeng et al\textsuperscript{44} in 2007 used cone-beam computed tomography (CBCT) images to determine the factors that might affect buccal bone changes of maxillary posterior teeth after rapid maxillary expansion. They found that buccal crown tipping and reduction of buccal bone thickness and buccal marginal bone level of the maxillary posterior teeth are immediate effects of RME. Factors that showed significant correlation to buccal bone changes and dental tipping were age, appliance expansion, initial buccal bone thickness, and differential expansion, but rate of expansion and retention time had no significant association.

Garib et al\textsuperscript{45} in 2006 examined the periodontal effects of rapid maxillary expansion with tooth-tissue-borne and tooth-borne expanders by computed tomography. Their sample comprised 8 girls, 11 to 14 years old. The appliances were activated 7-mm. Spiral CT scans were taken before expansion and after the 3-month retention period when the expander was removed. They found that RME reduced the buccal bone plate thickness of supporting teeth 0.6 to 0.9 mm and increased the lingual bone plate thickness 0.8 to 1.3 mm. RME induced bone dehiscences on the anchorage teeth’s buccal aspect where there was a significant reduction of alveolar crest level of 7.1 ± 4.6mm at the first premolars and 3.8 ± 4.4 mm at the mesiobuccal area of the first molars. They found a negative statistically significant correlation between the thickness of the buccal alveolar crest at treatment onset and the alveolar crest level changes after expansion.
CBCT validity

Several studies have been conducted to examine the validity and reliability of linear and angular measurements made on CBCT images. Others examined the ability of CBCT to detect periodontal bone defects.

Kau et al\(^{46}\) in 2010 analyzed CBCT scans of 30 subjects using InVivoDental (Anatomage, San Jose, Calif) software. They concluded that CBCT digital models are as accurate as OrthoCAD digital models in making linear measurements for overjet, overbite, and crowding measurements.

Moreira et al\(^{47}\) in 2009 researched the precision and accuracy of maxillofacial linear and angular measurements obtained by cone-beam computed tomography (CBCT) images. They utilized 15 dry human skulls that were submitted to CBCT. Linear and angular measurements based on conventional craniometric anatomical landmarks, and were identified in CBCT images by 2 radiologists on two occasions, independently. Subsequently, physical measurements were made by a third examiner using a digital caliper and a digital goniometer. Regarding accuracy tests, no statistically significant differences were found from the comparison between the physical and CBCT-based linear and angular measurements for both examiners. The mean difference between the physical and 3D-based linear measurements varied from 0.04 to −0.27 mm. The highest difference between the physical and 3D-based angular measurements was 2.76° and the lowest value was −0.03%. They concluded that CBCT images can be used to obtain dimensionally accurate linear and angular measurements from bony maxillofacial structures and landmarks.

Baumgaertel et al\(^{48}\) in 2009 investigated the reliability and accuracy of dental measurements made on cone-beam computed tomography (CBCT) reconstructions. Thirty human skulls were scanned with dental CBCT, and 3-dimensional reconstructions of the dentitions were generated. Ten
measurements (overbite, overjet, maxillary and mandibular intermolar and intercanine widths, arch length available, and arch length required) were made directly on the dentitions of the skulls with a high-precision digital caliper and on the digital reconstructions with commercially available software. They concluded that dental measurements from CBCT volumes can be used for quantitative analysis. They found a small systematic error, which became statistically significant only when combining several measurements.

Stratemann et al\textsuperscript{49} in 2008 conducted a study to determine the accuracy of measuring linear distances between landmarks commonly used in orthodontic analysis on a human skull using two cone beam CT (CBCT) systems; the NewTom\textsuperscript{®} QR DVT 9000 (Aperio Inc, Sarasota, FL) and the Hitachi MercuRay (Hitachi Medico Technology, Tokyo, Japan). For the CB MercuRay, the mean absolute error to the gold standard caliper measurements for the human skull was 0.00±0.22 mm, with a median of 0.01 mm and a range of −0.39 mm to 0.24 mm. The error was slightly smaller in the CB MercuRay than in the NewTom. They concluded that the volumetric data rendered with both CBCT systems provided highly accurate data compared with the gold standard of physical measures directly from the skulls, with less than 1% relative error.

Mol and Balasundaram,\textsuperscript{9} in 2008 assessed the accuracy of NewTom 9000 cone beam CT images for the detection and quantification of periodontal bone defects in three dimensions. A sample of 146 sites in 5 dry skulls provided the ground truth. Half of the sample had bone loss of at least 3 mm. Measurements on the CBCT images were compared to measurements on a full mouth X-ray series. They concluded that the NewTom 9000 cone beam CT scanner provides better diagnostic and quantitative information on periodontal bone levels in three dimensions than conventional radiography. The accuracy in the anterior aspect of the jaws is limited.
Misch et al\textsuperscript{10} in 2006 evaluated the accuracy of cone beam computed tomography for periodontal defect measurements. Artificial osseous defects were created on mandibles of dry skulls. CBCT scanning, periapical radiography (PA), and direct measurements using a periodontal probe were compared to an electronic caliper that was used as a standard reference. All bony defects were identifiable and measurable directly or with CBCT. In comparison, buccal and lingual defects could not be measured with radiographs. They concluded that all three modalities are useful for identifying interproximal periodontal defects and that compared to radiographs, the three-dimensional capability of CBCT offers a significant advantage because all defects including buccal and lingual defects can be detected and quantified.

