A COMPARISON OF MAXILLO-MANDIBULAR TRANSVERSE WIDTH RATIOS IN PATIENTS WITH CLASS III ANTEROPOSTERIOR DISCREPANCIES

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A COMPARISON OF MAXILLO-MANDIBULAR TRANSVERSE WIDTH RATIOS IN PATIENTS WITH CLASS III ANTEROPOSTERIOR DISCREPANCIES

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DEDICATION

I would like to dedicate this thesis to my family for always supporting me in every endeavor. To my husband, Linh, thank you for your constant love and support. Thank you, Emma and Branden, for giving me so much love and happiness. Finally, I would like to thank my parents who always made me believe that any dream was possible.

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ABSTRACT

Introduction: With the emergence of Cone-Beam Computed Tomography (CBCT), it enabled improved evaluation of maxillary and mandibular transverse widths.

Historically, orthodontic diagnosis solely utilized the use of lateral cephalometric radiographs which gave a two-dimensional assessment of a three-dimensional entity. The transverse dimension is understudied compared to the vertical and anteroposterior (AP) dimensions. The only analysis currently available uses only posterior landmarks to diagnose transverse discrepancies. We can determine where treatment should be focused if there are transverse differences in the population and improve our diagnosis thus providing our patients with the best treatment outcome. The purpose of this study was to compare the maxillo-mandibular transverse widths in a sample of a Class I patient population to a Class III patient population sample. This study will demonstrate if there is an AP discrepancy, will a concurrent transverse discrepancy exist. If so, it will document what the significance is of the transverse difference between the Class I and III patient populations. **Method:** Pretreatment CBCT images of 30 Class I patients (Class I), 30 Class III patients due to maxillary hypoplasia (Class IIIR), and 30 Class III patients due to mandibular hyperplasia (Class IIIP) were utilized. Linear transverse measurements were made from anterior and posterior landmarks in the maxilla and mandible. From these linear measurements, a maxillo-mandibular anterior and posterior ratio was calculated. **Results:** A significance at the $p<0.05$ level were found to exist in the anterior maxillo-mandibular ratio of the infraorbital foramina to the mandibular canine

root apices between the Class I and both Class III groups and in the area of the maxillary canine root apices to the mandibular canine root apices between the Class I and both Class III groups. A significance was observed in the Class III R group with the posterior maxillo-mandibular ratio of the maxillary first molar root apices to the lingula and the maxillary first molar root apices to the alveolar ridge at the mandibular first molar. **Conclusions:** Bilateral transverse linear width measurements showed that the Class III due to a retrusive maxilla patient population showed narrower dimensions in both the anterior and posterior maxilla and mandible compared to the Class III due to a hyperplastic mandible patient population. The Class III due to a hyperplastic mandible patient population demonstrated larger intercanine and intermolar widths in the maxilla and mandible compared to the Class I and Class III due a retrusive maxilla patient populations.

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I. BACKGROUND AND LITERATURE REVIEW

A. Background

In the field of Orthodontics, radiographic assessment historically consisted of the lateral cephalometric analysis of the three dimensions of the craniofacial complex. Although, the lateral cephalogram provides information in the anteroposterior and vertical dimensions it lacks diagnostic information about the transverse dimension therefore offering two-dimensional measurements about a three-dimensional entity. The transverse dimension can be radiographically measured only in the posterior-anterior cephalogram (PA). Ricketts developed the Rocky Mountain Analysis and he devised norms and chose radiographic landmarks and measurements to assess transverse discrepancy between the maxilla and mandible (Betts et al 1995). These landmarks were JR (jugale right), JL (jugale left), AG (antigonion right), GA (antigonion left), ZR (zygomatic right), and ZL (zygomatic left). By utilizing these landmarks, effective maxillary width, effective mandibular width, and the frontolateral facial lines could be constructed. The effective maxillary width is the linear measurement between the points JL and JR. The effective mandibular width is the linear measurement between AG and GA points. The frontolateral facial lines are the two lateral lines connecting ZR, ZL to the points AG and GA. These landmarks allow us to arrive at two differential measurements used to evaluate transverse deficiencies radiographically. The first is the Maxillomandibular Width Differential and the second is the Maxillomandibular Transverse Differential Index. The Maxillomandibular Width Differential is measured from the frontolateral facial line to JL and JR along the effective maxillary width line and compared to a normal value of

10+/- 1.5 mm. If this radiographic measurement exceeds 10 mm, a transverse discrepancy exists between the maxilla and mandible. The Maxillomandibular Transverse Differential Index is the expected maxillomandibular difference subtracting the actual measured maxillomandibular difference. The expected maxillomandibular difference is the age appropriate-expected AG-GA distance minus the age appropriate expected J point-J point distance. The actual maxillomandibular difference is the actual AG-GA measurement minus the actual J point-J point measurement (Betts et al 1995). If the Maxillomandibular Transverse Differential Index is greater than 5 mm, the patient may require a surgically assisted expansion. If the differential index is less than 5 mm, orthodontic or orthopedic expansion may be adequate.

