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Tooth Size Ratio in Orthodontic Patients with Varied Sagittal Skeletal Patterns; A CBCT Study

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LOMA LINDA UNIVERSITY
School of Dentistry
in conjunction with the
Faculty of Graduate Studies

Tooth Size Ratio in Orthodontic Patients with Varied Sagittal Skeletal Patterns; A CBCT Study

by

James Barra

A Thesis submitted in partial satisfaction of
the requirements for the degree
Master of Science in Orthodontics and Dentofacial Orthopedics

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September 2015

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT OF THE THESIS

Tooth Size Ratio in Orthodontic Patients with Varied Sagittal Skeletal Patterns;
A CBCT Study

by

James Barra

Master of Science Graduate program in Orthodontics and Dentofacial Orthopedics
Loma Linda University, September 2015
Dr. Kitichai Rungcharassaeng, Chairperson

Objective: Maxillomandibular tooth size ratio (TSR) is an important aspect in achieving a satisfactory orthodontic outcome. The purpose of this study is to compare TSR among orthodontically treated patients with different skeletal anteroposterior (AP) patterns.

Methods and Materials: The post-treatment (T2) cone beam computed tomograms (CBCTs) of patients treated orthodontically without extraction and finished with canine and molar class I occlusion were evaluated. The subjects were categorized into class I, class II and class III skeletal pattern by analyzing A point-Nasion-B point (ANB) at T2. Overbite (OB), overjet (OJ), TSR for canine to canine (TSR_{3-3}) and molar to molar (TSR_{6-6}), maxillary incisor to sella-nasion (U1-SN) angle, sella-nasion to mandibular plane (SN-MP) angle, lower incisor to mandibular plane (L1-MP) angle and interincisal angle (IIA) were measured and recorded. The data were compared using Kruskal-Wallis one-way analysis of variance and correlated using Spearman rank-correlation coefficient at $\alpha = 0.05$.

Results: Of the 128 patients, 68 were skeletally class I, 29 were class II, and 31 were class III. The overall mean values for TSR_{3-3} and TSR_{6-6} were 77.0% and 92.4%, respectively. Significant differences ($p < .05$) were observed in all parameters when compared among different skeletal patterns except for both TSR values ($p > .05$). TSR_{3-3} and TSR_{6-6} were correlated with each other ($\rho = 0.485$; $p < .001$) but bore no statistically significant relationship with any other parameter.

Conclusion: The TSR values for dental class I non-extraction orthodontic cases are similar regardless of skeletal pattern and comparable to Bolton's published values.

CHAPTER ONE

REVIEW OF LITERATURE

The most visible aspect of orthodontics, the alignment of canine to canine and how the upper "social six" relate to the lower and how that varies with certain confounding factors is one of the least well established in orthodontic literature. Angle provided one of the first estimates of "one third" varying according to temperament age and growth.[1] Strang estimated that the overbite approximated one third of the inciso-gingival length of the maxillary incisors, but affirmed that this was merely an approximation.[2] He went on to describe race, tooth morphology, and the anatomy of the individual as factors in determining the proper interincisal relationship.

Steadman recognized that curve of Spee, thickness of anterior teeth, and tooth size discrepancy could contribute to a high degree of variability in the final occlusion.[3] He concluded that the overbite was to be determined uniquely for the individual by examining the overjet in addition to the angulation of the upper incisor to the lower [a sentiment echoed by Magill[6], Prakash and Margolis[7], and Bishara and Jacobsen[8].][5] From an examination of the original ideal occlusal models, an average overbite of 3.1 mm ± 1.9 mm, average overjet of 1.6 mm ± 1.6 mm, and interincisal angulation of 35.7 degrees ± 2.5 degrees were observed.[4] The authors concluded that no normative values could be applied universally to a "good occlusion." This was supported by Bjork whose findings showed greater variability for overjet than that for overbite.[9]

It had been established that the twelve anterior teeth were of greatest concern to the patients and that tooth size discrepancy was an important factor in determining overbite and overjet.[39] In the Bolton's landmark article, 44 treated and 11 untreated "excellent occlusions" were examined[11]. A ratio of lower canine to canine to that of the upper was found to be 77.2% and for molar to molar 91.3%. While the individuality of patients was again acknowledged, a well-conceived analysis was devised that has been in continued use to the present. One admitted shortcoming in Bolton's study is a lack cephalometric evaluation. This was subsequently addressed by Ellis and McNamara in their comprehensive study of the best methods for cephalometrically evaluating position of incisors.[13] Despite their findings that the best analyses to assess incisal position are those that use nearby location such as the palate as a reference, the ABO has accepted the upper incisor to sella-nasion and lower incisor to mandibular plane (constructed gonion to menton) as its standard. With the limited side effects of cautious interproximal reduction, its been suggested that the orthodontist can work toward a set of normative or ideal values in striving to achieve optimal function and esthetics.[14]