**Orthodontic treatment and periodontal condition**

Huynh-Ba et al\textsuperscript{50} in 2010 analyzed the socket bone wall dimensions in the upper maxilla in relation to immediate implant placement. At the time of extraction of the tooth and after the tooth had been removed, intra-operative measurements of the socket, including the width of the buccal and palatal walls of the sockets were recorded. The width was measured 1mm apical to the alveolar crest level. Premolars buccal bone thickness mean was 1.1mm (range: 0.5–3mm, SD 0.5mm).

The relationship between orthodontic treatment and the periodontal condition has been investigated in various studies.

A systematic review by Bollen et al\textsuperscript{51} in 2008 found that subjects in the orthodontically treated group had, on average, a pocket depth 0.3 millimeter deeper than that of subjects in the untreated groups. The mean alveolar bone loss was 0.13 mm greater among the groups that had been
orthodontically treated than among the groups that had not. The orthodontically treated group had gingival recession 0.03 mm greater than did the untreated group.

Allais and Melsen\textsuperscript{52} in 2003 evaluated the association between the extent of labial movement of the lower incisors and the prevalence and severity of gingival recession in orthodontically treated adult patients. They analyzed study casts and intra oral slides of 300 adult patients. One hundred and fifty pairs matched by age and sex were selected using simple random sampling. Although the difference in prevalence of individuals with gingival recession among cases and controls was statistically significant, no significant difference in the mean recession value could be found between cases and controls. The mean value of the extent of recession of the four lower incisors amounted to 0.36 mm for treated subjects and 0.22 mm for the controls. This mean difference of 0.14 mm was not clinically relevant. They recommended that labial movement of lower incisors is a valuable alternative to extraction leading to no clinically relevant deterioration of the periodontium.

Janson et al\textsuperscript{53} in 2003 compared the heights of the alveolar bone crests among orthodontic patients treated with either the standard edgewise technique, the edgewise straight-wire system, or bioefficient therapy. These 3 groups were compared with an untreated control group. The first premolars were extracted in every treated patient, and measurements were performed on bitewing radiographs taken after a mean posttreatment period of 2.17 years. The distances from the AC to the cementoenamel junction (CEJ) on the mesial and distal surfaces of the first molars and second premolars and on the distal surface of the canines were measured. All treated groups had larger, statistically significant CEJ-AC distances than the untreated group, primarily at the extraction areas.
Thomson\textsuperscript{54} in 2002 examined the long term outcomes of orthodontic treatment. According to his findings, there were no significant differences in caries experience, periodontal disease occurrence, or tooth loss between those who had and had not been treated by the age of 26.

Bondemark\textsuperscript{55} in 1998 investigated the periodontal condition for two groups of 20 adolescents, one treated orthodontically and one untreated, and followed them longitudinally for 5 years. The interdental alveolar bone level was estimated as the distance between the cementoenamel junction and the alveolar bone crest on bite-wing radiographs of the upper and lower premolars and molars on three occasions, the first at the start of treatment, the second after 2.8 years, and the third at the end of the 5-year study period. At the start of this study, no significant difference in alveolar bone level between treated and untreated groups was found. It was demonstrated that there was a small but significant decrease in interdental alveolar bone support ranging between 0.1 and 0.5 mm during the 5-year observation period both in the treated and untreated group. Neither group had any sites with clinically significant bone loss, i.e., a distance > 2 mm between the cementoenamel junction and the alveolar bone crest.

Jager et al\textsuperscript{56} in 1990 examined the long term influence of orthodontic mandibular arch expansion therapy on the periodontal condition of the posterior teeth. 11 years after the end of treatment, 31 former patients were compared with a control group of matched age and sex distribution. They found some additional loss of periodontal attachment for the treated group, however the differences were not considered to be of clinical significance.

Zachrisson and Alnaes\textsuperscript{57, 58} in 1973 and 1974 examined 51 patients with Cl II Div. 1 malocclusion treated with all first premolars extracted. The treatment duration was 19.1 months; the
mean age of the patients was 16.2 years. They selected 54 individuals to match the treated group. The patients were examined 2 years after finishing orthodontic treatment. They clinically found the orthodontic patients to demonstrate slightly but significantly more loss of attachment than the control group. Radiographically the orthodontic patients showed more alveolar bone loss than did the control group.

Statement of the Problem

Based on this review of the literature, several aspects of differences between SLB and NSLB have been studied however there are no reports that investigated the difference in the buccal bone changes between the SLB and NSLB. Several studies have investigated the buccal bone changes with rapid maxillary expansion and indicated that bone loss occurs with expansion. Several clinical studies indicate that orthodontic treatment can have a mild detrimental effect on the periodontium but there is limited quantitative data. There are limited reports that compared the arch dimension changes but none compared the angulation changes for the posterior teeth. This study will examine the buccal bone changes and will investigate the difference in posterior arch dimensions and molar angulation for the different types of brackets.

Specific Aim and Hypothesis to be tested

The specific aim is to compare the changes in buccal bone and buccal angulation of posterior teeth after orthodontic treatment with SLB or conventional brackets and to determine if the change in tooth position affects the buccal bone changes. The first null hypothesis is that there is no difference between patients treated with SLB or conventional brackets for buccal bone changes (buccal bone height and buccal bone thickness).
The second null hypothesis is that there is no difference between patients treated with SLB or conventional brackets for buccal angulation of posterior teeth and intermolar distance.

The third null hypothesis is that the change in buccal angulation of posterior teeth and intermolar distance does not affect the buccal bone changes (buccal bone height and buccal bone thickness).

References


CHAPTER 2

MATERIALS AND METHODS

Human Subjects Approval

This study was approved by the Institutional Review Board of the Ohio State University, Columbus, OH (OSU protocol number: 2008H0210). In addition; the research was approved for the inclusion of children, waiver of the consent process, and waiver of HIPAA Research Authorization throughout the entire research study.