Although the posterior anterior (PA) cephalogram provides important diagnostic information, it has some disadvantages. First, it requires that a patient takes another radiograph thus increasing his/her exposure to radiation and is dependent upon how the patient's head was orientated when the radiograph was captured. In addition, it has been difficult to visualize pertinent structures due to superimposition from other structures. Use of the antegonial notch as the sole landmark to measure the width of the mandible is another shortcoming of the PA radiograph. The antegonial notch is not actually a landmark but is the most superior point along the curvature of the inferior border of the mandible anterior to the gonial angle which is very subjective during identification of the point. A disparity between the use of PA and lateral cephalograms was identified with only 13% of Orthodontists routinely using the PA

cephalogram compared to 69-82% for lateral cephalograms (Gottlieb 1990). This was found to be due to a shortage of accepted landmarks in the PA cephalogram, additional radiation exposure to the patient, and errors due to head orientation relative to the film.

CBCT or Cone Beam Computed Tomography offers a vast potential for 3D diagnosis and treatment planning compared to conventional radiographs. The image is acquired by a production of a three dimensional image by computer software that builds the image from voxels (the volumetric base image unit). A CBCT can allow us to reconstruct frontal and lateral cephalometric images. In addition, it allows making slices of any plane (coronal, sagittal, or axial) further increasing the diagnostic ability of the transverse dimension. The problem of the orientation of the patient head is alleviated due to the ability to reorient the head using the imaging software. Although the CBCT is advantageous for many reasons, there are some negative qualities. The CBCT image shows less fine detail, decrease in contrast, increase in background noise, and increased susceptibility errors due to movement. Also, if the orthodontist utilizes the CBCT in his/her practice, someone qualified to diagnosis radiographic pathology is required to analyze each CBCT captured.

Concerns about increased exposure to radiation by taking a CBCT has surfaced. Most of the scans used in Orthodontics expose the patient to approximately 30-80 microsieverts compared to about 24 microsieverts for a digital panoramic and lateral cephalogram (Miracle 2009).

The transverse development in a normal Class I population has been studied. It has been reported that the skeletal transverse width develops more rapidly in the mandible than in the maxilla from age 10-18 (Huertas and Ghafari 2001). The etiology of transverse maxillary deficiency is varied including congenital, traumatic, developmental and iatrogenic (cleft palate repair) causes. Highest heritability estimates were for transverse arch widths, which averaged about 60% (Cassidy et al 1998). Mandibular growth and transverse development is the result of resorption and apposition. Mandibular width changes through resorption on the infero-medial surfaces while the lateral aspect of the mandible displays deposition of bone. The transverse dimension is the first to cease growing in patients therefore causing the diagnosis of a transverse deficiency very difficult to make. It has been reported that molar and canine arch widths did not change after 13 years of age in females and 16 years of age in males (Uysal et al 2005). The difference between skeletal maxillary widths and mandibular widths in Class III malocclusions is already established before age 10 and is not self-correcting and increases with time (Chen et al 2007). Minimal soft tissue changes are seen in patients with transverse deficiencies therefore clinicians rely on the clinical examination and maxillomandibular dental relationships. Skeletal transverse problems can be demonstrated by posterior crossbites, a lateral functional shift, wide buccal corridors and a highly vaulted palate. In contrast, anteroposterior and vertical deficiencies are easier to diagnosis since they are accompanied by obvious soft tissue characteristics (Betts et al 1995).

Little research on the transverse dimension has been documented. Braun et al examined the human dental arch using 40 sets of pretreatment orthodontic models and found that mandibular dental arch widths found in Class III occlusions were on average, 2.1 mm wider than Class I mandibular arches commencing in the premolar region. Uysal reported in his study that the mandibular intercanine and intermolar alveolar widths were significantly larger in the Class III sample when compared with the normal occlusion sample ($P < .001$). Maxillary interpremolar, intermolar widths and all maxillary alveolar width measurements were significantly narrower in the Class III group ($P < .001$). Subjects with Class III malocclusion tend to have the maxillary teeth inclined to the lingual and mandibular teeth inclined toward the buccal direction because of the restriction of maxillary growth and development according to dental arch width measurements. Maxillary width was smaller in both Cl-II and Cl-III subjects compared with normal as measured conventionally. In Cl-II and Cl-III subjects the maxillary width was smaller 2.5 and 4 mm, respectively (Uysal et al 2005). Braun et al reported on differences in arch dimensions between Angle classifications and found that Class II mandibular arches showed generalized reduced arch width and depth compared to Class I arches and Class III mandibular arches had reduced arch depth and greater arch width than Class I arches.

