Assessment of Nonsurgical Adult Maxillary Expansion and Gingival Recession

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THESIS

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LIST OF ABBREVIATIONS

3D	Three-Dimensional
CBCT	Cone Beam Computed Tomography
CCH	Clinical Crown Height
CEJ	Cemento-Enamel Junction
CI	Confidence Interval
MARPE	Miniscrew-Assisted Nonsurgical Palatal Expansion
MD	Mean Difference
RAP	Regional Acceleratory Phenomenon
RME	Rapid Maxillary Expansion
SARPE	Surgically Assisted Rapid Palatal Expansion
SD	Standard Deviation
TAD	Temporary Anchorage Device
UIC	University of Illinois at Chicago

SUMMARY

The purpose of this study was to evaluate nonsurgical adult maxillary expansion and assess the gingival buccal attachment levels pre-treatment and post-treatment in adult patients with constricted arches where the maxillary arch was expanded.

Nonsurgical adult maxillary expansion is thought to be unsuccessful, unstable and associated with significant periodontal consequences. Since 2000 there have been few studies on adult nonsurgical expansion in the literature. In this study we were concerned if the level of gingival recession, naturally occurring in periodontally healthy individuals, is accelerated by nonsurgical adult maxillary expansion.

This was a retrospective study utilizing pre-treatment and post-treatment dental study models on subjects who required maxillary expansion (n=26) and subjects that did not require expansion (n=31). Patients in the expansion group were treated with a Haas-type expander turning every other day in association with their orthodontic treatment. Models were scanned and digitized with the Lythos Digital Impression System (Ormco), imported into Geomagic Control software (3D systems) and uploaded into Ortho Insight 3D (Motion View Software, LLC). Maxillary model measurements included clinical crown height of premolars and first molars, transarch width of premolars and first molars, dental angulation of first premolars and first molars, and palatal vault angle at the first premolars and first molars.

The results showed a significant increase in clinical crown height in the expansion group from pre-treatment to post-treatment in five out of the six sites measured - right first premolar (0.48 mm), right second premolar (0.37 mm), right first molar (0.09 mm), left first premolar (0.43 mm), left second premolar (0.42 mm), and left

first molar (0.19 mm). When compared to the non-expanded group this increase was significant ($p<0.05$) for the right first premolar (0.40 mm) and left second premolar (0.33 mm).

There was a significant increase in transarch width in the expansion group from pre-treatment to post-treatment in all sites measured – first premolars (3.23 mm), second premolars (3.14 mm), and first molars (2.53 mm). This increase was significant ($p<0.05$) when compared to the non-expanded group - first premolars (2.51 mm), second premolars (2.40 mm), and first molars (2.07 mm). Associated with this expansion was a significant increase in dental angulation at the first premolars (10.92 degrees). This increase was significant ($p<0.05$) when compared to the non-expanded group (7.38 degrees). No difference was found in palatal vault angle.

A small subgroup of expanded adults was followed for 2 years or more into retention. No change was noted for all variables measured, indicating stability of the expansion treatment and an absence in progression of gingival buccal attachment loss. The exception was an increase in clinical crown height of the right first molar (0.72 mm).

The amount of gingival buccal attachment loss as measured by clinical crown height associated with nonsurgical adult maxillary expansion found in this study was minimal and showed a propensity for premolars. Considering the natural increase in prevalence and severity of gingival recession with age in periodontally healthy individuals, it is the opinion of the authors that the amount found in this study was clinically irrelevant. These findings support the relative safety of nonsurgical adult maxillary expansion in patients with a healthy periodontium.

1. INTRODUCTION

1.1 Background

Adult orthodontic treatment has emerged as a significant subset of orthodontic practice in the United States. Estimates of its contribution to the average office are in upwards of thirty percent (Proffit et al., 2013). The nature of adult orthodontic treatment is unique from children and adolescents in that clinically relevant growth is absent.

Rapid maxillary expansion (RME) has received significant attention in the early mixed dentition and adolescent patient populations. RME has been implemented as a viable treatment option for resolving posterior crossbites as well as the treatment for bimaxillary constriction in association with concurrent mandibular expansion (Haas, 1961; 1965; 1970; Howe et al., 1983; Brust & McNamara, 1995). The effectiveness of RME has been attributed to the opening of the midpalatal suture, which is still patent and only starts to fuse in the late teens (Haas, 1961; Melson, 1975; Perrson & Thilander, 1977).

Surgically Assisted Rapid Palatal Expansion (SARPE) has proven effective and stable and is considered the gold standard for adult maxillary expansion (Kennedy et al., 1976; Lehman & Haas, 1989). Nonsurgical adult maxillary expansion is thought to be “unreliable, unfeasible, and presents with significant side effects” due from the increased resistance of midpalatal and lateral maxillary sutures (Proffit et al., 2013). Complications associated with RME in skeletally mature humans in the literature are limited treatment effectiveness, instability, pain and discomfort, dental tipping, and displacement of teeth through the alveolus leading to gingival recession (Proffit et al., 2013; Vanarsdall, 1994).

Lagravère et al. (2005) conducted a systemic review of dental arch changes following maxillary expansion treatment. Of the 41 studies initially identified to meet eligibility, four articles were considered “evidence based”, only one of which focused on adults (Handelman et al., 2000). This article found similar results for nonsurgical adult expansion and RME in children with limited complications. Buccal attachment loss was found in adult females, but according to the authors, to a clinically irrelevant degree. Bassarelli et al. (2005) reported no change in clinical crown height in adults treated with maxillary expansion using a quadhelix and lingual expansion arch. Despite the positive conclusions of these studies, the two major textbooks on orthodontics and the profession in general have not accepted nonsurgical adult maxillary expansion as a viable treatment measure due to concerns with violation of buccal bone and gingival attachment (Proffit et al., 2013; Vanarsdall in the Graber Text Book, Fifth edition).

1.2 Specific Aims

The purpose of this study was to evaluate nonsurgical adult maxillary expansion and assess the gingival buccal attachment levels pre-treatment and post-treatment in adult patients with constricted arches where the maxillary arch was expanded.

1.3 Null Hypothesis

There is no mean difference in gingival buccal attachment levels between pre and post-treatment for each of the non-surgically expanded adults and non-expanded adult groups.

There is no mean difference between non-surgically expanded adults and non-expanded adults for all variables measured in this study: clinical crown height, transarch width, dental angulation, & palatal vault angle.

2. REVIEW OF LITERATURE

2.1 Rapid Maxillary Expansion

Rapid maxillary expansion has become a widely accepted protocol in correction of posterior crossbites in children and adolescents where relative or absolute maxillary constriction is present. While the first mention of maxillary expansion dates back to the 19^{th} century by E.H. Angell (1860), it was uncommon in clinical practice until studies by Haas demonstrated radiographic midpalatal suture opening with minor complications (Haas, 1961; 1965; 1970). A follow-up study by Wertz concluded RME for correction of maxillary constriction was a "safe and dependable procedure that can be both exciting and advantageous in routine clinical practice" (Wertz, 1970). Howe et al. (1983) argued that RME should be considered in cases with dental crowding or protrusion when associated with small dental arches. RME results in an increase in arch perimeter and is reported to be 0.7 times the amount of posterior expansion at the level of the first premolars (Adkins et al., 1990). RME has been advocated in the mixed dentition alone or in addition to other adjunctive procedures such as conventional braces or functional appliances (Spillane & McNamara, 1995). RME has also been justified in growing children to improve nasal airway volume, reduce upper airway resistance and alter tongue posture (Maia et al., 2011; Yamasaki et al., 2013).

2.2 Maxillary Expansion in Adults

Rapid maxillary expansion in adults has a more controversial history. Skeletal maturity is associated with skeletal rigidity and sutural calcification. Anatomical studies of adults in the palatomaxillary region reveal close articulation of bones and suture synostoses when evaluated histologically (Melsen, 1982). Perrson and Thilander reported closure of facial sutures may start in the juvenile period depending on extrinsic functional demands (Perrson & Thilander, 1977). The resistance to RME extends beyond the palate into the maxillary articulations (Isaacson & Ingram, 1964). Not surprisingly, RME in older individuals has resulted in reduced orthopedic correction (Wertz, 1970). Several authors have stated following sutural obliteration in the third decade, nonsurgical correction with RME carries a poor prognosis and results in the tipping of teeth and bending of the alveolus with limited expansion and relapse (Timms, 1968; Bell & Epker, 1976).