Patient Selection

The CBCT images before and after treatment of fifty patients were obtained from a university graduate clinic. The patients were treated with full fixed appliances-- either SLB or NSLB. A sensitivity power analysis was completed using G power software.\(^9\) A sample size of 45 patients had 85% power and could detect a difference in intermolar distance of 1.5mm, molar angulation of 3.3°, bone height of 0.2mm and bone thickness of 0.2mm.

The exclusion criteria were patients who received RPE or headgear; patients with craniofacial anomalies; patients with facial asymmetry or patients who had orthognathic surgery.

Forty five images (26 with NSLB and 19 with SLB) were analyzed because five images were removed due to errors in the data set. The SLB used were Damon 3 (Ormco, Orange, California), Smart clip (3M Unitek, Monrovia, California) and GAC Innovation R (GAC, Bohemia, NY). The
conventional brackets used were preadjusted edgewise twin bracket (3M Unitek; TP Orthodontics, La Porte, IN).

The CBCT images were analyzed using Dolphin Imaging software (version 10.5 Dolphin Imaging and Management Solutions, Chatsworth, CA).

1) Buccal bone height and bone thickness measurements (Fig. 2)

The pretreatment images were designated T1 and the post treatment images were designated T2. The orientation tool was used where the image was first oriented from the front so that a horizontal line connected hard tissue Orbitale to Orbitale. A vertical orientation line was constructed perpendicular to the horizontal line at hard tissue Nasion.

For the measurements of the first molar, the orientation was set to be parallel to the occlusal plane of the first molar with the cut at the level of the cementoenamel junction. The trough was drawn to bisect the maxillary first molar mesiodistally and buccolingually (Fig. 1). Ten cross sections with a thickness of 1mm and uniform spacing were made through the maxillary first molar (M1), the second premolar (P2) and the first premolar (P1). The slice with the maximum bone thickness was utilized for comparison.

To measure buccal bone height (BBH), the long axis of the buccal root (LA) was drawn from the buccal cusp tip to the buccal root tip. At the most occlusal point where the bone was in contact with the tooth, the first perpendicular line (PL1) was drawn to LA. The distance on the LA from the PL1 to the cusp tip was the BBH. A second perpendicular line (PL2) was drawn where the buccal bone curvature stabilized and reached a consistent maximum thickness. The distance from the root surface to the bone surface on the second perpendicular line was the buccal bone thickness (BBT). The distance on the LA from PL2 to the cusp tip represented the buccal bone thickness level (BTL)
and where the BBT of the post treatment (T2) image would be measured. The procedure was repeated for the T2 measurements and BTL at T1 determined the position of PL2 on the T2 image (Fig. 2). The same procedure was repeated for the measurements of the first and second maxillary premolar.

The BBT change resulted by subtracting the T1 value from the T2 value; whereas the BBH change was derived by subtracting the T2 value from the T1 value. Negative values of those changes accounted for bone loss. This method of measurement was adopted from a previous study by Rungcharassaeng et al.¹

2) Intermolar distance (ID) measurement (Fig. 3)

From the axial section of the T1 images, at the crown level of the maxillary first molar, a cut was made buccolingually at the center of the crown (determined both mesiodistally and buccolingually) so that it passed through the greatest depth of the central fossae bilaterally. On the coronal image derived from the cut, a line connecting the central fossae was drawn and the measurement represented the intermolar distance (ID). The procedure was repeated for the T2 measurements, and their difference was the amount of dental expansion (positive) or constriction (negative).

3) Molar angulation (MA) measurement (Fig. 3)

On the coronal image derived from the previous cut, lines were drawn from the central fossa to the furcation area. The angle formed by the intersection of this line and a line tangent to the greatest height of the palate represented the buccolingual inclination of the tooth. The procedure was repeated for the T2 measurements, and their difference represented the amount of molar tipping. A
positive value represented buccal crown tipping and a negative value represented lingual crown tipping.

The difference between SLB and NSLB were compared in terms of: initial, final and change in buccal bone height and buccal bone thickness for the maxillary first molar, maxillary first and second premolars; initial, final and change in intermolar distance and buccolingual angulation of the maxillary first molars.

**Statistical analysis**

Ten CBCT images were randomly selected and remeasured at least 2 weeks apart to assess intraexaminer reliability for bone height, bone thickness, intermolar distance and molar angulation measurements.

The data were analyzed with SAS 9.2 software (SAS Institute Inc., Cary, NC). Means and standard deviations were calculated for each parameter. The data was analyzed by the t-test, ANOVA and ANCOVA.

ANOVA was used to detect the effect of the bracket type (SLB and NSLB), time, tooth (M1, P2, P1) and side (right and left) on the measured parameters (buccal bone height and thickness, intermolar distance and molar angulation).

T-tests was used to compare the difference between SLB and NSLB for initial, final and change in buccal bone height and buccal bone thickness of the maxillary first molar, maxillary first and second premolars, and for initial, final and change in intermolar distance and buccolingual angulation of the maxillary first molars.
ANCOVA was used to determine if the change in buccal bone height, thickness, molar angulation and intermolar distance depended on their respective initial values. ANCOVA was also used to determine if the change in molar angulation and intermolar distance affected the change in buccal bone thickness and height and whether the change in buccal bone height depended on the initial buccal bone thickness. The significance level of 0.05 was used for all statistical analyses.