The aim of this study was to reconfirm bilateral anterior and posterior skeletal landmarks in the maxilla and mandible found in a previous study conducted by Brewer and Stewart (2012) and measure CBCT pretreatment linear widths of these landmarks in a Class I population sample with normal transverse widths, a Class III

patient population due to maxillary hypoplasia and a Class III patient population due to mandibular hyperplasia. Subsequently, an anterior and posterior transverse maxilla-mandibular ratio for the Class I and III patient populations were calculated. Therefore, skeletal transverse widths can be appreciated using reliable landmarks in the maxilla and mandible. The most reliable landmarks in the anterior maxilla were the infraorbital foramina and canine root apices. The most reliable landmarks in the posterior maxilla were the greater palatine foramina and the maxillary first molar palatal root apices. The most reliable bilateral landmarks to measure in the anterior mandible were found to be the canine root apices and the mental foramen. In the posterior mandible, the alveolar ridge at the first molar and the lingula were found to be the most reliable. From this data, we may conclude that if a discrepancy exists in the anteroposterior dimension, will a concurrent discrepancy in the transverse plane exist. This information can improve our diagnostic ability and enable us to provide the best possible treatment to our patients.

II. OBJECTIVES

A. Overall Objective

The overall objective of this study was to determine if a sample of patients with a discrepancy in maxillary and mandibular anteroposterior growth would have a concurrent deficiency in the transverse dimension. The goal of this study was to first verify anterior and posterior maxillary and mandibular landmarks found in a previous study, take linear measurements of these landmarks, and then calculate a maxillo-mandibular anterior and posterior width ratio in a Class I population and Class III patient populations due to maxillary hypoplasia and mandibular hyperplasia, respectively.

B. Specific Hypotheses

If a discrepancy of the maxilla and mandible occurs in the anteroposterior (AP) plane, it will also occur in the transverse dimension.

III. MATERIALS AND METHODS

A. Experimental Design

This retrospective study evaluated patients who were examined at the Tri-Service Orthodontic Residency Program with pretreatment CBCTs on file taken on Classic iCAT machines (Imaging Sciences International, Hatfield, PA). An archived Class I sample population of 30 patients from the program's Dolphin Management database was utilized. The data was verified and determined to be accurate by inter-rater reliability. The 30 subjects met the following inclusion criteria:

1. Males who were at least 16 years old and females who were at least 14 years old.

2. No history of Orthodontic treatment.

3. Skeletal Class I with an ANB (A point-Nasion-B point) angle between 0-4 degrees possessing bilateral Class I molars and canines.

4. No existing crossbites or transverse dental compensations as diagnosed by the principal investigator.

5. Less than 8 mm of crowding present.

6. No impacted canines.

7. An angular measurement of Sella-Nasion to Mandibular Plane (SN-MP) between 28-38 degrees.

The measurements from a Class III sample due to maxillary deficiency comprised of 30 subjects who also had pretreatment CBCTs taken with the Classic iCAT machine (Imaging Sciences International, Hatfield, PA) on file was also utilized for this study. This patient population met the following inclusion criteria were verified and deemed accurate by intra-rater reliability:

1. Males at least 16 years old and females at least 14 years old.
2. No history of Orthodontic treatment.
3. Skeletal Class III due to maxillary deficiency demonstrated by an ANB (A point-Nasion-B point) angular measurement less than 0 degrees and SNA (Sella-Nasion-A point) angle of less than 80 degrees.
4. Less than 8 mm of crowding present.
5. No impacted canines.
6. An angular measurement of Sella-Nasion to Mandibular Plane between 28-38 degrees.

A second set of 30 Class III patients possessing mandibular excess was selected using the same preexisting database. The initial 30 Class III patients to meet the following inclusion criteria were selected:

1. Males at least 16 years old and females at least 14 years old.
2. No history of Orthodontic treatment.

3. Skeletal Class III due to mandibular excess demonstrated by an ANB angular measurement no greater than 0 degrees and SNB (Sella-Nasion-B point) angle greater than 83 degrees and or B point to Nasion perpendicular greater than 0 mm. No deviations in the angulation of the cranial base.