Tooth size discrepancies (TSD) and their prevalence among various populations have been examined extensively, with most studies indicating that significant TSDs are underdiagnosed.[15] The level at which a TSD becomes significant has been a potential source of this underdiagnosis, with Bolton and subsequently Profitt citing 1.5 mm as the level at which point significance is reached.[16] A study showed that 30% of the patients in the sample fell outside of this category,[17] a much higher number than that obtained when applying the rule of 2 standard deviations as described in other studies.[15] Additionally, it has been observed that the method of measurement could lead to the discrepancies in reports which has caused some to reexamine the methods for analyzing TSD. Ho and Freer found that digital calipers will provide the most reproducible results and should be used when possible, a finding echoed by Zilberman et al.[18,19] Regardless of method of measurement, studies largely concur that patients with class III malocclusion have the largest probability of having a significant TSD, followed by patients with Class I which in turn is more common than those with class II.[20-22] A review of the literature reveals little if any significant relationship to ethnicity or gender.[23] For patients having premolar extractions for orthodontic purposes, Bolton found that overall ratio is usually lowered as the mandibular second bicuspids to be extracted are typically larger than their maxillary counterparts.[12]

Recently, digitization and the use of cone beam computed tomography (CBCT) have impacted nearly every aspect of orthodontics.[26,27] Tooth size measurements are not exempt from this treatment.[28] Tomasetti et al demonstrated clinically significant differences between 3 methods of digitized model measurements and those achieved traditionally with stone and vernier calipers.[24] Baumgartel et al, however, found only slight statistical difference between tooth size measurements gathered from models and those taken from CBCT.[25] They suggested these differences were not clinically significant. Tarazona et al found no clinically significant difference between CBCT measurements and digitized versions of plaster casts.[26] Other studies have confirmed this finding.[27,28] Further still, Lagravere suggested mean CBCT measurements were not 1mm or 1° different from a coordinate measurement machine, the standard for accuracy in measurement.[28] These findings suggest that CBCT can be used as a reliable means of calculating not only tooth size measurements, bur other linear and angular measurements as they apply to orthodontics.

In addition to the relationship of tooth mass of the maxilla with the tooth mass of the mandible, many other factors have been studied and used as predictors of final occlusal outcomes. In the early days of cephalometrics, Margolis constructed the maxillofacial triangle to attempt to determine ideal characteristics for treatment for a "nonprognathous, well-developed face."[29] Tweed as well as Ricketts acknowledged that the maxillofacial complex for people with ideal occlusions often fell within certain normal limits, and that varying the relationship of the bones required alterations in the expected positions of the dentition.[30,32] Solow's landmark article suggested that significant correlations between craniofacial landmarks exist in all planes of space, such that can be predictive of other factors and growth.[33] While Ludwig found no correlation between facial pattern and pretreatment and post retention angulation of maxillary or mandibular incisors, interincisal angulation or overbite, he did find a relationship between interincisal angulation and overbite.[35] Recently the relatedness of each of these factors have been used to reject historic "ideal" normative values[41] and build a case for "floating norms" as means of predicting what results can be expected as certain variables are altered.[42,43] It is this concept that serves as the basis for the research conducted herein.

The purpose of this study was to compare TSR among orthodontically treated patients with varied skeletal anteroposterior (AP) relationships. The correlations between TSR and other dental and skeletal components were also evaluated.

CHAPTER TWO

TOOTH SIZE RATIO IN ORTHODONTIC PATIENTS WITH VARIED SAGITTAL SKELETAL PATTERNS; A CBCT STUDY

Abstract

Objective: Maxillomandibular tooth size ratio (TSR) is an important aspect in achieving a satisfactory orthodontic outcome. The purpose of this study is to compare TSR among orthodontically treated patients with varied skeletal anteroposterior (AP) relationships.

Methods and Materials: The post-treatment (T2) cone beam computed tomograms (CBCTs) of patients treated orthodontically without extraction and finished with canine and molar class I occlusion were evaluated. The subjects were categorized into class I, class II and class III skeletal pattern by analyzing A point-Nasion-B point (ANB) at T2. Overbite (OB), overjet (OJ), TSR for canine to canine (TSR_{3-3}) and molar to molar (TSR_{6-6}), maxillary incisor to sella-nasion (U1-SN) angle, sella-nasion to mandibular plane (SN-MP) angle, lower incisor to mandibular plane (L1-MP) angle and interincisal angle (IIA) were measured and recorded. The data were compared using Kruskal-Wallis one-way analysis of variance and correlated using Spearman rank-correlation coefficient at $\alpha = 0.05$.

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and TSR_{6-6} were correlated with each other (ρ =0.485; $p < .001$) but bore no statistically significant relationship with any other parameter.

Conclusion: The TSR values for dental class I non-extraction orthodontic cases are similar regardless of skeletal pattern and comparable to Bolton's published values.

Introduction

The relationship of the size and position of anterior teeth relative to the opposing arch and the maxillofacial complex with the ultimate occlusion is of the utmost importance in orthodontics. Angle and Strang suggested that the overbite approximated one third of the inciso-gingival length of the maxillary incisors but recognized that myriad factors affected these values.[1,2] Others found similar results but concluded that despite trends, no normative values could be applied universally to a "good occlusion."[3-10] In Bolton's landmark article, individuality of patients was again acknowledged, however a well-conceived analysis was devised to provide treatment goals based on the aforementioned trends as relates to tooth mass of one arch relative to the other.[11] He subsequently suggested adjustments be made to these values to compensate for premolar extractions as part of orthodontics treatment.[12] These studies were later confirmed and expounded upon with the aid of cephalometrics.[13] With the limited side effects of cautious interproximal reduction, it has been suggested that the orthodontist can work toward a set of normative or ideal values in striving to achieve optimal function and esthetics.[14]