References

CHAPTER 3

MANUSCRIPT

BUCCAL BONE CHANGES WITH SELF LIGATING BRACKETS VERSUS CONVENTIONAL BRACKETS. A COMPARATIVE STUDY

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ABSTRACT

Introduction: Self ligating brackets (SLB) manufacturers claim that expansion of arches and alveolar bone building is facilitated by their bracket design. The objective of this study was to determine whether SLB brackets have a different effect on buccal bone changes compared with conventional brackets (NSLB) during orthodontic treatment. Methods: Cone beam computed tomography (CBCT) images were obtained before and after treatment of 45 patients (26 treated with conventional brackets (NSLB) and 19 with SLB). The CBCT images were compared between groups for buccal bone height and thickness at the maxillary first molars, maxillary second and first premolars using imaging software. The intermolar distance and buccolingual angulation were assessed for the maxillary first molars as potentially confounding factors. Differences for each variable measured before and after treatment were compared between the two groups. Results: Initial and final thickness and height of buccal bone were significantly different between the teeth (p <0.001). The buccal bone height (p <0.001) and thickness (p= 0.018) significantly decreased after treatment for both groups. The mean changes of buccal bone height and thickness measured were not significantly different between SLB and NSLB groups (p>0.05). The intermolar distance and molar angulation changes were not significantly different between the 2 groups (p >0.05).
bone height depended on the initial bone thickness where the greater the initial bone thickness, the less the decrease in bone height (p < 0.01). The change in bone thickness was affected by the change in intermolar distance where the bone thickness decreased when the intermolar distance increased (p < 0.01). **Conclusions:** The buccal bone changes during orthodontic treatment regardless of which bracket type is used. Based on these data and those from RME studies, the implication is that, in the absence of other data, there is a trend that increased arch dimensions may lead to adverse bony changes depending on the patient’s initial bony status. Arch expansion and molar angulation can be similarly controlled by either type of appliance.

**KEY WORDS:** CBCT, self ligating, buccal bone, intermolar

**INTRODUCTION**

Self ligating brackets (SLB) have received much attention in the past few years and many manufacturers now offer SLB, but they are not new in orthodontics. They were introduced in the early 20th century with the ‘Russell Lock’ edgewise attachment described in 1935.¹ Some early SLB were the Ormco Edgelok (1972), Forestadent Mobil-Lock (1980), Orec SPEED (1980), and “A” Company Activa (1986).² Other designs have appeared, but currently the popular SLB are Damon, Time, Speed, SmartClip, and In-Ovation R.³

Various claims are made by SLB manufacturers. One of these possibilities is increased arch dimension changes. Sound scientific evidence is required in order to accept manufacturers’ claims about SLB.
The Damon self ligating system claims that using biologically sensible forces which work with the body’s adaptive processes will naturally create space allowing most cases to be treated without extraction and without the need for headgear or palatal expanders. They also claim that posttreatment computed tomography (CT) images show transverse arch development and normal alveolar bone on lingual and buccal surfaces. Low friction and low force are purported to be good for physiologically rebuilding the alveolar bone.4

On the other hand, excessive expansion can force the teeth through the cortical plate.5 This can ultimately cause bone dehiscence and gingival recession.6

The three dimensional capability of cone beam computed tomography (CBCT) technology makes it possible to non-invasively assess alveolar bone changes for posterior teeth7 where buccal bone defects can be detected and quantified.8

The objective of this study was to compare the difference between patients treated with SLB and conventional brackets (NSLB) in regards to the changes in buccal bone height and thickness, while monitoring buccolingual root angulation and intermolar distance.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board. The CBCT images before and after treatment of fifty patients were obtained from a university graduate clinic. The patients were treated with full fixed appliances either SLB or NSLB. A sensitivity power analysis was done using G power software.9,10 A sample size of 45 patients was used for 85% power that could detect a
difference in intermolar distance of 1.5mm, molar angulation of 3.3°, bone height of 0.2mm and bone thickness of 0.2mm.

The exclusion criteria were patients who received RPE or headgear; patients with craniofacial anomalies; patients with facial asymmetry or patients who had orthognathic surgery.

Forty five images (26 with NSLB and 19 with SLB) were analyzed because five images were removed because of errors in the data set. The SLB used were Damon 3 (Ormco, Orange, California), Smart clip (3M Unitek, Monrovia, California) and GAC Innovation R (GAC, Bohemia, NY). The conventional brackets used were preadjusted edgewise twin bracket (3M Unitek; TP Orthodontics, La Porte, IN).

The CBCT images were analyzed using Dolphin Imaging software (version 10.5 Dolphin Imaging and Management Solutions, Chatsworth, CA).

1) Buccal bone height and bone thickness measurements (Fig. 2)

The pretreatment images were designated T1 and the post treatment images were designated T2. The orientation tool was used where the image was first oriented from the front so that a horizontal line connected hard tissue Orbitale to Orbitale. A vertical orientation line was constructed perpendicular to the horizontal line at hard tissue Nasion.

For the measurements of the first molar, the orientation was set to be parallel to the occlusal plane of the first molar with the cut at the level of the cementoenamel junction. The trough was drawn to bisect the maxillary first molar mesiodistally and buccolingually (Fig. 1). Ten cross sections with a thickness of 1mm and uniform spacing were made through the maxillary first molar (M1), the second premolar (P2) and the first premolar (P1). The slice with the maximum bone thickness was utilized for comparison.
To measure buccal bone height (BBH), the long axis of the buccal root (LA) was drawn from the buccal cusp tip to the buccal root tip. At the most occlusal point where the bone was in contact with the tooth, the first perpendicular line (PL1) was drawn to LA. The distance on the LA from the PL1 to the cusp tip was the BBH. A second perpendicular line (PL2) was drawn where the buccal bone curvature stabilized and reached a consistent maximum thickness. The distance from the root surface to the bone surface on the second perpendicular line was the buccal bone thickness (BBT). The distance on the LA from PL2 to the cusp tip represented the buccal bone thickness level (BTL) and where the BBT of the post treatment (T2) image would be measured. The procedure was repeated for the T2 measurements and BTL at T1 determined the position of PL2 on the T2 image (Fig. 2). The same procedure was repeated for the measurements of the first and second maxillary premolar.