4. Less than 8 mm of crowding present.

5. No impacted canines.

6. An angular measurement of Sella-Nasion to Mandibular Plane between 28-38 degrees.

From previous theses research, four maxillary anterior and posterior and four mandibular anterior and posterior landmark measurements were verified to be accurate by inter-rater reliability. The maxillary anterior landmarks were the canine root apices and the infraorbital foramina. The maxillary posterior landmarks were the first molar palatal root apices and the greater palatine foramina. The mandibular anterior landmarks were mental foramen and the canine apices. The mandibular posterior landmarks were the lingula and the alveolar ridge at the mesial buccal cusp of the first molar. Linear measurements of the bilateral anterior and posterior maxillary and mandibular skeletal landmarks from the pretreatment CBCT slices were performed. Using different combinations of the maxillary and mandibular anterior and posterior landmarks, the maxillo-mandibular anterior to posterior transverse ratios of the Class I archived population, Class III due to maxillary deficiency patient population and Class III patient population due to mandibular

hyperplasia were calculated. A comparison between the maxillo-mandibular transverse width ratios in Class III patients with anteroposterior discrepancies and Class I patients was accomplished.

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Figure 1

Maxillary Anterior Landmark: Canine Root Apices (CRA)

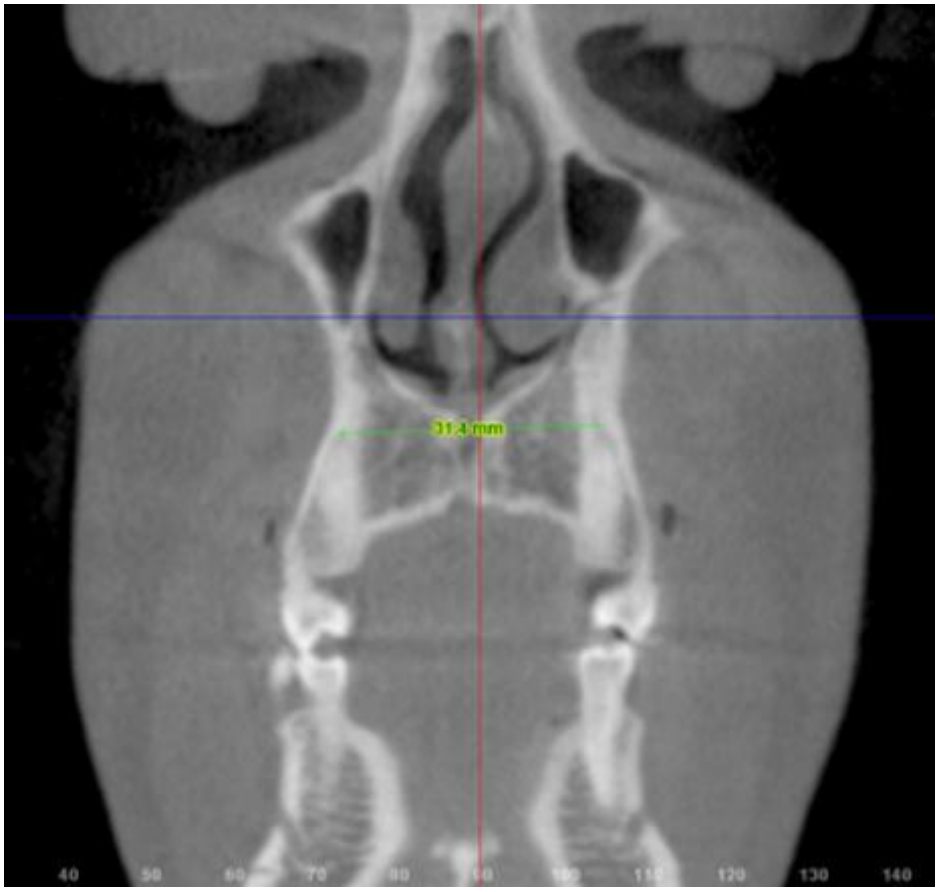


Figure 2

Maxillary Anterior Landmark: Infraorbital Foramen (iF)