In response to the practitioner’s concern in treating adults with maxillary transverse deficiency, other approaches were soon suggested. The most notable of which is RME with surgical augmentation. Bell and Kennedy published results in which RME was performed on Rhesus monkeys following select maxillary osteotomies (Kennedy et al., 1976). Case reports soon followed describing successful transverse correction and apparent stability in humans (Bell & Epker, 1976). Surgically Assisted Rapid Palatal Expansion (SARPE) has become a commonly utilized procedure in adults with maxillary transverse deficiencies and is considered both predictable and stable. Although considered to be a short and uncomplicated procedure, risks of SARPE include but are not limited to “hemorrhage, gingival recession, root resorption, injury to the branches of the maxillary nerve, infection, pain, devitalization of teeth, periodontal breakdown, sinus infection, alar base flaring, extrusion of teeth attached to the appliance, relapse, and unilateral expansion” (Suri & Taneja, 2008). SARPE is an expensive procedure necessitating insurance coverage and approval for the majority of patients. SARPE also requires a long recovery period following surgery and large diastema formation during the expansion phase. It is thus not uncommon for clinicians and patients to elect compromised treatment objectives and accept an existing maxillary transverse deficiency.

Out of this environment evidence has developed supporting nonsurgical maxillary expansion as a means of treating maxillary transverse deficiency. Handelman et al. (2000) reported findings on 47 adult patients successfully treated with nonsurgical RME expanding 1/4 turn per day with minimal complications. The expansion achieved in the adults average age 29.9 was similar to that achieved in children average age 9.5. Of the 47 subjects, 10 reported symptoms of palatal swelling, pain or headache. The authors now elect a slower expansion schedule of every other day or slower depending on age. Buccal gingival attachment loss in males was not significant when compared to adult controls, however in females, a statistically significant loss was found (0.5 mm). No significant relapse was noted for patients from one to five years out of retention.

Northway & Meade (1997) reported on 43 adult patients treated with SARPE and compared results to 15 adults treated with nonsurgical expansion. They concluded both techniques were acceptable in correction of transverse discrepancies and stable at the time of follow-up. The nonsurgical expansion group had an increase in clinical crown length at the premolars (0.7 mm) and molars (0.8 mm) immediately following treatment, “however no teeth were severely compromised from a periodontal perspective” (Northway & Meade, 1997). The authors concluded that as the increase in crown length was twice that of surgically treated cases (0.2 mm), they preferred the surgical alternative.

Bassarelli et al. (2005) evaluated gingival recession in adults treated with quadhelices or lingual expansion arches (with no palatal acrylic coverage). 50 adults' ages 18-50 were evaluated retrospectively and compared with adult controls. They reported an increase in transarch width of 3 mm in the treatment group, which was not associated with an increase in clinical crown height (Bassarelli et al., 2005).

In the fall of 2011, the American Journal of Orthodontics and Dentofacial Orthopedics featured a Point/Counterpoint on palatal expansion in adults: surgical versus nonsurgical approaches. The nonsurgical approach insisted that the hesitation of the orthodontic profession towards nonsurgical expansion is based on existing paradigms that sutural separation is a necessary requirement, ignoring the evidence of at least 50 percent non-sutural expansion at the dentoalveolar complex following RME in children and adolescents (Handelman, 2011). Nonsurgical expansion is a legitimate treatment modality in the majority of cases, however the clinician must be able to diagnosis and determine those circumstances where it is advisable to use surgical assistance. Patients with pre-existing periodontal risk factors - prominent alveolar root contours and a deficiency in thick keratinized tissue - or insufficient airway concerns are two such circumstances. (Handelman, 2011).

Handelman (2012) has argued for the use of adult nonsurgical maxillary expansion in association with nonsurgical mandibular expansion in cases with bidental arch constriction. This important distinction allowed for the use of nonsurgical maxillary expansion in cases without posterior crossbites. The protocol described included a modified Haas-type expander in conjunction with a mandibular fixed lateral type expander delivered simultaneously. In the cases presented, minor relapse in mandibular transarch width were noted following discontinuation of retainers, but to no detriment of the occlusion. No periodontal consequences were reported.

2.3 Gingival Recession in Adults

It has long been noted by clinicians that gingival recession often occurs in individuals with high levels of oral hygiene and adequate periodontal health (Serino et al., 1994). Gingival recession, defined as the apical migration of gingiva from a normal position on the crown to beyond the cemento-enamel junction (CEJ) with resulting root exposure, is both an esthetic and clinical problem (Paterson, 1979).

The accepted position of the gingival margin is 0.5-2.0 mm above the CEJ in fully erupted teeth (Löe, 1980). The curvature of the CEJ extends apically between the interproximal line angles of the teeth, which establishes the gingival scalloping associated with health and ideal esthetics. The appearance of the gingival architecture and its importance in crown and smile esthetics has been embraced by the esthetic dentistry movement (Kokich, 1996).

Epidemiologic studies report greater loss of attachment on buccal surfaces when compared to interproximal surfaces in all ages and populations. The prevalence of recession increases with age and has been reported to be higher in men than women (Gorman, 1967). A longitudinal study of randomly selected Norwegian males found recession present in over 60 percent of subjects at age 20, over 70 percent of subjects at age 30, and over 90 percent of subjects at age 50 (Löe, 1992). In the U.S. gingival recession is reported to be present in 78-100 percent of middle-aged individuals. In these individuals, the recession was present in 22-33 percent of their teeth (Vehkalahti, 1989).

Etiological factors of gingival recession are thought to include “oral hygiene habits, tooth malpositioning, high muscle attachments with frenal pull, and bone dehiscences” (Löe, 1992). The occurrence of gingival recession has been positively related to tooth brushing frequency (Vehkalahti, 1989). One study found that subjects with buccal attachment loss reported brushing their teeth more often than subjects without (Kallestal & Uhlin, 1992). Orthodontic treatment has reportedly been associated with the prevalence, extent and severity of labial gingival recession, however no systematic review supports the statement (Renkema et al., 2013; Slutzkey & Leven, 2008; Bollen et al., 2008).

A possible explanation to inconsistencies in the literature is a disregard for individual susceptibilities. Serino et al. (1994) reported that a relatively low number of subjects comprised a large number of recession sites thus increasing the level of attachment loss for that age group. In addition, sites that presented with recession at baseline had the greatest severity over the 12-year period (Serino et al., 1994).

Clinical crown height (length), defined as “the distance from the most apical concavity of the gingival margin to the incisal edge or occlusal surface”, is an objective method to quantify the gingival margin position (Volchansky et al., 2001). Clinical crown height has also been implemented in the diagnosis of gingival recession in orthodontic study model analysis (Handelman et al., 2000; Northway & Meade, 1997).

3. MATERIALS AND METHODS

3.1 Institutional Review Board Approval

This study was reviewed by the Office for the Protection of Research Subjects at the University of Illinois at Chicago (UIC) Institutional Review Board and deemed not to meet the definition of human subject research defined by 45 CFR 46.102(f) on March 4th, 2015, IRB Protocol # 20150273 (Appendix A).

3.2 Study Design

This is a retrospective study evaluating pre-treatment, post-treatment and retention study models of adult patients treated with nonsurgical maxillary expansion in association with their orthodontic treatment. A separate group comprised of pre-treatment and post-treatment study models of adult patients treated without maxillary expansion as a part of their orthodontic treatment by the same practitioner was also evaluated (Dr. Ronald Snyder, Apple Valley, MN).

Subjects were selected for the nonsurgical adult expansion by an office coordinator based on the inclusion criteria. All records were collected and de-identified by the office coordinator. All subjects were provided with a case number (1,2,3, etc.) and stages were determined by the treatment date (T1, T2, T3). Demographic information (age, sex) was provided to the principal investigator.

According to the orthodontic literature with a sample of approximately 26 subjects in the expansion group and 31 subjects in the non-expansion group, the study had a power of at least 80%, (type error of 5%) to detect 1.25 standard deviation mean difference between the groups (Handelman et al., 2000).