The BBT change resulted by subtracting the T1 value from the T2 value; whereas the BBH change was derived by subtracting the T2 value from the T1 value. Negative values of those changes accounted for bone loss. This method of measurement was adopted from a previous study by Rungcharassaeng et al.11

2) Intermolar distance (ID) measurement (Fig. 3)

From the axial section of the T1 images, at the crown level of the maxillary first molar, a cut was made buccolingually at the center of the crown (determined both mesiodistally and buccolingually) so that it passed through the greatest depth of the central fossae bilaterally. On the coronal image derived from the cut, a line connecting the central fossae was drawn and the measurement represented the intermolar distance (ID). The procedure was repeated for the T2
measurements, and their difference was the amount of dental expansion (positive) or constriction (negative).

3) Molar angulation (MA) measurement (Fig. 3)

On the coronal image derived from the previous cut, lines were drawn from the central fossa to the furcation area. The angle formed by the intersection of this line and a line tangent to the greatest height of the palate represented the buccolingual inclination of the tooth. The procedure was repeated for the T2 measurements, and their difference represented the amount of molar tipping. A positive value represented buccal crown tipping and a negative value represented lingual crown tipping.

The difference between SLB and NSLB were compared in terms of: initial, final and change in buccal bone height and buccal bone thickness for the maxillary first molar, maxillary first and second premolars; initial, final and change in intermolar distance and buccolingual angulation of the maxillary first molars.

Statistical analysis

Ten CBCT images were randomly selected and remeasured at least 2 weeks apart to assess intraexaminer reliability for bone height, bone thickness, intermolar distance and molar angulation measurements.

The data were analyzed with SAS 9.2 software (SAS Institute Inc., Cary, NC). Means and standard deviations were calculated for each parameter. The data was analyzed by the t-test, ANOVA and ANCOVA.
ANOVA was used to detect the effect of the bracket type (SLB and NSLB), time, tooth (M1, P2, P1) and side (right and left) on the measured parameters (buccal bone height and thickness, intermolar distance and molar angulation).

T-tests was used to compare the difference between SLB and NSLB for initial, final and change in buccal bone height and buccal bone thickness of the maxillary first molar, maxillary first and second premolars, and for initial, final and change in intermolar distance and buccolingual angulation of the maxillary first molars.

ANCOVA was used to determine if the change in buccal bone height, thickness, molar angulation and intermolar distance depended on their respective initial values. ANCOVA was also used to determine if the change in molar angulation and intermolar distance affected the change in buccal bone thickness and height and whether the change in buccal bone height depended on the initial buccal bone thickness. The significance level of 0.05 was used for all statistical analyses.

RESULTS

The study included 45 patients; 18 males and 27 females with a mean age of 14.1 ± 1.3 years and a range of 12-17 years. Twenty-six patients had NSLB and 19 had SLB. The demographic distribution for the patients is presented in Table I.

The intraclass correlation coefficients for the bone thickness and bone height measurements were 0.73 and 0.78, respectively. The intraclass correlation coefficients for the intermolar distance and molar angulation measurements were 0.88 and 0.81, respectively. The measurement error for the bone thickness and bone height measurements were 0.32mm and 0.4mm, respectively. The
measurement error for the intermolar distance and molar angulation measurements were 0.8mm and 2.71° respectively.

The means and standard deviations for the buccal bone height, bone thickness, intermolar distance and molar angulation at pretreatment (T1), post treatment (T2) and the change (T1-T2) are shown in Table II through V.

The bone height significantly decreased after treatment for both bracket types (p <0.001). The initial (p=0.183), final (p=0.184) and change (p=0.973) in bone height were not statistically significantly different between the two bracket types. The change in bone height was not affected by the initial bone height (p=0.187). Bone height (initial and final) was significantly different between the maxillary first molar, second premolar and first premolar (p <0.001) regardless of bracket type. There was no significant difference between right and left side for bone height (p=0.097).

The bone thickness significantly decreased after treatment for both bracket types (p= 0.017). The initial bone thickness (p=0.021) and the final bone thickness (p=0.006) were significantly different between the two bracket types (the initial and final bone thickness was less for the self ligating bracket group) but the change (p=0.270) was not significantly different between the two bracket types. The change in bone thickness was not affected by the initial bone thickness (p=0.652). Bone thickness (initial and final) were significantly different between the maxillary first molar, second premolar and first premolar (p <0.001) regardless of bracket type. There was a significant difference between the right and left side for bone thickness (p= 0.022); the right side was greater.

The intermolar distance increased after treatment for both bracket types. The initial (p=0.130), final (p=0.159) and change (p=0.719) in intermolar distance were not significantly different between the 2 bracket types. The change in intermolar distance was affected by the initial intermolar distance.
where the greater the initial intermolar distance, the lesser the change in intermolar distance (p=0.007).

The molar angulation decreased after treatment for both bracket types. The initial (p=0.312), final (p=0.489) and change (p=0.767) in molar angulation were not significantly different between the two bracket types. There was no significant difference between right and left side for molar angulation (p=0.220). The change in molar angulation was affected by the initial molar angulation where the greater the initial molar angulation, the lesser the change in molar angulation (p=0.037).