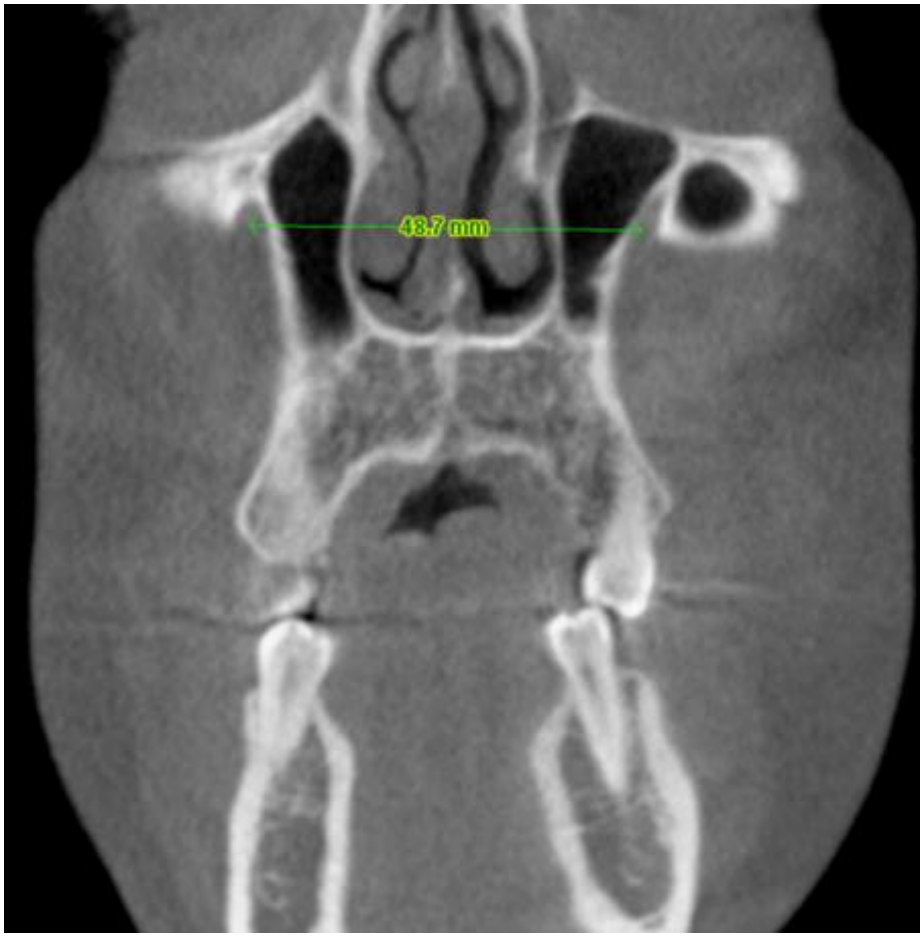


Figure 3

Maxillary Posterior Landmark: Maxillary First Molar Palatal Root Apices (MRA)