Tooth size discrepancies and their prevalence among various populations have been examined extensively, with most studies indicating that significant TSDs are underdiagnosed.[15] Bolton and Profitt cite 1.5 mm as the level at which point significance is reached.[12,16] One study showed that 30% of the patients in the sample fell outside of this category, a much higher number than that obtained when applying the rule of 2 standard deviations as described in other studies.[15, 17] Additionally, it has been observed that the method of measurement could lead to the discrepancies in reports which has caused some to reexamine the methods for analyzing TSD. Several studies suggest that digital calipers will provide the most reproducible results and should be used when possible.[18,19] Regardless of method of measurement, studies largely concur that patients with class III malocclusion have the largest probability of having a significant TSD, followed by patients with Class I occlusion which in turn is more common than those with class II.[20-22] A review of the literature reveals little if any significant relationship to ethnicity or gender.[23]

Recently, digitization and the use of cone beam computed tomography (CBCT) have impacted nearly every aspect of orthodontics. Tooth size measurements are not exempt from this treatment. Clinically significant differences have been noted between three methods of digitized model measurements and those achieved traditionally with stone and vernier calipers.[24] Others, however, found only slight statistical and non-clinically significant difference between tooth size measurements gathered from models, plaster or digitized, and those taken from CBCT.[25-28]

Many factors in addition to tooth size have been studied and used as predictors of final occlusal outcomes since the nascent days of cephaolometrics. The intellectual pillars of orthodontics have constructed systems and norms to predict occlusal outcomes and direct ideal treatment plans from dental and skeletal realtionships.[29-40] Recently the relatedness of each of these factors have been used to reject or modify historic “ideal” normative values[41] and build a case for “floating norms” as means of predicting what results can be expected as certain variables are altered[4,1-43]. It is this concept that serves as the basis for the research conducted herein.

The purpose of this study was to compare TSR among orthodontically treated patients with varied skeletal anteroposterior (AP) relationships. Further, it was our goal quantitatively evaluate CBCT records of treated cases with a variety of skeletal anteroposterior (AP) discrepancies to find the relationship of incisors to their opposing teeth by establishing interincisal angle, overjet, overbite, and tooth size relationship (TSR.) It was necessary to evaluate the incisors' relationship to their internal and external references such as lower incisor to mandibular plane and upper incisor to sella-nasion. Any relationship between the variables and their impact on the treated result was to be determined through statistical analysis.

Patient Selection

This study was approved by the Institutional Review Board of Loma Linda University, California, USA. Included in the study were patients treated orthodontically since January 2009 at the Graduate Orthodontic Clinic, Loma Linda University School of Dentistry who had completed active orthodontic treatment and finished with class I canine and molar occlusal outcomes. The Newtom 3G or 5G (AFP Imaging Corporation, Elmsford, NY) was used to obtain post-treatment (T2) images the day active orthodontic treatment was completed. Class I was defined as those cases within 1 standard deviation of ANB (0-4°) and those above and below those values were noted as Class II and Class III, respectively. The occlusal result was only found to be ideal if both the cusp tips of the maxillary canines were within 1 mm of the embrasures created by the mandibular canines and first premolars and the mesiobuccal cusps of the first maxillary molars were within 1 mm of the buccal groove of the mandibular first molar.

Data Collection

Demographic information for each patient was collected from the patient's record. This includes gender, age at time of treatment completion and ethnicity. It is standard procedure at Loma Linda University to obtain 12 inch field of view CBCT scans on patients prior to orthodontic treatment and at the completion of orthodontic treatment. The 12 bit grayscale CBCT scans were performed at 110 kV and a scan time of 36s. Smart-beam technology automatically sets the radiation level based on the patient's anatomical density so mAs values fluctuate with a maximum of 15 mAs. Patients were scanned in supine position, utilizing a chin and shoulder rest, as well as a vertical sighting beam to ensure accurate and repeatable positioning of the subjects. The NewTom 3g or 5g data of each patient was reconstructed with 0.5 mm slice thickness and the DICOM (Digital Imaging and Communications in Medicine) images were assessed using OsiriX MD (Pixmeo SARL, Bernex Switzerland.) All measurements were performed by one examiner. Linear and angular measurements were made to the nearest 0.01 mm and 0.01 degree respectively. The following parameters were evaluated and recorded:

Fig. 1 Cephalometric Measurments from CBCT

- A point – Nasion – B point (ANB): ANB was measured as the internal angle created by the intersection of line segments A point –Nasion and B point – Nasion.