The change in bone height did not depend upon the change in molar angulation (p=0.919) and intermolar distance (p=0.402). The change in bone height depended on the initial bone thickness (p=0.006) where the greater the initial bone thickness, the less the decrease in bone height.

The change in bone thickness was not affected by the change in molar angulation (p=0.748) however it was affected by the change in intermolar distance (p=0.007) where the bone thickness decreased when the intermolar distance increased.

**DISCUSSION**

Information from available CBCT images can provide noninvasive insight into the dynamics of tooth movement. Various studies\textsuperscript{12, 13} have indicated that CBCT images can be used to obtain accurate linear and angular measurements. Others\textsuperscript{14} found a small systematic error, which became statistically significant only when combining several measurements.

The accuracy of CBCT images for the detection and quantification of periodontal bone defects in three dimensions has been evaluated. Misch et al\textsuperscript{8} concluded that the three dimensional capability
of CBCT offered a significant advantage because all defects including buccal and lingual defects could be detected and quantified. Mol and Balasundaram\textsuperscript{7} concluded that CBCT images provide better diagnostic and quantitative information on periodontal bone levels in three dimensions than conventional radiography but the accuracy in the anterior aspect of the jaws was limited.

Our data represents baseline information for buccal bone height and thickness in cases of comprehensive orthodontic treatment that can be compared to rapid maxillary expansion (RME) studies.\textsuperscript{11, 15, 16} The initial bone height and thickness dimensions were comparable for the current study and previous studies.\textsuperscript{11, 15, 16} This appears to verify the usual pretreatment status of posterior buccal bone.

In a systematic review by Bollen et al\textsuperscript{17}, they suggested that orthodontic therapy was associated with small amounts of alveolar bone loss, gingival recession and increased pocket depth. Our findings also showed small, but statistically significant buccal bone loss after orthodontic treatment, most probably changes that would be considered clinically insignificant.

With rapid maxillary expansion, a significant amount of bone loss was reported by Garib et al\textsuperscript{15} who found that RME reduced the buccal bone plate thickness of supporting teeth 0.6 to 0.9 mm and induced bone dehiscences on the buccal aspect where there was a significant reduction of alveolar crest level of 7.1 ± 4.6 mm at the first premolars and 3.8 ± 4.4 mm at the mesiobuccal area of the first molars. Rungcharassaeng et al\textsuperscript{11} found that buccal crown tipping and reduction of buccal bone thickness and height of the maxillary posterior teeth were immediate effects of RME. Ballanti et al\textsuperscript{16} found a significant reduction in buccal alveolar bone thickness of maxillary molars with the greatest amount of bone resorption being 0.4mm.
So, in cases where substantial and purposeful RME expansion was accomplished, a significant amount of bone loss was reported. We found that increasing the intermolar distance minimally would negatively affect the bone thickness. This appears to suggest there is a trend and relationship between bone loss and increased transverse dimension. Without precise data for intervening magnitudes of expansion, there is a need for care when decisively increasing posterior arch width, regardless of the appliance used in order to avoid potential bone loss.

We found that the change in bone height depends on the initial bone thickness where the greater the initial bone thickness, the less the decrease in bone height. This is in agreement with the findings of Rungcharassaeng et al\textsuperscript{11} whose results suggest that buccal bone level was better preserved with greater buccal bone thickness. Garib et al\textsuperscript{15} also found a negative correlation between the thickness of the buccal alveolar crest at treatment onset and the alveolar crest level changes after expansion.

The clinical significance of buccal bone loss is the accompanying gingival recession with exposure of cementum that has been reported to occur at an early age on single or multiple teeth, and can be associated with orthodontic treatment.\textsuperscript{6} Localized recession during orthodontic treatment has been associated with excessive forces that have not permitted the repair and remodeling of the alveolar bone.\textsuperscript{5} Gingival recession is always accompanied by bone dehiscence which can happen as a result of uncontrolled expansion of teeth through the cortical plate.\textsuperscript{6} Pretreatment buccal bone thickness appears to be a determining factor related to bone loss. In the absence of a practical means to assess buccal bone thickness on a routine basis and given the potential for buccal bone loss as noted above, again, it appears judicious to avoid aggressive transverse arch expansion.
Claims have been made that SLB can result in broader archforms than conventional brackets.\textsuperscript{18} We found that the maxillary intermolar width increased insignificantly for both the SLB group and the NSLB group and there was no significant difference between the two brackets groups. Consistent with this finding, Tecco et al\textsuperscript{19} found that both self ligating and traditional straight wire appliances increased maxillary dentoalveolar widths but there was no significant difference between the groups in patients with mild crowding.

We found no difference in controlling buccolingu al angulation of the maxillary first molar between the two bracket types. Other studies evaluated torque control for maxillary incisors where Pandis et al\textsuperscript{20} found that SLB were equally efficient in delivering torque to maxillary incisors. On the other hand, Morina et al\textsuperscript{21} found that the torque expression of SLB was less than conventional brackets.

It does not appear that one appliance offers an advantage over the other in terms of changes in buccal bone and control of molar angulation and intermolar distance when modest changes in arch form are the goal and result. Based on these data and those from RME studies, the implication is that, in the absence of other data, there is a trend that increased arch dimensions may lead to adverse bony changes depending on the patient’s initial bony status.

**CONCLUSIONS**

1. There is no difference between patients treated with SLB or conventional brackets for buccal bone changes (buccal bone height and buccal bone thickness).
2. Buccal bone height and buccal bone thickness decrease significantly after treatment.
3. There is no difference between patients treated with SLB or conventional brackets for buccal angulation of maxillary first molar and intermolar distance.