3.3 Selection Criteria

The inclusion criteria for the expansion group were as follows:

1. Patients that underwent nonsurgical expansion of the maxilla as part of their comprehensive orthodontic treatment.
2. Patients were 20 years of age or older.
3. Initial and final treatment study models available.
4. 2-year or longer retention study models available for select retention group.

Exclusion criteria

1. Patients with craniofacial anomalies
2. Patients in active orthodontic treatment
3. Patients with incomplete records
4. Patients with active periodontal disease
5. Patients treated with surgical adult expansion
6. Patients with canine substitution

The non-expansion group was established with inclusion criteria as follows:

1. Patients that underwent orthodontic treatment and did not require maxillary expansion.
2. Patients 20 years of age or older.
3. Initial and final treatment study models available.

3.4 Study Groups

There was two study groups: *expansion* and *non-expansion*. The expansion group with initial and final models consisted of 26 subjects treated with nonsurgical maxillary expansion as a part of their orthodontic treatment. In addition, seven subjects had 2-year post-treatment or longer retention models. The non-expansion group consisted of 31 subjects treated without nonsurgical maxillary expansion as a part of their orthodontic treatment. The same practitioner treated all subjects in the study. The intention was that both groups should be similar in age, gender distribution, and pre-treatment measures of clinical crown height, dental angulation and palatal vault angle. The only difference between the groups should be that the expansion group had constricted maxillary transarch widths.

3.5 Data Acquisition

The office coordinator obtained the following data:

1. De-identified initial, final and retention study models
2. Patient gender
3. Patient age

3.6 Clinical Protocol

The decision to utilize nonsurgical adult expansion was based on the judgment of the clinician that the maxillary arch was constricted with or without posterior crossbite. The expansion screws of the Haas expander were turned every other day until overcorrection was achieved (lingual cusp of maxillary molars occluding with buccal cusps of mandibular molars). Maxillary expanders were left in place for a 2-3 month retention period, at which time a removable palatal retainer was delivered and fixed orthodontic brackets were placed. Study models were taken 2 months after debonding to allow for soft tissue healing. Patients that were at least two years into retention were recalled for retention study models.

3.7 Measurements

All de-identified study models were scanned and digitized at the orthodontic office with the Lythos Digital Impression System intraoral scanner (Ormco). The scanned models included upper teeth with palate, lower teeth, and centric occlusion. Models were uploaded to the Ormco Digital website and later downloaded at the UIC laboratory in the form of zip files. All files were extracted and imported into Geomagic Control 2014 (3D Systems). A custom script was written with Geomagic Control to convert the Lythos scans into three dimensionally oriented stereolithography STL files. A new patient was created with Ortho Insight 3D (Motion View Software, LLC) utilizing the converted STL files. Linear measurements were conducted with Ortho Insight 3D model analysis using the Linear Measurement tool. All angular measurements were conducted in Dolphin Imaging with the Annotations and Measurements feature. All measurements were entered into Microsoft Excel:

1. Clinical crown height of maxillary teeth (premolars to first molars)
2. Transarch widths for maxillary teeth (premolars to first molars)
3. Dental angulation of maxillary teeth (first premolars and first molars)
4. Palatal vault angle (measured at level of first premolar and first molar).

3.7.1 Clinical Crown Height

Measurements were made on digital models utilizing Ortho Insight 3D model analysis. The clinical crown height of maxillary premolars was measured by selecting the buccal cusp tip and the height of contour of the buccal gingiva. The distance was then calculated to the hundred's of a millimeter utilizing the Linear Measurement tool. The clinical crown height of maxillary first molars was measured by selecting the most occlusal point of the mesiobuccal groove and the height of contour of the buccal gingiva. This distance was similarly calculated to the hundred's of a millimeter utilizing the Linear Measurement tool as shown in Figure 1. This method allowed for an exact distance to be calculated not limited by the buccal surface of the crown. If one pair of premolars was missing at initial and final records, the premolar measurements were recorded as first premolars.

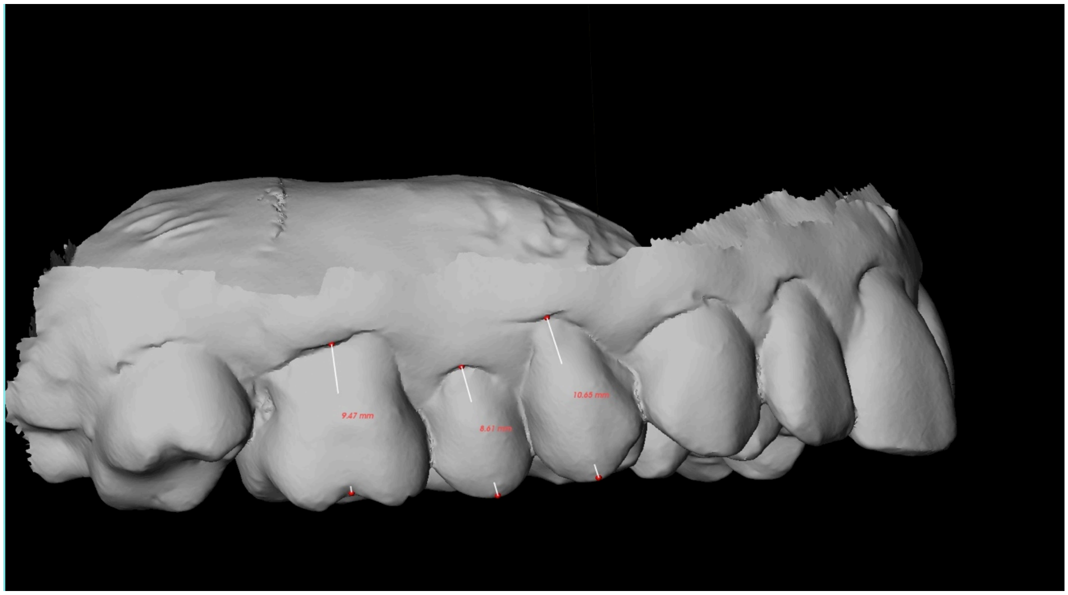

Figure 1. Clinical crown height measurement with Ortho Insight 3D model analysis.

3.7.2 Transarch Widths

The maxillary transarch width was recorded at the level of the first premolars, second premolars, and first molars. The measurement was made from the gingival margins at the lingual height of contour for the premolars to the contralateral tooth (Brust & McNamara, 1995). The measurement was made from the mesiolingual grooves at the level of the gingival margin for the first molar to the contralateral tooth as shown in Figure 2. If teeth were absent the measurement was excluded for both time points on that patient. If one pair of premolars was missing at initial and final records, the single premolar measurement was recorded as first premolar transarch width.

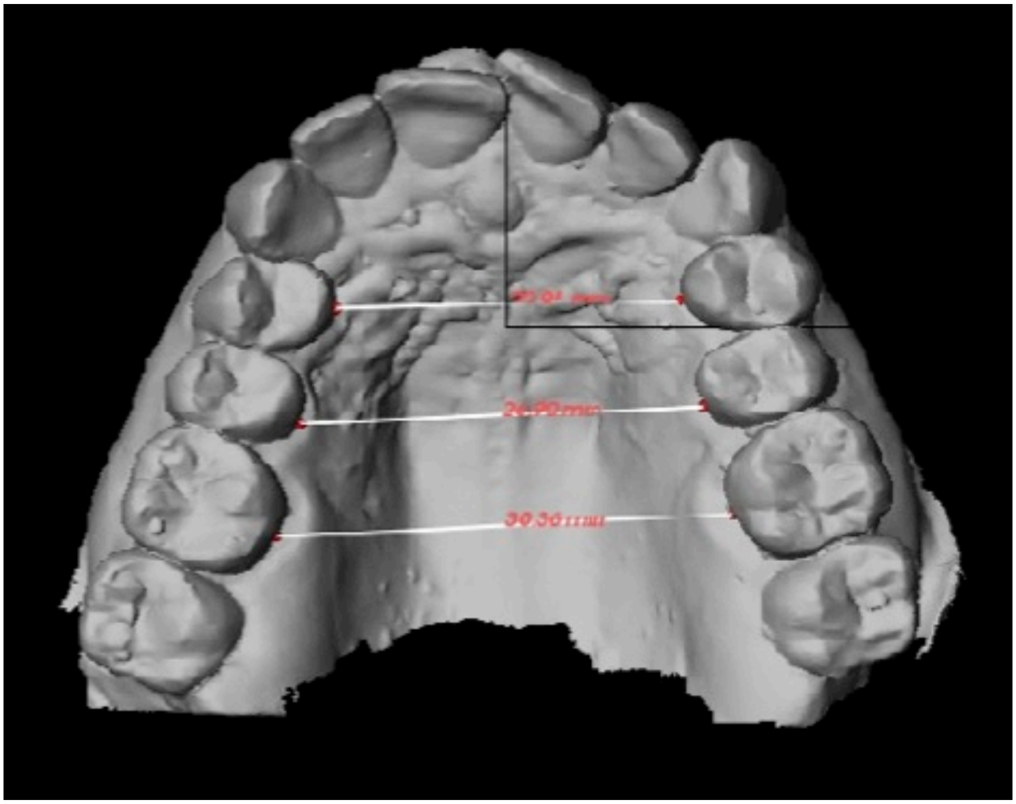

Figure 2. Transarch width measurement with Ortho Insight 3D model analysis.