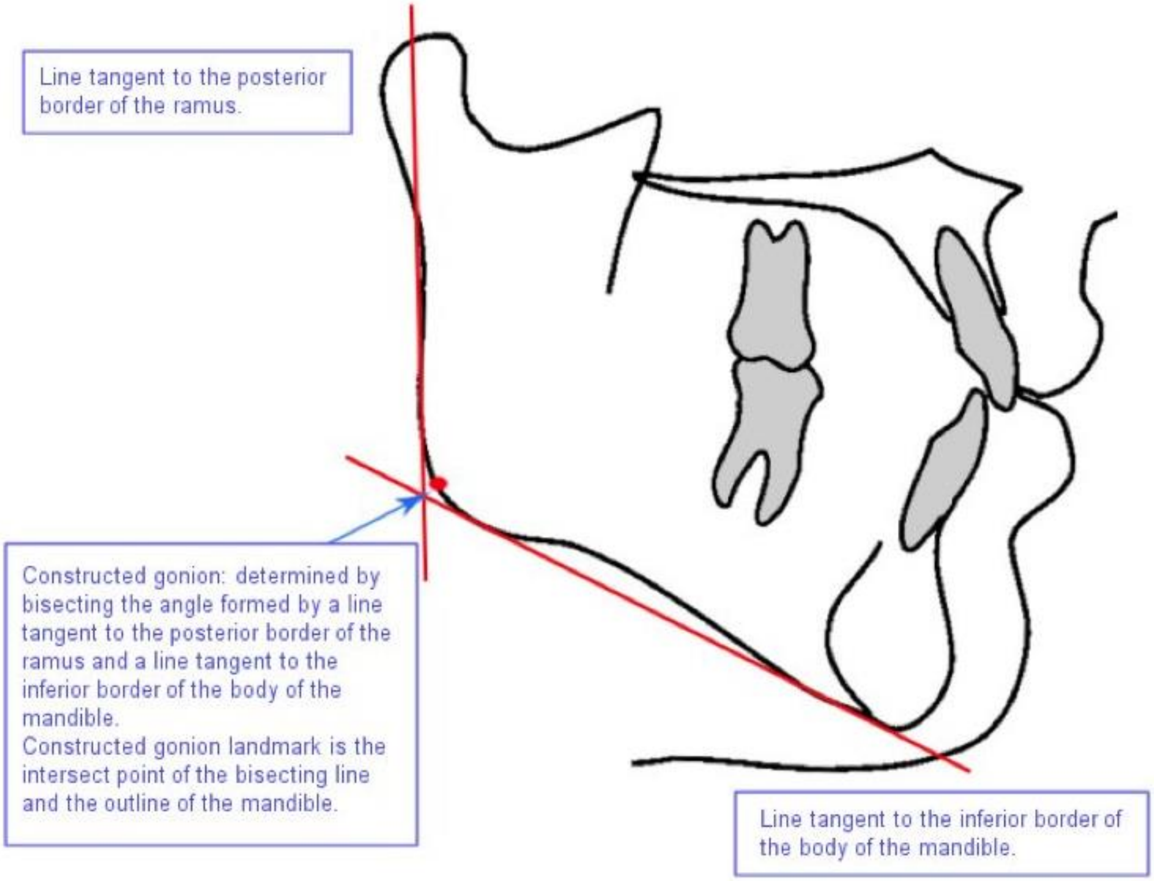

Fig. 2 Constructed Gonion as used in Mandibular Plane as per ABO (2013)

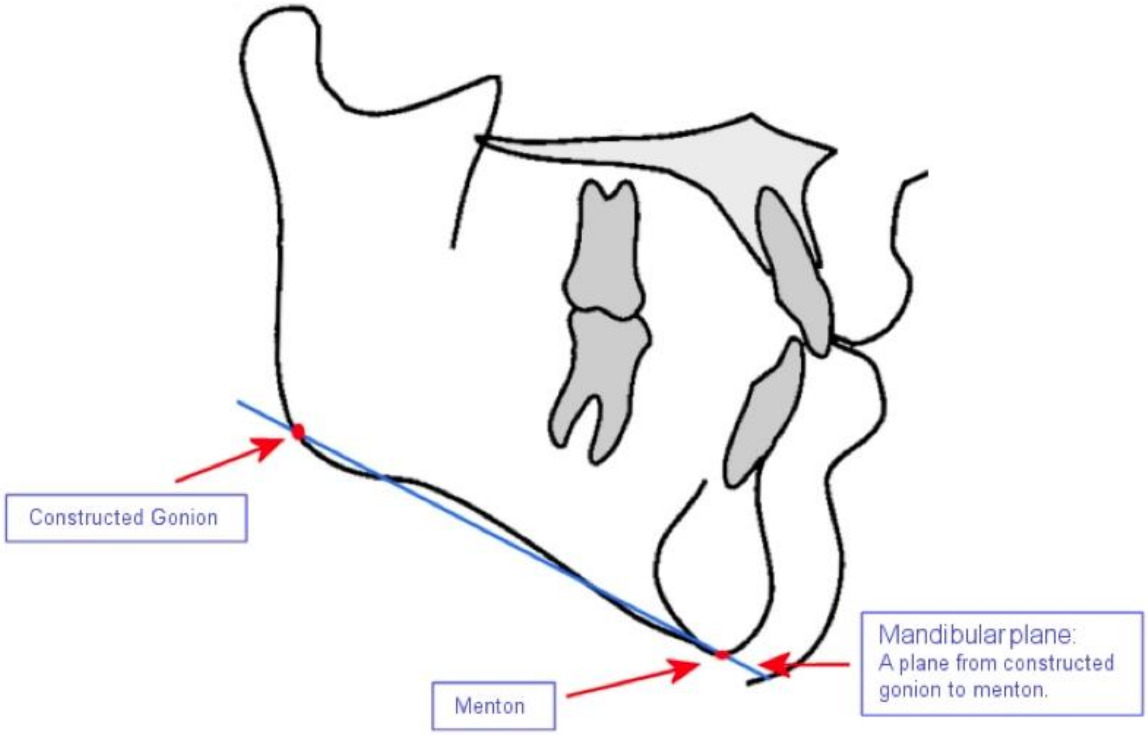

Fig. 3 Construction of Mandibular Plane as per ABO (2013)