4. The change in bone height depends on the initial bone thickness where the greater the initial bone thickness, the less the decrease in bone height.

5. The change in bone thickness is affected by the change in intermolar distance where the bone thickness decreases when the intermolar distance increases.
Fig 1. The orientation was set to be parallel to the occlusal plane of the first molar; the cut was done at the level of the cementoenamel junction. The trough was drawn to bisect the maxillary first molar.
Fig. 2 Buccal bone height and thickness measurements
Fig. 3 Landmark identification for buccolingual angulation and intermolar distance measurements
Fig. 4 Buccolingual angulation and intermolar distance measurements
**Table I: Demographic distribution of patients studied**

<table>
<thead>
<tr>
<th>Type of bracket</th>
<th>Number of patients</th>
<th>Gender</th>
<th>Age</th>
<th>Treatment duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>NS</td>
<td>26</td>
<td>12</td>
<td>14</td>
<td>14.3 ± 1.3y</td>
</tr>
<tr>
<td>S</td>
<td>19</td>
<td>6</td>
<td>13</td>
<td>13.7 ± 1.3y</td>
</tr>
<tr>
<td>Overall</td>
<td>45</td>
<td>18</td>
<td>27</td>
<td>14.1 ± 1.3y</td>
</tr>
</tbody>
</table>

NSLB: Conventional brackets, SLB: Self ligating brackets

**Table II: Means and standard deviations for the initial, final and change in bone height (mm)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Tooth*</th>
<th>T1 (Mean ± SD)</th>
<th>T2 (Mean ± SD)</th>
<th>Change (T1-T2)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLB</td>
<td>M1</td>
<td>7.66 ± 0.57</td>
<td>7.78 ± 0.44</td>
<td>-0.12 ± 0.28</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>7.90 ± 0.54</td>
<td>8.04 ± 0.54</td>
<td>-0.14 ± 0.20</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>8.78 ± 0.61</td>
<td>8.96 ± 0.62</td>
<td>-0.19 ± 0.16</td>
</tr>
<tr>
<td>NSLB</td>
<td>M1</td>
<td>7.92 ± 0.65</td>
<td>8.04 ± 0.60</td>
<td>-0.11 ± 0.26</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>7.96 ± 0.59</td>
<td>8.08 ± 0.59</td>
<td>-0.12 ± 0.30</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>9.00 ± 0.71</td>
<td>9.23 ± 0.80</td>
<td>-0.23 ± 0.29</td>
</tr>
</tbody>
</table>

T1: Before treatment, T2: After treatment
SLB: Self ligating brackets, NSLB: Conventional brackets
M1: Maxillary first molar, P2: Maxillary second premolar, P1: Maxillary first premolar
* Significant difference between teeth
**Significant difference for the change

**Table III: Means and standard deviations for the initial, final and change in bone thickness (mm)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Tooth*</th>
<th>T1 (Mean ± SD)**</th>
<th>T2 (Mean ± SD)†</th>
<th>Change (T2-T1)††</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLB</td>
<td>M1</td>
<td>1.87 ± 0.43</td>
<td>1.79 ± 0.40*</td>
<td>-0.08 ± 0.26</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>1.91 ± 0.42</td>
<td>1.75 ± 0.56**</td>
<td>-0.16 ± 0.37</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>1.07 ± 0.40</td>
<td>0.96 ± 0.42</td>
<td>-0.11 ± 0.14</td>
</tr>
<tr>
<td>NSLB</td>
<td>M1</td>
<td>2.21 ± 0.38</td>
<td>2.20 ± 0.46</td>
<td>-0.01 ± 0.21</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>2.22 ± 0.54</td>
<td>2.11 ± 0.49</td>
<td>-0.12 ± 0.34</td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>1.16 ± 0.54</td>
<td>1.11 ± 0.47</td>
<td>-0.05 ± 0.30</td>
</tr>
</tbody>
</table>

T1: Before treatment, T2: After treatment
SLB: Self ligating brackets, NSLB: Conventional brackets
M1: Maxillary first molar, P2: Maxillary second premolar, P1: Maxillary first premolar
* Significant difference between teeth
**Significant difference for the initial values between SLB and NSLB
† Significant difference for the initial values between SLB and NSLB
†† Significant difference for the change
Table IV: Means and standard deviations for the initial, final and change in intermolar distance (mm)

<table>
<thead>
<tr>
<th>Type</th>
<th>T1 (Mean ± SD)</th>
<th>T2 (Mean ± SD)</th>
<th>Change (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>45.41 ± 2.47</td>
<td>45.56 ± 2.27</td>
<td>0.15 ± 1.39</td>
</tr>
<tr>
<td>NS</td>
<td>44.15 ± 2.86</td>
<td>44.48 ± 2.64</td>
<td>0.33 ± 1.83</td>
</tr>
</tbody>
</table>

T1: Before treatment, T2: After treatment  
NSLB: Conventional brackets, SLB: Self ligating brackets

Table V: Means and standard deviations for the initial, final and change for molar angulation (°)

<table>
<thead>
<tr>
<th>Type</th>
<th>T1 (Mean ± SD)</th>
<th>T2 (Mean ± SD)</th>
<th>Change (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>95.15 ± 2.59</td>
<td>94.77 ± 3.23</td>
<td>-0.38 ± 3.30</td>
</tr>
<tr>
<td>NS</td>
<td>93.96 ± 5.11</td>
<td>93.87 ± 5.39</td>
<td>-0.09 ± 3.22</td>
</tr>
</tbody>
</table>

T1: Before treatment, T2: After treatment  
NSLB: Conventional brackets, SLB: Self ligating bracket

Acknowledgements

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References


CHAPTER 4

DISCUSSION AND CONCLUSIONS

Information from available CBCT images can provide noninvasive insight into the dynamics of tooth movement. Various studies\(^1\)\(^-\)\(^2\) have indicated that CBCT images can be used to obtain accurate linear and angular measurements. Others\(^3\) found a small systematic error, which became statistically significant only when combining several measurements.