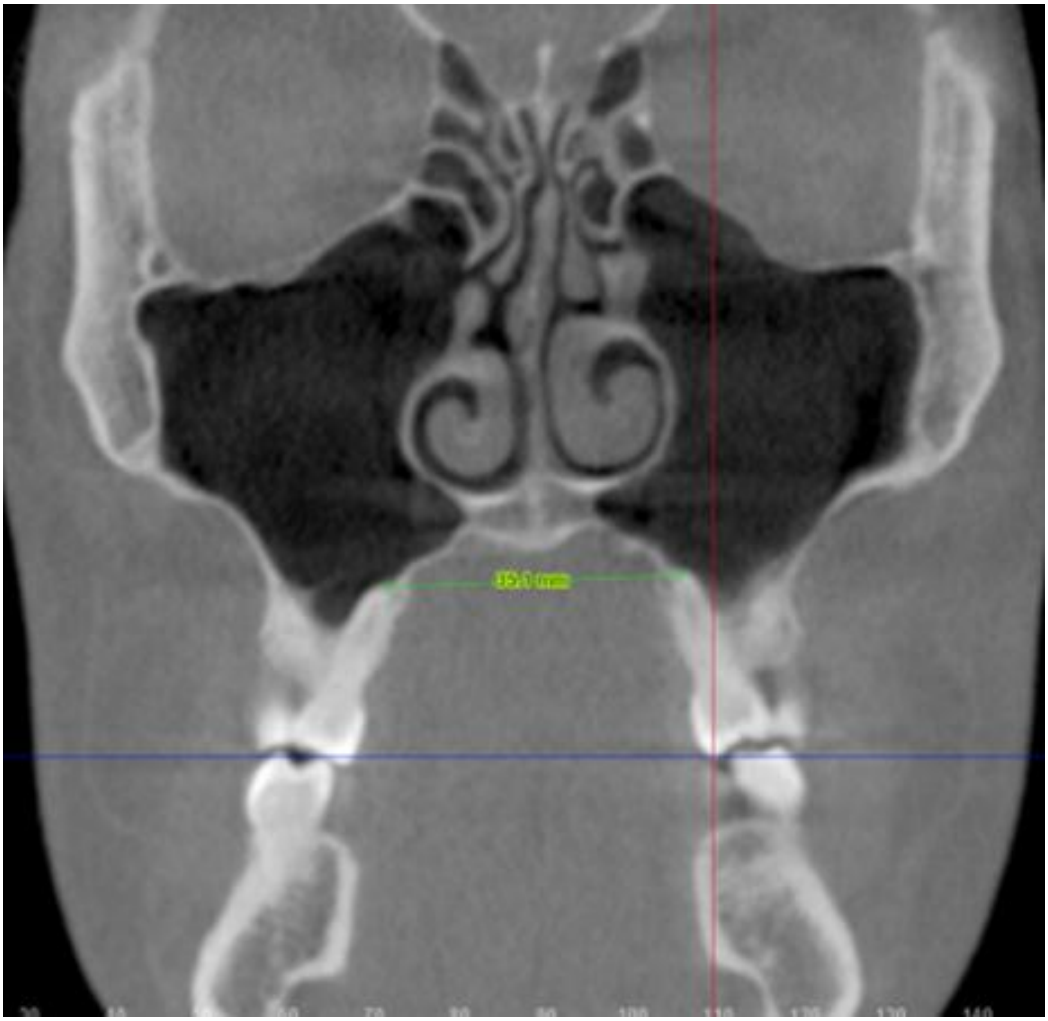


Figure 4

Maxillary Posterior Landmark: Greater Palatine Foramen (GPF)