- Lower incisor to mandibular plane (L1-MP): The lower incisor to mandibular plane was measured from the long axis of the tooth (from the incisal edge to the center of the apex) to the mandibular plane defined as Constructed Gonion to Menton by the ABO.
- Interincisal angle (IIA): The interincisal angle was measured at the point of intersection of the long axes of the upper and lower incisors. This differs from Bolton in that it is a value taken from the cephalogram and revolves around the long axis of the entire tooth as opposed to the coronal long axis.
- Upper incisor to Sella-Nasion (U1-SN): The angle created by the long axis

of the maxillary central incisor (from the incisal edge to the center of the apex) and a line connecting Sella and Nasion as defined by the ABO.

- Sella – Nasion to Mandibular plane (SN-MP): SN-MP was measured as the internal angle created by the intersection of the line segments Sella – Nasion and the mandibular plane as defined above.

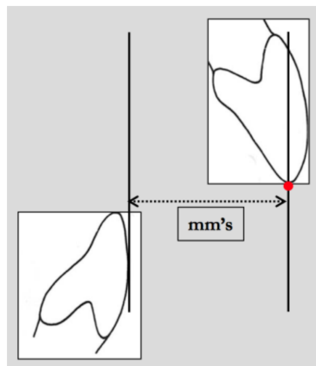

Fig. 4 Measurement of Overjet as per ABO (2013)

- Overjet (OJ): OJ is to be measured between "two antagonistic anterior teeth (lateral or central incisors) comprising the greatest overjet and is measured as a line segment from the facial surface of the most lingual mandibular tooth to the middle of the incisal edge of the more facially positioned maxillary tooth parallel to the occlusal plane.

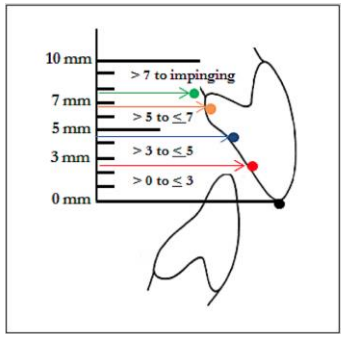

Fig. 5 Measurement of Overbite as per ABO (2013)

- Overbite (OB): OB is to be measured between "two antagonistic (lateral or central incisors comprising the greatest overbite." This is to be recorded as a millimetric measurement by placing a point on the labial surface of the lower incisor from a line that is parallel to the occlusal plane and intersects the incisal edge of the maxillary central incisor. The length of a line segment perpendicular to the occlusal plane from this point to a line parallel to occlusal plane that passes through the incisal tip of the lower central incisor is to be measured millimetrically.