3.7.3 Dental Angulation

A cross-section was made on the digital model utilizing Ortho Insight 3D at the level of the buccal and lingual cusp tips of the first premolar and the mesiobuccal and mesiolingual cups tips of the first molar perpendicular to the 3D Bottom orientation as viewed from the 3D Portrait Rear as seen in Figure 3. A screenshot of the model was taken and imported into Microsoft Paint. After confirming the image was a 1:1 representation, it was saved and imported into Dolphin Imaging (Dolphin Imaging & Management Solutions) as a lateral cephalometric image. To calibrate, a generic distance of 100 was accepted (as only angular measurements were to be utilized). The long axis of the tooth was indicated with the 3-point Angle feature by designating a reference plane through the occlusal surface from cusp tip to cups tip and extending the second plane at a 90 degree angle through the model reference base line. The angle of the long axis to the base was measured with the 3-point Angle feature to the tenth of a degree as seen in Figure 4. The cusp tips were used as reliable and reproducible landmarks as no enamelplasty or equilibration was performed during treatment. It was presumed that occlusal wear was limited between time points.

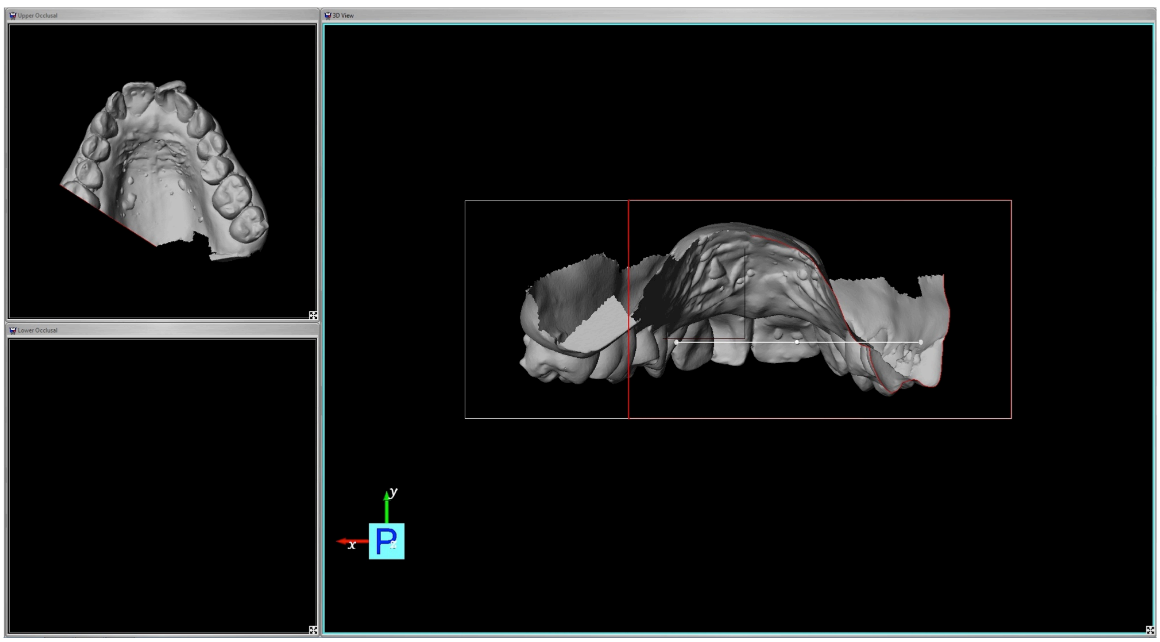

Figure 3. Creation of a dental cross-section using Ortho Insight 3D.

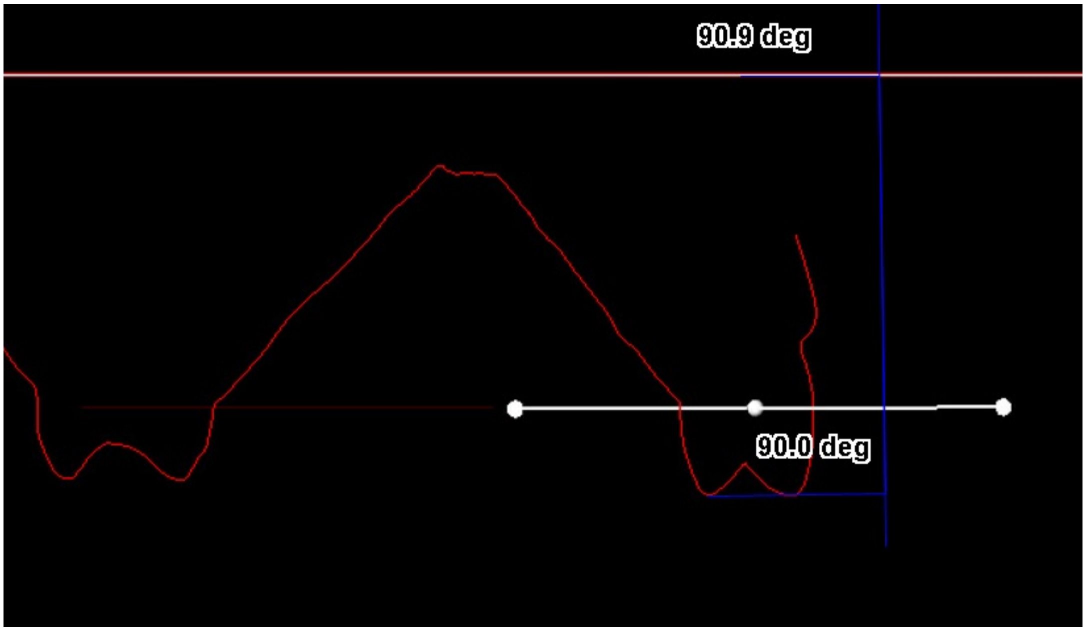

Figure 4. Quantification of dental angulation using Dolphin Imaging.

3.7.4 Palatal Vault Angle

The model was cross-sectioned utilizing Ortho Insight 3D at the level of the lingual cusp tips of the first premolars and the mesial lingual grooves of the first molars perpendicular to the 3D Bottom orientation as viewed from the 3D Portrait Rear as seen in Figure 5. A screenshot of the model was taken and imported into Microsoft Paint. After confirming the image was a 1:1 representation, it was saved and imported into Dolphin Imaging as a lateral cephalometric image. While viewing the image the Annotations and Measurements feature was selected. To calibrate, a generic distance of 100 was accepted (as only angular measurements were to be utilized). Reference lines were drawn tangent to the middle two-thirds of the palatal surface with the Distance tool and the respective angle was measured with the 3-point Angle feature as in seen Figure 6.