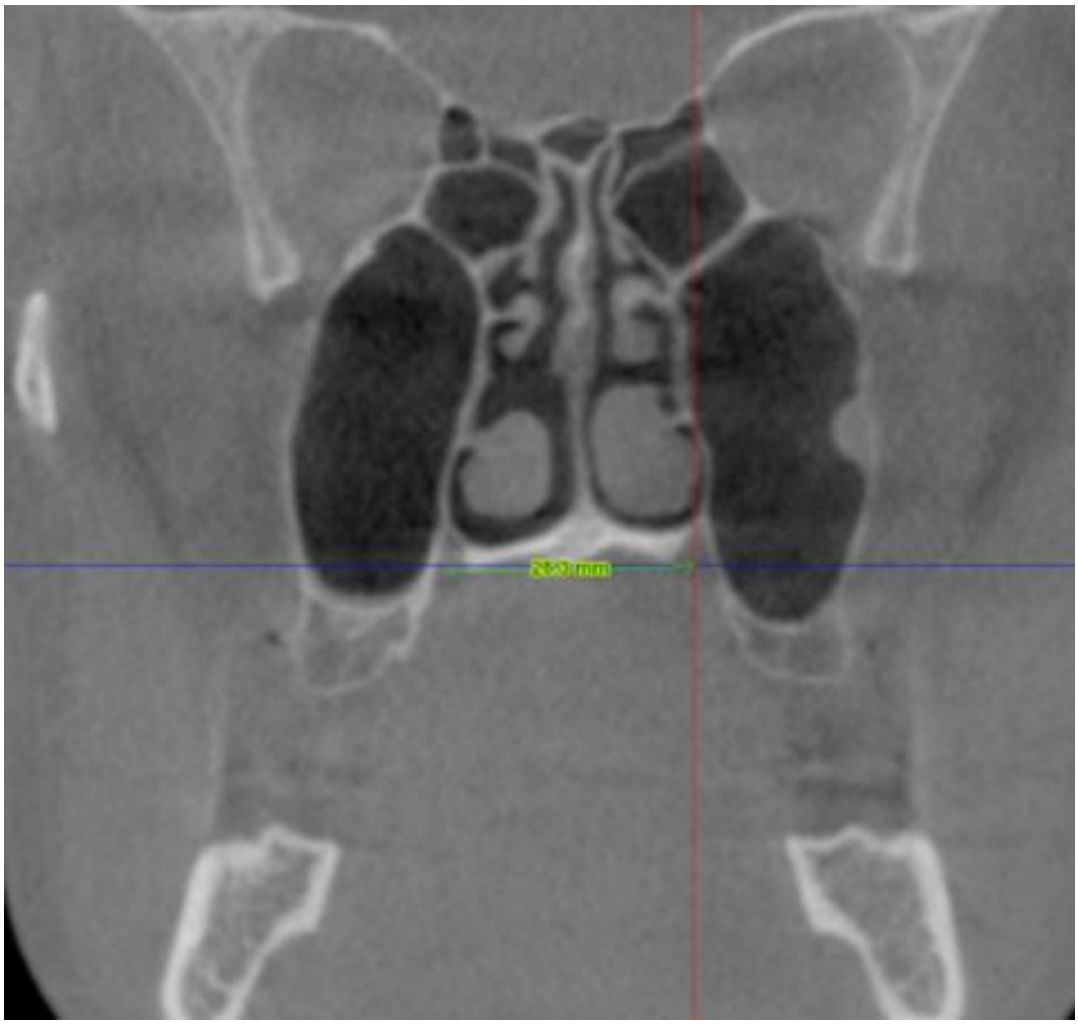


Figure 5

Mandibular Anterior Landmark: Mental Foramen (MF)

Figure 6

Mandibular Anterior Landmark: Mandibular Canine Root Apices (CR)

Figure 7

Mandibular Posterior Landmark: Lingula (L)

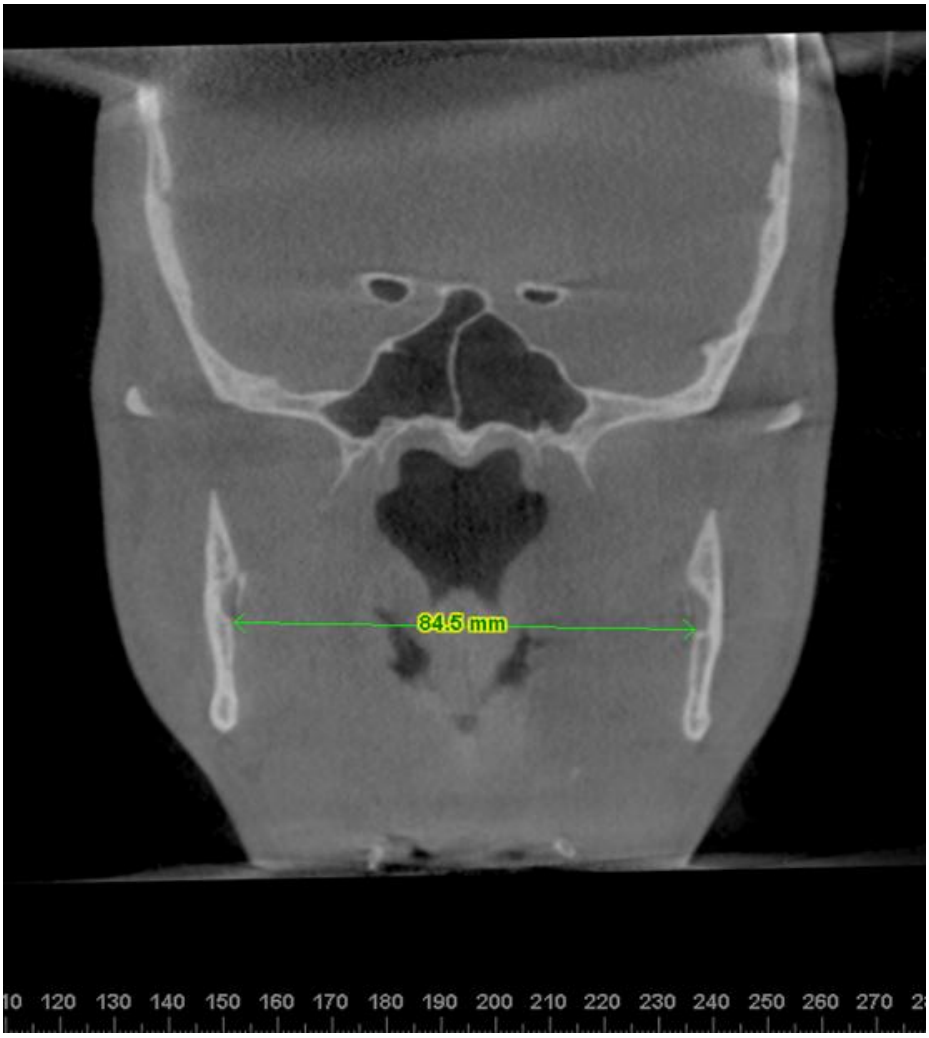
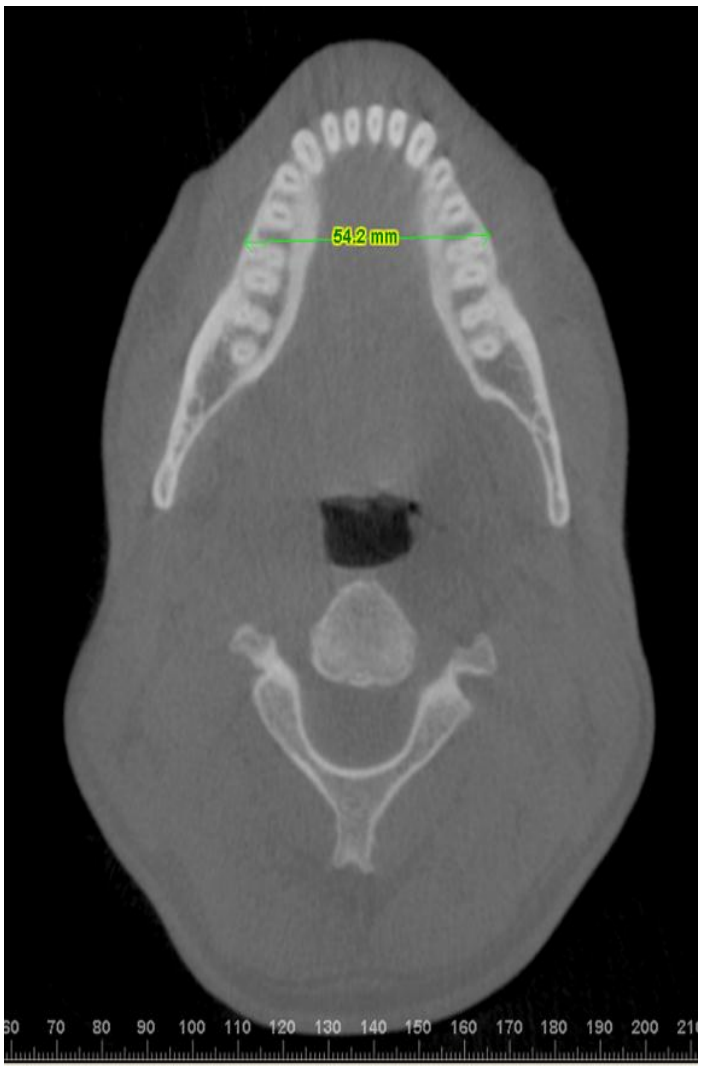