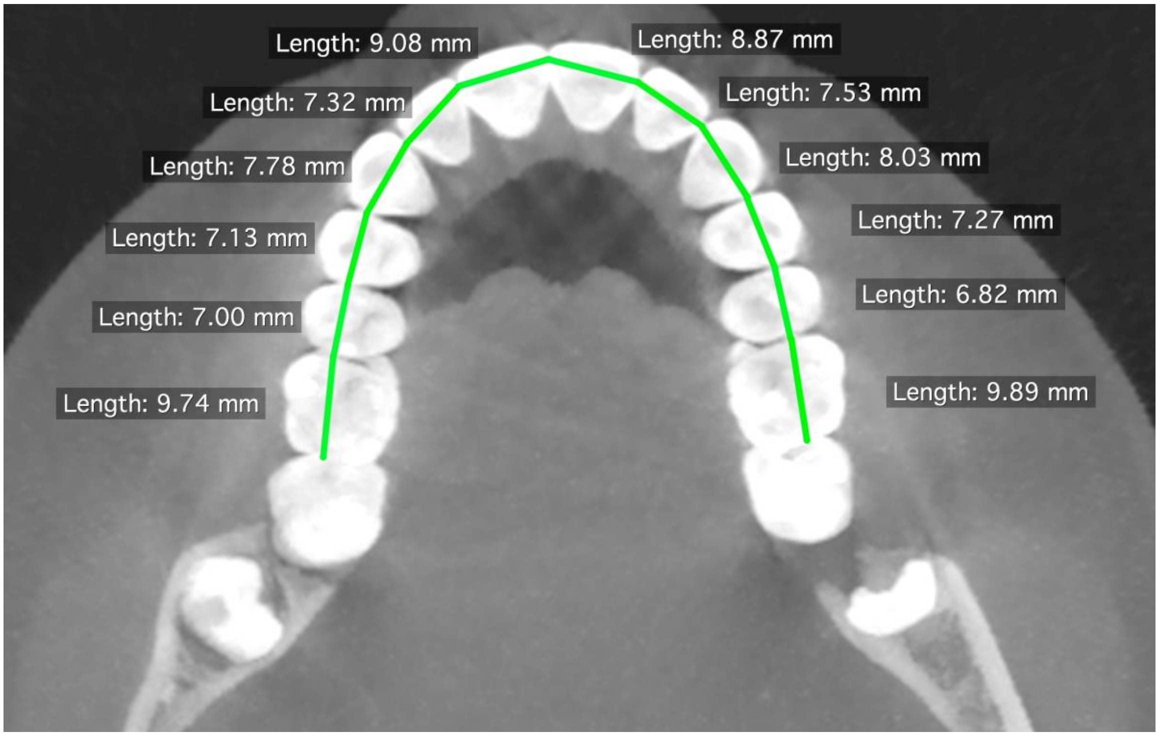

Fig. 6a Tooth Size Relationship Measurement Maxilla

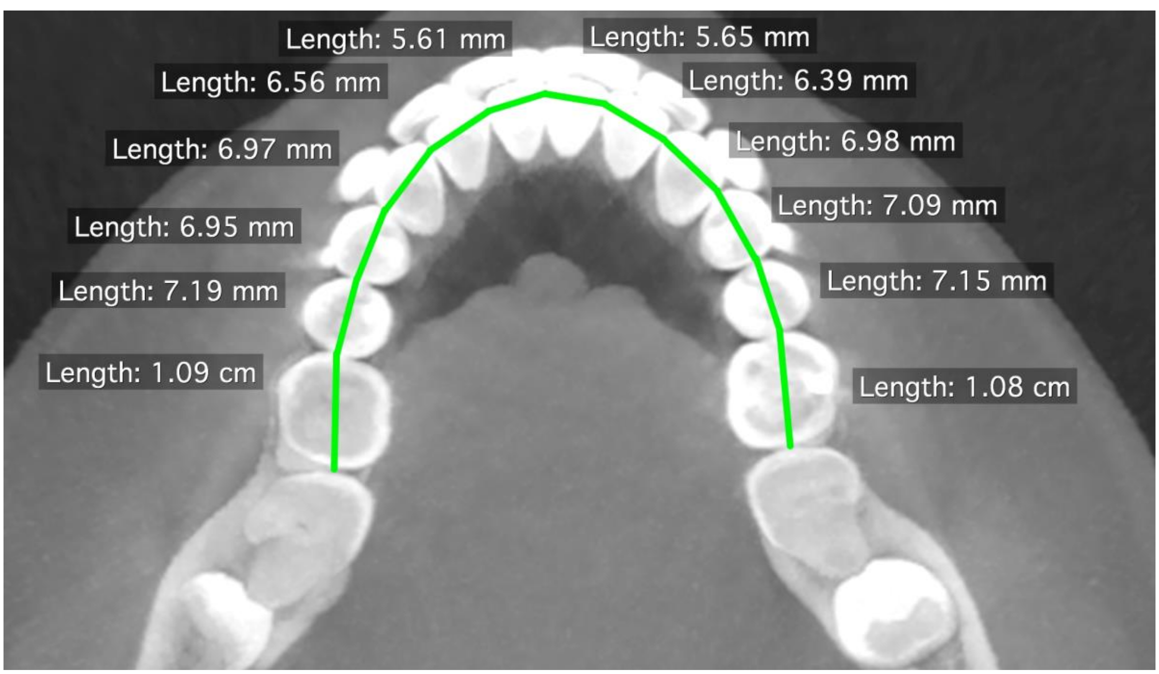

Fig. 6b Tooth Size Relationship Measurement Mandible

- Tooth size ratio (TSR): Mesial-distal width of each tooth, from right first molar to left first molar will be measured and recorded from the CBCT. The sum of tooth width (STW) from molar-to-molar (6-6) and canine-to-canine (3-3) of each arch will be recorded and the ratios of $MdSTW_{6-6}/MxSTW_{6-6}$ and $MdSTW_{3-3}/MxSTW_{3-3}$ calculated as TSR_{6-6} and TSR_{3-3}, respectively. These values are to be found by scrolling vertically to find the contact points for each tooth, creating line segments, propagating these measurements throughout the entire series, and summing the measurements.

Exclusion criteria included: (1) either maxillary canine being more than 1 mm mesial or distal of the contact created by the mandibular canine and 1st premolar, (2) either molar being more than 1 mm from the mesiobuccal groove of the lower 1st molar (3) having extractions of bicuspids as part of orthodontic treatment (4) congenitally or otherwise missing dentition from 1st molar to 1st molar in either arch (5) and lack of anterior incisal contact.

Statistical Analysis:

The intra-examiner reliability of the measurements were assessed and assured by recording double measurements on 20 records (CBCT) at least two weeks apart and expressed as the intraclass coefficient (ICC). Means and standard deviations were measured and reported for all parameters. Analysis was made using Spearman rank-correlation coefficient. Regression analysis to find any relationship between the variables was performed after all measurements were made. The measures as well as trends observed of these treated cases were presented by the most contemporarily accepted and thoroughly explanatory means possible. Statistical significance was accepted when $p<0.05$. Comparison of parameters was made according skeletal relationship using Kruskal-Wallis one way analysis of variance.