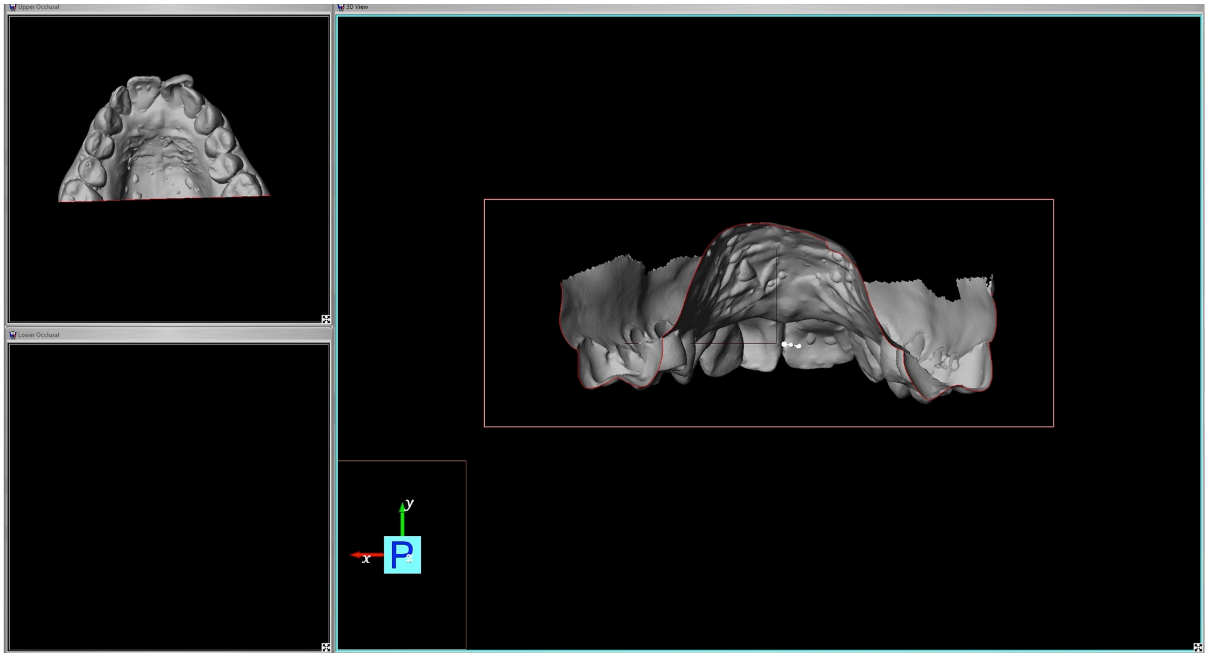

Figure 5. Creation of a palatal cross-section using Ortho Insight 3D.

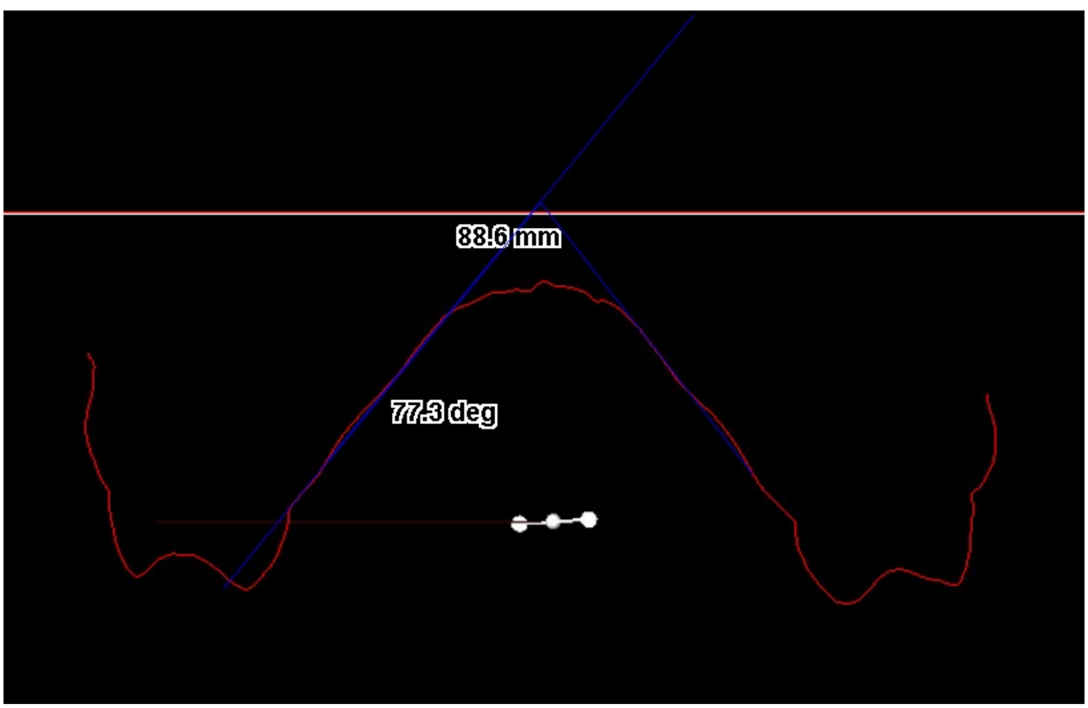

Figure 6. Quantification of palatal vault angle using Dolphin Imaging.

3.8 Method Error

All measurements were assessed by the principle investigator and checked for inter and intra-reliability of the study methodology. The data was entered into Microsoft Excel.

3.9 Data Analysis

Intra-class correlations were estimated to determine the intra-reliability and inter-reliability of each variable. The assumption of normal distribution was verified using the Shapiro-Wilk test. Descriptive statistics were computed for all the variables. Based on the distribution of the raw data, mean differences between the two study groups and initial and final measurements of each study group were tested using Student *t*-tests. Parametric and nonparametric tests were performed when necessary. Statistical significance was set at $p<0.05$. All tests and calculations were carried out using IBM SPSS Statistics for Windows (version 22.0, IBM Corp., Armonk NY).

4. RESULTS

4.1 Reliability

The reliability of all measurements was evaluated by statistical analysis of ten subjects. Intra-reliability was conducted as outlined previously and all measurements were repeated two weeks later. Inter-reliability was conducted on all measurements with a trained research assistant. Intra-class correlation coefficient (ICC) was used to test the inter-examiner reliability.

ICC was higher than 0.80 and showed to have a good support for reliability of the method used. The Shapiro-Wilk test showed that the majority of the variables in the study had a normal distribution. Parametric statistic analysis was used for data analysis. One sample *t*-tests were performed to determine the mean differences at pre-treatment as well as at post-treatment for both groups. One sample *t*-tests were performed to determine the mean differences from pre-treatment to post-treatments within the two groups. Independent student *t*-tests were performed to determine the mean differences between the expansion group and non-expansion group from pre-treatment to post-treatment.

TABLE I

DESCRIPTIVE STATISTICS: AGE, GENDER, AND DIAGNOSIS

Variable	Group	N	Mean	SD
Age	Expansion	26	39.19	11.15
	Non-expansion	31	41.58	12.09

Variable	Group		Frequency	Percent
Gender	Expansion	Male	10	38.5
		Female	16	61.5
	Non-expansion	Male	11	35.5
		Female	20	64.5

Group	Diagnosis at Presentation	Frequency	Percent
Expansion	Bilateral Crossbite	3	11.5
	Unilateral Crossbite	9	34.6
	Constricted	14	53.8

TABLE II

INDEPENDENT t-TEST FOR THE MEAN DIFFERENCE BETWEEN GROUPS (PRE-TREATMENT)

Variable	Group	N	T1	Difference between groups	Sig.
CCH R 1st Premolar (mm)	Expansion	26	7.74	0.46	0.12
	Non-expansion	30	8.20		
CCH R 2nd Premolar (mm)	Expansion	22	6.95	0.31	0.29
	Non-expansion	27	7.26		
CCH R 1st Molar (mm)	Expansion	26	6.37	0.08	0.77
	Non-expansion	31	6.45		
CCH L 1st Premolar (mm)	Expansion	26	7.49	0.47	0.09
	Non-expansion	31	7.97		
CCH L 2nd Premolar (mm)	Expansion	22	6.58	0.27	0.28
	Non-expansion	28	6.85		
CCH L 1st Molar (mm)	Expansion	26	5.94	0.27	0.26
	Non-expansion	31	6.22		
TAW 1st Premolar (mm)	Expansion	26	24.23	2.85*	0.00
	Non-expansion	30	27.08		
TAW 2nd Premolar (mm)	Expansion	21	29.54	2.54*	0.007
	Non-expansion	28	30.93		
TAW 1st Molar (mm)	Expansion	26	32.39	2.67*	0.004
	Non-expansion	31	35.05		

INDEPENDENT t-TEST FOR THE MEAN DIFFERENCE BETWEEN GROUPS (PRE-TREATMENT)

Variable	Group	N	T1	Difference between groups	Sig.
DA 1st Premolar (°)	Expansion	25	161.88	3.96	0.33
	Non-expansion	29	165.83		
DA 1st Molar (°)	Expansion	25	195.46	0.42	0.91
	Non-expansion	31	195.88		
PA 1st Premolar (°)	Expansion	25	86.96	11.69*	0.043
	Non-expansion	30	98.64		
PA 1st Molar (°)	Expansion	25	56.95	7.30	0.059

*p<0.05 indicates there is a statistically significant difference between groups.