The accuracy of CBCT images for the detection and quantification of periodontal bone defects in three dimensions has been evaluated. Misch et al\(^4\) concluded that the three dimensional capability of CBCT offered a significant advantage because all defects including buccal and lingual defects could be detected and quantified. Mol and Balasundaram\(^5\) concluded that CBCT images provide better diagnostic and quantitative information on periodontal bone levels in three dimensions than conventional radiography but the accuracy in the anterior aspect of the jaws was limited.

Our data represents baseline information for buccal bone height and thickness in cases of comprehensive orthodontic treatment that can be compared to rapid maxillary expansion (RME) studies.\(^6\), \(^7\), \(^8\) The initial bone height and thickness dimensions were comparable for the current study and previous studies.\(^6\), \(^7\), \(^8\) This appears to verify the usual pretreatment status of posterior buccal bone.
In a systematic review by Bollen et al\textsuperscript{9}, they suggested that orthodontic therapy was associated with small amounts of alveolar bone loss, gingival recession and increased pocket depth. Our findings also showed small, but statistically significant buccal bone loss after orthodontic treatment, most probably changes that would be considered clinically insignificant.

With rapid maxillary expansion, a significant amount of bone loss was reported by Garib et al\textsuperscript{7} who found that RME reduced the buccal bone plate thickness of supporting teeth 0.6 to 0.9 mm and induced bone dehiscences on the buccal aspect where there was a significant reduction of alveolar crest level of 7.1 ± 4.6 mm at the first premolars and 3.8 ± 4.4 mm at the mesiobuccal area of the first molars. Rungcharassaeng et al\textsuperscript{6} found that buccal crown tipping and reduction of buccal bone thickness and height of the maxillary posterior teeth were immediate effects of RME. Ballanti et al\textsuperscript{8} found a significant reduction in buccal alveolar bone thickness of maxillary molars with the greatest amount of bone resorption being 0.4mm.

So, in cases where substantial and purposeful RME expansion was accomplished, a significant amount of bone loss was reported. We found that increasing the intermolar distance minimally would negatively affect the bone thickness. This appears to suggest there is a trend and relationship between bone loss and increased transverse dimension. Without precise data for intervening magnitudes of expansion, there is a need for care when decisively increasing posterior arch width, regardless of the appliance used in order to avoid potential bone loss.

We found that the change in bone height depends on the initial bone thickness where the greater the initial bone thickness, the less the decrease in bone height. This is in agreement with the findings of Rungcharassaeng et al\textsuperscript{6} whose results suggest that buccal bone level was better preserved with greater buccal bone thickness. Garib et al\textsuperscript{7} also found a negative correlation between the
thickness of the buccal alveolar crest at treatment onset and the alveolar crest level changes after expansion.

The clinical significance of buccal bone loss is the accompanying gingival recession with exposure of cementum that has been reported to occur at an early age on single or multiple teeth, and can be associated with orthodontic treatment.\textsuperscript{10} Localized recession during orthodontic treatment has been associated with excessive forces that have not permitted the repair and remodeling of the alveolar bone.\textsuperscript{11} Gingival recession is always accompanied by bone dehiscence which can happen as a result of uncontrolled expansion of teeth through the cortical plate.\textsuperscript{10} Pretreatment buccal bone thickness appears to be a determining factor related to bone loss. In the absence of a practical means to assess buccal bone thickness on a routine basis and given the potential for buccal bone loss as noted above, again, it appears judicious to avoid aggressive transverse arch expansion.

Claims have been made that SLB can result in broader archforms than conventional brackets.\textsuperscript{12} We found that the maxillary intermolar width increased insignificantly for both the SLB group and the NSLB group and there was no significant difference between the two brackets groups. Consistent with this finding, Tecco et al\textsuperscript{13} found that both self ligating and traditional straight wire appliances increased maxillary dentoalveolar widths but there was no significant difference between the groups in patients with mild crowding.

We found no difference in controlling buccolingual angulation of the maxillary first molar between the two bracket types. Other studies evaluated torque control for maxillary incisors where Pandis et al\textsuperscript{14} found that SLB were equally efficient in delivering torque to maxillary incisors. On the other hand, Morina et al\textsuperscript{15} found that the torque expression of SLB was less than conventional brackets.
It does not appear that one appliance offers an advantage over the other in terms of changes in buccal bone and control of molar angulation and intermolar distance when modest changes in arch form are the goal and result. Based on these data and those from RME studies, the implication is that, in the absence of other data, there is a trend that increased arch dimensions may lead to adverse bony changes depending on the patient’s initial bony status.

CONCLUSIONS

1. There is no difference between patients treated with SLB or conventional brackets for buccal bone changes (buccal bone height and buccal bone thickness).
2. Buccal bone height and buccal bone thickness decrease significantly after treatment.
3. There is no difference between patients treated with SLB or conventional brackets for buccal angulation of maxillary first molar and intermolar distance.
4. The change in bone height depends on the initial bone thickness where the greater the initial bone thickness, the less the decrease in bone height.
5. The change in bone thickness is affected by the change in intermolar distance where the bone thickness decreases when the intermolar distance increases.
LIST OF REFERENCES