CHAPTER THREE

RESULTS

This study included 128 patient subjects used to evaluate dental and skeletal relationships with class I molar and canine occlusion. Patients were classified on the basis of T2 ANB. Of the 128 patients, 68 were skeletally class I, 29 were skeletally class II and 31 were skeletally class III. ICC values were very high for intra-examiner ($r \geq 0.918$) data, indicating that the identification methods were reliable and reproducible.

Table 2 displays the means and standard deviations of all parameters for each subgroup of patients across all parameters while table 3 displays mean values for the total patient population. When comparing the L1-MP, IIA, U1-SN, SN-MP OJ, and OB across class I, II and III for ANB using Spearman's rank-correlation coefficient, statistically significant differences were found in all parameters ($p<0.01$) [Table 1]. No significant correlation was found between ANB and either TSR value. Correlations for each variable as summarized in Table 1 follow.

The only factor showing significant correlation with TSR_{3-3} is TSR_{6-6}. The factors not significantly correlated with TSR_{3-3} are 1) ANB 2) L1-MP 3) Interincisal angle 4) U1-SN 5) Overjet 6) Overbite 7) SN-MP. The complementary statement is true of TSR_{6-6}..

Table 3; Mean ± SD of Different Parameters Among Patients with Class I Canine and Molar Dental Occlusion

	Total Population (n=128)
ANB (°)	1.99 ± 2.90
	[2.19; -7.7 – 9.20]
L1-MP (°)	98.01 ± 8.72
	[98.52; 77.09 - 121.98]
IIA (°)	119.61 ± 9.27
	[119.40; 100.00 - 141.39]
U1-SN (°)	108.89 ± 8.14
	[108.13; 84.89 – 131.46]
SN−MP (°)°	33.49 ± 6.30
	[33.20; 18.18 - 56.52]
OJ (mm)	2.47 ± 0.74
	[2.46; 0.68 - 4.13]
OB (mm)	2.38 ± 0.70
	[2.47; 0.80 - 4.22]
TSR3-3 (%)	77.0 ± 2.8
	[77.0; 68.7- 85.2]
TSR6-6 (%)	92.4± 2.0
	[92.4; 87.8 – 98.8]

Table 2; Comparison of Mean ± SD of Different Parameters Among Patients with Different Skeletal Classification using Kruskall-Wallis test, and correlated using Spearman's Rho at α = 0.05.

	Mean ± SD [Median; Range]			
	Class I (n = 68)	**Class II (n = 29)**	**Class III (n = 31)**	P-value
ANB (°)	2.11 ± 1.02	5.76 ± 1.43	-1.81 ± 1.43	
	[2.24; 0.03 - 3.88]	[5.38; 4.04 - 9.20]	[-1.09; -7.76 - -0.21]	
L1-MP (°)	98.52 ± 7.94[a]	101.94 ± 9.37[a]	93.22 ± 7.90[b]	0.001**
	[98.99; 77.09 - 112.35]	[100.93; 80.01 - 121.98]	[93.79; 77.15 - 105.14]	
IIA (°)	120.37 ± 8.74[a, b]	115.75 ± 8.26[a]	121.59 ± 10.62[b]	0.037*
	[119.39; 103.20 - 141.39]	[115.75; 100.00 - 134.44]	[122.77; 105.59 - 137.50]	
U1-SN (°)	107.79 ± 6.62[a]	105.22 ± 8.86[a]	114.72 ± 7.80[b]	0.000**
	[106.60; 92.58 - 126.29]	[104.97; 84.89 - 118.52]	[115.32; 93.24 - 131.46]	
SN–MP (°)°	33.32 ± 6.26[a]	37.09 ± 6.82[a]	30.48 ± 4.04[b]	0.000**
	[33.20; 18.18 - 50.52]	[35.96; 25.75 - 56.50]	[30.76; 18.63 - 37.12]	
OJ (mm)	2.60 ± 0.73[a]	2.83 ± 0.70[a]	2.02 ± 0.57[b]	0.000**
	[2.51; 0.68 - 4.13]	[2.75; 1.56 - 4.12]	[2.06; 1.01 - 3.09]	
OB (mm)	2.43 ± 0.72[a]	2.61 ± 0.60[b]	2.05 ± 0.65[a]	0.004**
	[2.51; 0.80 - 4.22]	[2.61; 1.20 - 3.88]	[1.88; 0.99 - 3.41]	
TSR3-3 (%)	77.5 ± 2.7	76.9 ± 3.2	76.4 ± 2.8]	0.216
	[77.2; 69.9 - 85.2]	[76.7; 68.7 - 83.7]	[76.5; 71.1 - 82.1]	
TSR6-6 (%)	92.6 ± 1.9	92.4 ± 2.7	91.9 ± 1.6	0.129
	[92.9; 87.8 - 96.1]	[92.4; 88.1 - 98.8]	[91.8; 88.8 - 95.7]	