4.2 Clinical Crown Height

TABLE III

ONE SAMPLE t-TEST FOR THE MEAN DIFFERENCE BETWEEN PRE & POST FOR EACH GROUP

Variable	Group	N	T1	T2	T2-T1 (x $\pm$ SD)	Sig. (T2-T1)
CCH R 1^{st} Premolar (mm)	Expansion	26	7.74	8.22	0.48 +/- 0.72*	0.002
	Non-expansion	30	8.20	8.28	0.08 +/- 0.57	0.428
CCH R 2^{nd} Premolar (mm)	Expansion	22	6.95	7.25	0.37 +/- 0.61*	0.012
	Non-expansion	27	7.26	7.34	0.08 +/- 0.46	0.361
CCH R 1^{st} Molar (mm)	Expansion	26	6.37	6.46	0.09 +/- 0.74	0.536
	Non-expansion	31	6.45	6.54	0.09 +/- 0.45	0.281
CCH L 1^{st} Premolar (mm)	Expansion	26	7.49	7.92	0.43 +/- 0.72*	0.005
	Non-expansion	31	7.97	8.05	0.08 +/- 0.64	0.483
CCH L 2nd Premolar (mm)	Expansion	22	6.58	7.00	0.42 +/- 0.28*	0.000
	Non-expansion	28	6.85	6.90	0.09 +/- 0.52	0.405
CCH L 1^{st} Molar (mm)	Expansion	26	5.94	6.13	0.19 +/- 0.41*	0.032
	Non-expansion	31	6.22	6.16	-0.06 +/- 0.62	0.591

*p<0.05 indicates there is a statistically significant difference in the change of clinical crown height pre-treatment to post-treatment.

TABLE IV

CLINCIAL CROWN HEIGHT - INDEPENDENT t-TEST FOR THE MEAN DIFFERNCE BETWEEN GROUPS (PRE TO POST)

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	MD	Std. Error Difference	95% CI	
						Lower	Upper
CCH R 1st Premolar (mm)	2.31	54	0.025	0.40*	0.17	0.05	0.74
CCH R 2nd Premolar (mm)	1.85	46	0.07	0.28	0.15	-0.02	0.59
CCH R 1st Molar (mm)	0.01	55	0.99	0.00	0.16	-0.32	0.32
CCH L 1st Premolar (mm)	1.93	55	0.059	0.35	0.18	-0.01	0.71
CCH L 2nd Premolar (mm)	2.66	45	0.009	0.33*	0.12	0.08	0.58
CCH L 1st Molar (mm)	1.73	55	0.090	0.25	0.14	-0.04	0.53

*$p<0.05$ indicates there is a statistically significant difference in the change of clinical crown height between groups (pre-treatment to post-treatment).

Note: equal variances assumed

Levene's test for equality of variances was not statistically significant except for the left second premolar, p=0.039. The Null Hypothesis is rejected based on independent student *t* -test comparing the expansion and non-expansion groups that had a statistical significance difference for the right first premolar and left second premolar.

There was a significant increase in clinical crown height from pre-treatment (T1) to post-treatment (T2) for the expansion group at the right first premolar (0.48 mm), the right second premolar (0.37 mm), the left first premolar (0.43 mm), the left second premolar (0.42 mm), and the left first molar (0.19 mm). There was not a significant increase in clinical crown height from pre-treatment (T1) to post-treatment (T2) for the non-expansion group. There was also statistical significance for the difference in clinical crown height from pre-treatment (T1) to post-treatment (T2) between groups for the right first premolar (0.40 mm) and left second premolar (0.33 mm).

4.3 Transarch Widths

TABLE V

TRANSARCH WIDTH - ONE SAMPLE t-TEST FOR THE MEAN DIFFERENCE BETWEEN PRE & POST FOR EACH GROUP

Variable	Group	N	T1	T2	T2-T1 ($x \pm SD$)	Sig. (T2-T1)
TAW 1st Premolar (mm)	Expansion	26	24.23	27.46	3.23 +/- 1.48*	0.000
	Non-expansion	30	27.08	27.80	0.72 +/- 1.41*	0.009
TAW 2nd Premolar (mm)	Expansion	21	29.54	32.81	3.14 +/- 1.05*	0.000
	Non-expansion	28	30.93	32.80	0.73 +/- 1.34*	0.011
TAW 1st Molar (mm)	Expansion	26	32.39	34.92	2.53 +/- 1.41*	0.000
	Non-expansion	31	35.05	35.52	0.46 +/- 1.06*	0.021

*p<0.05 indicates there is a statistically significant difference in the change of transarch width from pre-treatment to post-treatment.

TABLE VI

TRANSARCH WIDTH - INDEPENDENT t-TEST FOR THE MEAN DIFFERNCE BETWEEN GROUPS (PRE TO POST)

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	MD	Std. Error Difference	95% CI	
						Lower	Upper
TAW 1st Premolar (mm)	6.49	54	0.00	2.51*	0.38	1.73	3.29
TAW 2nd Premolar (mm)	2.93	48	0.00	2.40*	0.36	1.68	3.13
TAW 1st Molar (mm)	6.31	55	0.00	2.07*	0.33	1.41	2.72

*p<0.05 indicates there is a statistically significant difference in the change of transarch width between groups (pre-treatment to post-treatment).

Note: equal variances assumed

The Null Hypothesis is rejected based on independent student *t* -test comparing the expansion and non-expansion groups that had a statistical significance difference for premolars and first molars.

There was a significant increase in transarch width from pre-treatment (T1) to post-treatment (T2) for the expansion group at the first premolars (3.23 mm), second premolars (3.14 mm) and first molars (2.53 mm). There was a significant increase in transarch width from pre-treatment (T1) to post-treatment (T2) for the non-expansion group for first premolars (0.72 mm), second premolars (0.73 mm) and first molars (0.46 mm). There was also statistical significance for the difference in transarch width from pre-treatment (T1) to post-treatment (T2) between the expansion and non-expansion groups for first premolars (2.51 mm), second premolars (2.40 mm) and first molars (2.07 mm).

4.4. Dental Angulation

TABLE VII

DENTAL ANGULATION - ONE SAMPLE t-TEST FOR THE MEAN DIFFERENCE BETWEEN PRE & POST FOR EACH GROUP

Variable	Group	N	T1	T2	T2-T1 (x $\pm$ SD)	Sig. (T2-T1)
DA 1st Premolar (°)	Expansion	25	161.88	172.80	10.92 +/- 10.62*	0.000
	Non-expansion	29	165.83	169.21	3.54 +/- 8.51*	0.033
DA 1st Molar (°)	Expansion	25	195.46	196.06	0.60 +/- 11.70	0.800
	Non-expansion	31	195.88	194.57	-1.31 +/- 6.44	0.268

*p<0.05 indicates there is a statistically significant difference of the change in dental angulation pre-treatment to post-treatment.

TABLE VIII

DENTAL ANGULATION - INDEPENDENT t-TEST FOR THE MEAN DIFFERNCE BETWEEN GROUPS (PRE TO POST)

	t-test for Equality of Means						
	T	Df	Sig. (2-tailed)	MD	Std. Error Difference	95% CI	
						Lower	Upper
DA 1st Premolar (°)	2.84	52	0.006	7.38*	2.60	2.16	12.61
DA 1st Molar (°)	0.77	54	0.442	1.91	2.46	-3.03	6.84

*p<0.05 indicates there is a statistically significant difference of the change in dental angulation between groups (pre to post-treatment).

Note: equal variances assumed

Levene's test for equality of variances was statistically significant for the variable DA 1st Molar, p value = 0.023. The Null Hypothesis is rejected based on independent student *t* -test comparing the expansion and non-expansion groups that had a statistical significance difference for first premolars.

There was a significant increase in dental angulation from pre-treatment (T1) to post-treatment (T2) for the expansion group for first premolars (10.92 degrees, or 5.46 degrees per tooth). There was a significant increase in dental angulation from pre-treatment (T1) to post-treatment (T2) for the non-expansion group for first premolars (3.54 degrees, or 1.77 degrees per tooth). There was statistical significance for the difference in dental angulation pre-treatment (T1) to post-treatment (T2) between groups for first premolars (7.38 degrees or 3.69 per tooth). There was no statistical difference found in molar angulation.

4.5 Palatal Vault Angle

TABLE IX

PALATAL VAULT ANGLE - ONE SAMPLE t-TEST FOR THE MEAN DIFFERENCE BETWEEN PRE & POST FOR EACH GROUP

Variable	Group	N	T1	T2	T2-T1 (x ± SD)	Sig. (T2-T1)
PA 1st Premolar (°)	Expansion	25	86.96	89.65	1.18+/- 11.25	0.61
	Non-expansion	30	98.64	97.09	-1.56 +/- 9.75	0.389
PA 1st Molar (°)	Expansion	25	56.95	55.83	-1.12 +/- 7.08	0.44
	Non-expansion	31	64.25	65.19	0.94 +/- 6.06	0.394

TABLE X

PALATAL VAULT ANGLE - INDEPENDENT t-TEST FOR THE MEAN DIFFERNCE BETWEEN GROUPS (PRE TO POST)

	t-test for Equality of Means						
	T	df	Sig. (2-tailed)	MD	Std. Error Difference	95% CI	
						Lower	Upper
PA 1^{st} Premolar (°)	0.97	53	0.339	2.73	2.83	-2.94	8.41
PA 1^{st} Molar (°)	-1.18	54	0.245	-2.06	1.76	-5.58	1.46

Note: equal variances assumed

Levene's test for equality of variances was not statistically significant.

There was not statistical significance for the difference in palatal vault angle from pre-treatment (T1) to post-treatment (T2) for the expansion group or the non-expansion group. There was not statistical significance for the difference in palatal vault angle from pre-treatment (T1) to post-treatment (T2) between groups.

4.6 Additional Findings

TABLE XI

ADDITIONAL FINDINGS: CLINICAL CROWN HEIGHT - ONE SAMPLE t-TEST FOR THE MEAN DIFFERENCE BETWEEN POST-TREATMENT AND RETENTION

Variable	Group	N	T3	T3-T2 (x $\pm$ SD)	Sig. (T2-T1)
CCH R 1st Premolar (mm)	Expansion	7	9.36	0.75 +/- 1.09	0.118
CCH R 2nd Premolar (mm)	Expansion	5	8.75	0.96 +/- 0.80	0.054
CCH R 1st Molar (mm)	Expansion	7	7.63	0.72 +/- 0.66*	0.027*
CCH L 1st Premolar (mm)	Expansion	7	8.84	0.55 +/- 0.76	0.102
CCH L 2nd Premolar (mm)	Expansion	5	7.94	0.59 +/- 0.55	0.073
CCH L 1st Molar (mm)	Expansion	7	7.30	0.70 +/- 1.15	0.157

*$p<0.05$ indicates there is a statistically significant difference in clinical crown height.

There was a significance increase in clinical crown height from post-treatment (T2) to retention (T3) for the expansion group for the right first molar (0.72 mm). All other teeth showed no significant change.

5. DISCUSSION

5.1 Interpretation of the Results

This study is one of few investigations evaluating nonsurgical maxillary expansion in adults. The focus of this study was on periodontal consequences using clinical crown height as indirect quantification of gingival recession. In addition, multiple variables corresponding to nonsurgical adult expansion treatment were evaluated. The decision was made to assess the maxillary arch only utilizing study model analysis similar to Northway and Meade (1997) and Handelman et al. (2000).

5.1.1 Clinical Crown Height

There was no difference in clinical crown height between the two groups prior to treatment (Table II). There was an increase in clinical crown height from pre-treatment to post-treatment in the expansion group that was not replicated in the non-expansion group (Table III). Furthermore, when we compared the two groups, there was an increase in clinical crown height from pre-treatment to post-treatment for the right first premolar (0.40 mm) and left second premolar (0.31 mm) for the expansion group (Table IV). This indicates that the expansion treatment caused an increase in clinical crown height most notable for premolars.

The finding of gingival recession is supported by Northway & Meade (1997), which reported an increase in clinical crown height in non-surgically expanded adults of premolars (0.7 mm) and molars (0.8 mm) - compared to 0.2 mm of recession for the conventional surgical group. Handelman et al. (2000) reported an increase in gingival recession of 0.5 mm for females when compared to controls, which was similar to the values found in this study.

The sample size of this study did not allow for analysis by gender, and the difference between right and left clinical crown heights negated the possibility of combing sites. We are unable to explain with certainty why premolars were more vulnerable to recession than first molars. Nor can we elucidate why the change in clinical crown height was not comparable between the right and left sides.

It must be emphasized that gingival buccal attachment loss as measured by the increase in clinical crown height of 0.48 mm for the 1st premolar and 0.31 mm for the second premolar may be considered clinically acceptable since naturally occurring recession of comparable amounts over time is observed in an untreated adult population (Serino et al., 1994).

5.1.2 Transarch Width

The expansion group had a significantly smaller transarch width compared to the non-expansion group prior to treatment (Table II). There was a moderate increase in transarch width from pre-treatment to post-treatment in the expansion group for the first premolars (3.23 mm), second premolars (3.14) and first molars (2.53). There was also an increase for the non-expansion group for the first premolars (0.72 mm), second premolars (0.73 mm) and first molars (0.46 mm) (Table V). When we comparing the two groups, the expansion group had an increase in transarch width from pre-treatment to post-treatment for the first premolar (2.51 mm) second premolar (2.40 mm) and first molar (2.07 mm) greater than the control group (Table VI). This indicates that the expansion treatment was effective in increasing transarch width.

The findings of Handelman et al. (2000) and Northway & Meade (1997) support the increase in transarch width utilizing nonsurgical expansion reported in this study that was not present in the control group. The degree of expansion achieved in this study was less than previously mentioned studies, likely due to the small number of subjects with posterior crossbite at initial presentation. Utilizing a slightly different protocol, Bassarelli et al. (2005) reported a similar amount expansion on adults using a quadhelix or lingual expansion arch in males (2.4-3.4 mm) and females (1.8-2.5 mm).

5.1.3 Dental Angulation

There was no difference in dental angulation between the two groups prior to treatment (Table II). There was an increase in dental angulation from pre-treatment to post-treatment in the expansion and non-expansion group for the first premolars (Table VII). When we compared the two groups, the expansion group demonstrated an increase in dental angulation from pre-treatment to post-treatment for the first premolars (Table VIII). This indicates that the expansion treatment caused an increase in dental angulation at the level of the first premolars.

Northway & Meade (1997) reported no significant dental tipping following nonsurgical adult expansion, which contradicts the results of this study. Also in contradiction to this study are the findings of Handelman et al. (2000) who found a significant increase in molar angulation (6.2 +/- 11.5 degrees). A possible explanation to this is the varying design of the expanders. The expander utilized for this study was a standard Haas-type with bands on molars and first premolars connected with a buccal bar. The majority of cases treated by Handelman et al. (2000) used a modified Haas-type expander without buccal bars. Bassarelli et al. (2005) reported an increase in dental tipping that was associated with the degree of expansion, except for second premolars and first molars in females. The combined degree of tipping was significantly greater for the first premolars than molars in males (7.4 degrees versus 3.4 degrees) and females (6.8 degrees versus 1.3)(Bassarelli et al., 2005).

5.1.4 Palatal Vault Angle

There was a difference in palatal vault angle between the two groups prior to treatment at the level of the first premolars (Table II). There was no significant difference in palatal vault angle from pre-treatment to post-treatment in the expansion and non-expansion groups (Table IX). When we compared the two groups, there was no mean difference in palatal vault angle from pre-treatment to post-treatment (Table X). This indicates that the expansion treatment did not cause any notable alteration of the palatal architecture or dentoalveolar complex.