n = 128

** is significant at <0.05 * is significant at <0.01

Table 1; Spearman's Rank Correlation Coefficient (ρ) Among All Parameters

		ANB	L1-MP	IIA	U1-SN	OJ	OB	SN−MP	TSR 3-3	TSR 6-6
ANB	ρ	1.000								
	Sig. (2-tailed)									
L1-MP	ρ	.366**	1.000							
	Sig. (2-tailed)	.000								
Interincisal Angle	ρ	-.240**	-.656**	1.000						
	Sig. (2-tailed)	.006	.000							
U1-SN	ρ	-.425**	-.042	-.466**	1.000					
	Sig. (2-tailed)	.000	.640	.000						
Overjet	ρ	.408**	.415**	-.384**	-.092	1.000				
	Sig. (2-tailed)	.000	.000	.000	.301					
Overbite	ρ	.353**	.229**	-.109	-.155	.566**	1.000			
	Sig. (2-tailed)	.000	.009	.220	.080	.000				
SN−MP	ρ	.397**	-.276**	-.043	-.394**	.163	.044	1.000		
	Sig. (2-tailed)	.000	.002	.629	.000	.066	.624			
TSR$_{3-3}$	ρ	.037	.113	-.129	.034	.044	-.068	.042	1.000	
	Sig. (2-tailed)	.678	.206	.148	.704	.620	.444	.635		
TSR$_{6-6}$	ρ	.043	.004	-.066	.023	.023	.021	.147	.485**	1.000
	Sig. (2-tailed)	.632	.966	.456	.797	.794	.813	.097	.000	

n = 128
** is significant at <.05
* is significant at <.01

Discussion

TSR is an important aspect in orthodontic treatment requiring careful consideration in diagnosis and treatment planning.[11,15,20-23] TSDs were prevalent in the population observed in the present study, a finding corroborating the up to 30% of patients found to have a significant TSD in the literature.[15,51] There was no significant difference in TSR amongst different skeletal patterns. Further, there was no correlation between TSR and any parameter aside from the other TSR values. The means values for tooth size ratio from canine to canine are smallest in the class III group and largest in the class II subgroup, however, the difference is not statistically significant. The class III group again had the smallest mean value for tooth size ratio for molar to molar, but again this value was not statistically significant. This supports several of the studies previously mentioned. Crosby,[15] Alkofide,[20] and Araujo[21] found no significant difference in TSR amongst the different sagittal groups. It is in contrast, however with the results found by Nie and Lin.[22] The results of the present study seem to indicate that the position of the teeth within their foundation and relative to the opposing arch play a greater role.

The patients with skeletal class II sagittal relationship exhibited the highest L1-MP of all three subgroups, with the class I subgroup being over three degrees less and that of the class III subgroup being nearly nine degrees less. These differences are statistically and potentially clinically significant. L1-MP bears a correlation with all factors aside from tooth size ratio and U1-SN. Interestingly, the patients with a class I canine exhibited a mean L1-MP of 98.52 ± 7.94, a number far from the ideal 90 degrees suggested by Tweed. It must be noted, however, that dental occlusion was the only criteria used in determining the ideal occlusal relationship. Further, these values represent only cases treated without extractions, likely leading to incisors that are skewed to mean values that are more proclined for incisors and differences in TSR as noted in other studies.[12] Importantly, facial appearance and resultant periodontal status were not within the purview of this study, and attempts to use these numbers to establish ideal profiles would be misguided.

It is clear that the position of the mandibular incisor is affected by sagittal skeletal relationship, and the maxillary incisor is complementarily impacted. Less clear is the relationship between AP skeletal position and other skeletal parameters. Class II patients were significantly more dolichofacial, class III patients were less so, and class I patients were more mesiofacial. The class III patients had the most obtuse interincisal angle, though it was within nearly one degree of that for class I patients, a value that is not clinically significant. The class II patients had the most acute interincisal angle, six degrees more so than the class III patients. Additionally, the class II patients exhibited a mean overjet almost a millimeter more than that found in class III patients. Class I patients again exhibit a value between the others. As the interincisal angle becomes more acute, the mean values for overjet are larger. Similarly, the overjet is higher on average in patients in the class II subset compared with class III patients, with class I patients between the two again.

The study confirms many associations that have been common historically in the literature.[1-10] It also shows that within a group of patients most dental professionals would consider to have ideal dental canine and molar occlusion, there exists wide variation in both skeletal and dental relationships. Trends and correlations exist between the components of the maxillofacial complex. If the class I molar and canine occlusion is held as a constant, variation in one area requires adjustment in others, and this CBCT study helps to deepen the understanding of those relationships as relates to TSR.

Conclusion

Within the limitations of this study, the following conclusions can be made:

1. The TSR values for dental class I non-extraction orthodontic cases are similar regardless of skeletal pattern and comparable to Bolton's published values.
2. The measurements of tooth mass of anterior and their relationship to the opposing arch show significant correlation between those measurements of the total arch, and vice versa. Neither of these measurements, however, shows any significant correlation with the others factors studied.
3. ANB shows significant correlation with all factors studied except those relating to tooth size relationship. These include the box created by IIA, U1-SN, SN-MP, and L1-MP. Additional factors with significant correlation to ANB are OJ and OB
4. There was no significant correlation between U1-SN and L1-MP, IIA and SN-MP, and OJ and IIA.
5. L1-MP, the value made famous by Tweed, is the only other factor correlated with five factors, only lacking correlation with the Bolton numbers like all other factors and U1-SN.
6. Class II skeletal patients had deeper resultant bites with more overjet. Maxillary incisors for these patients were more retroclined, while mandibular incisors were more proclined. Class II patients were more dolichofacial and had more acute interincisal angles. Class III patients represented the opposite end of the spectrum in

all of these categories, with class I patients in the middle.

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