This contradicts previous studies, which reported an increase in palatal vault angle following nonsurgical adult expansion (Handelman et al., 2000). This also contradicts the superimposition of pre and post-treatment arches at the 1st molar in cross section that showed palatal vault expansion (Handelman et al., 1997). This may be partially explained by the smaller increase of transarch width found in this study. As mentioned previously, this may be due to the limited number of crossbites present prior to treatment.

5.2 Subject Selection

In an attempt to maximize numbers, all subjects meeting the previously outlined criteria were included in the expansion group. Subjects in the non-expansion group were selected to best match the expansion group in terms of gender and age. The expansion group was significantly narrower than the non-expansion group, which measured 27mm at the first premolar and 35mm at the first molar (Table II). This is similar to the measures of Handelman et al. (2000). The object of the selection of the two groups is that all pre-treatment parameters were the same with the exception of transarch width. This was achieved (Table II). The age of twenty was appointed as the minimal age of an adult. All initial and final records had to be available, thus excluding any patients who had nonsurgical expansion but still in active treatment. Models were also confirmed to be reasonably void-free and have a reproducible occlusion.

An existing crossbite was not a prerequisite for inclusion in the expansion group. In fact, 14 of the 26 presented with subjectively and objectively constricted upper and lower dental arches at pretreatment but without posterior crossbite.

5.3 Digital Model Analysis

Due to the intricacies and financial realities of transporting one hundred and thirty plaster models from the private practice in Minnesota to UIC, digitization of the study models was elected. The Lythos intraoral scanner was selected due to its portability and availability. Digitization allowed for seamless access of the digitized models and limited any chance of damage or alteration during transportation.

Geomagic Control 2014 proved an accurate method to convert intraoral scans to Ortho Insight 3D. The script utilized to orient the models was already written and available at the school. All but two of the 123 models were properly oriented using the script.

Utilization of Ortho Insight 3D allowed for accurate and reliable evaluation of the study models. All models were able to be magnified, rotated, and cross-sectioned while not adulterating the model. This proved useful when the identification of landmarks was questionable and in reliability testing when measurements had to be repeated. Distance calculations were precise as the real distance between points was determined with no limitation of caliber access.

Dolphin Imaging proved useful in analyzing dental angulation and palatal vault angle. The image produced with Microsoft Paint could be cropped and enlarged. The annotations and measurements feature produced accurate angles with no limitations to manual protractor approximation.

5.4 Additional Findings

The purpose of this study was to evaluate nonsurgical adult maxillary expansion and assess the gingival buccal attachment levels pre and post-orthodontic treatment. It is possible the periodontal consequences extend beyond the active treatment period. To evaluate this, an effort was made to recall as many patients two years or more out of treatment for retention records. Of the 26 adults included in the expansion group, 7 were able to contacted, scheduled and have impressions taken prior to initiation and IRB exemption of this study. There was no difference between the post-treatment and retention groups for all measurements, except for clinical crown height of the right first molar (0.72 mm)(Table XI). The number of individuals in the retention “group” was not enough to run definitive statistics.

5.5 Limitations of the Study and Future Research

There were several unavoidable limitations due to the retrospective nature of this study. We were satisfied with the number of the patients in the expansion and non-expansion group, however we intended to have more subjects in the retention group.

Due to the low numbers of patients with retention models, we were unable to be stricter with the minimum retention duration. It could be argued that a five or ten-year retention period would be more compelling than the elected two-year period.

It would be more credible to evaluate periodontal attachment levels directly with periodontal probing. Periodontal probing in adults with a healthy periodontium undergoing orthodontic treatment is not a standard of care and periodontal charting was not available at the practice where treatment was rendered. We thus decided to utilize clinical crown height, as it has been successfully implemented as an indirect quantifier of gingival recession (Handelman et al., 2000; Powell & McEniery, 1981; Northway & Meade, 1997).

It could further be asserted that gingival levels may not accurately reflect the level of buccal bone supporting the teeth. It is the opinion of some that nonsurgical adult expansion causes the teeth to perforate the buccal cortical bone, which predisposes to gingival recession (Vanarsdall, 1999). To address this concern, it may have been advantageous for the clinician to prescribe pretreatment and post-treatment cone beam computed tomography (CBCT) scans. Although possibly enlightening, no absolute conclusions on the presence of bone could be made without periodontal surgery to expose the bone levels as CBCT evaluation lends itself to false-positive detection of fenestrations and overestimation of dehiscence size (Sun et al., 2015). This is due to the buccal bone being thin and having similar density to cementum (Wood et al., 2013). Analysis of post-treatment CBCT scans would also presume any immature bone formed from expansion to have fully mineralized and thus be detectable.

No attempts were made to control for individual susceptibilities for gingival recession. The primary researcher did not have access to the photographic or examination records to distinguish between gingival biotype or frenal attachment level. A record of oral hygiene habits was also not available for interpretation. It was further not possible to separate males and females as males were underrepresented in both groups.

No true control group was included in this study as the non-expanded group still underwent active orthodontic treatment. The clinician utilized 022 brackets (022x028 mil), thus allowing for the option of stiffer and stronger arch wires. It was the intention of the authors to acquire a third group of pre-treatment and post-treatment study models of adults treated with wires that have large broad arch forms such as with the Damon system (Ormco); no such sample was located.

As all models were digitized directly from plaster models, the quality of both the impression and the pour-up were crucial. This was generally not an issue, however many presented with voids or distortion making landmark identification problematic. As intraoral scanners have become more practical for the average clinician, utilization of digital models obtained directly from patients in future studies would eliminate this concern.

Although confirmed by reliability testing, absolute accuracy and reliability of landmark identification was impossible. Measurement of clinical crown height and dental angulation assumed no attrition between time points, and transarch width, dental angulation, and palatal vault angle measurements assumed limited rotation of teeth between time points. The nature of the palatal vault angle – drawing a reference line tangent to the middle two-thirds of the palatal surface – is subjective due to the varying palatal architecture.

Future efforts should also consider investigation of less conventional adult expansion techniques such as TAD based expanders / miniscrew-assisted nonsurgical palatal expansion (MARPE), and conventional expanders in conjunction with surgically facilitated techniques such as Wilckodontics and microosteoperforation.

6. CONCLUSIONS

- There was a mean difference in gingival buccal attachment levels post-treatment for each of the non-surgically expanded adults and non-expanded adult groups.
- There was a statistically significant increase between non-surgically expanded adults and non-expanded adults for clinical crown height, transarch width and dental angulation especially in premolar areas.
- There was no statistically significant difference in palatal vault angle between non-surgically expanded adults and non-expanded adults.
- Digital model analysis was beneficial in analysis of all variables evaluated.
- Despite the statistically significant difference between non-surgically expanded adults and non-expanded adults, the amount of gingival buccal attachment loss was small and clinically acceptable.

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APPENDICIES

APPENDIX A

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Notice of Determination of Human Subject Research

March 4, 2015

20150273-88566-1

20150273-88566-1

David Goldberg
Orthodontics
801 South Paulina Street,
M/C 841
Chicago, IL 60612
Phone: (218) 209-8027

RE: **Protocol # 2015-0273**
Nonsurgical Adult Expression: A Second Look

Sponsor: None

Dear David Goldberg:

The UIC Office for the Protection of Research Subjects received your "Determination of Whether an Activity Represents Human Subjects Research" application, and has determined that this activity **DOES NOT meet the definition of human subject research** as defined by 45 CFR 46.102(f).

You may conduct your activity without further submission to the IRB.

If this activity is used in conjunction with any other research involving human subjects or if it is modified in any way, it must be re-reviewed by OPRS staff.

Phone: 312-996-1711 http://www.uic.edu/depts/ovcr/oprs/ Fax: 312-413-2929

VITA

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EDUCATION:	B.A., Biology, Society, & Environment. University of Minnesota – Twin Cities, Minnesota, 2008
	D.D.S., University of Michigan, Ann Arbor, Michigan, 2013
	M.S., Oral Sciences, University of Illinois at Chicago, Chicago, Illinois, 2016
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HONORS:	Donald A Kerr Award in Oral Pathology, 2011
	John T Richter Scholarship Award, 2008
	College of Liberal Art's Dean's List, Fall 2004, 2005, 2007
PROFESSIONAL MEMBERSHIP:	American Association of Orthodontists American Dental Association Chicago Dental Society Illinois Society of Orthodontists Illinois State Dental Society
EXPERIENCE:	