Figure 8

Mandibular Posterior Landmark: Alveolar Ridge at Mandibular First Molar (AVRM)



B. Statistical Management of Data

Eight landmarks (four in the maxilla and four in the mandible) were verified to be reliable and measured at three different time points using coronal slices from the CBCTs of thirty Class I patients, thirty Class III patients due to maxillary hypoplasia, and thirty Class III patients due to mandibular hyperplasia. Mean averages and standard deviations were determined from these widths. An anterior and posterior maxillo-mandibular width ratio was then calculated. Intra-rater reliability was calculated using the average standard deviation derived from the three linear measurements made from each individual.

Averages and standard deviations were obtained for each landmark and compared using Student's t test. Ratios were constructed using each of the combinations of anterior maxillo-mandibular and posterior maxilla-mandibular landmarks for each individual patient in all populations. These individual ratios were averaged for all populations and compared again using Analysis of Variance (ANOVA). Values of $p < 0.05$ were considered statistically significant.

IV. RESULTS

The anterior and posterior landmarks in the maxilla and mandible were verified to be reliable landmarks from a previous thesis study conducted by Brewer and Stewart. Bilateral linear measurements were measured 3 times by one examiner and an average and standard deviation was calculated. The intra-rater reliability of all the landmark measurements was shown statistically to be accurate by the Dahlberg formula. The anterior landmarks in the maxilla were the Canine Root Apices (CRA) and the Infraorbital Foramina (IF). The posterior landmarks in the maxilla were the Greater Palatine Foramina (GPF) and the First Molar Palatal Root Apices (MRA). The mandibular anterior landmarks were the Canine Root Apices (CR) and Mental Foramen (MF). The mandibular posterior landmarks were the lingula (L) and the Alveolar Ridge of the Mandibular First Molar (AvRM). An Analysis of Variance (ANOVA) statistical analysis was completed to compare the anterior and posterior maxillo-mandibular width ratios of the Class I, Class III due to a retrusive maxilla, and Class III due to a prognathic mandible groups. A value was considered significant if P was less than the 0.05 significance level.

For the bilateral linear measurements of the landmarks, there was a general trend for the Class III population groups to possess more narrow arch widths in the maxilla and have larger mandibular intercanine and intermolar alveolar widths (Tables I, II, III).

For the anterior maxillo-mandibular width ratios, a significance was found between the Infraorbital Foramina-Mandibular Canine Root Apex (IF-CR) width ratio. It was determined from the ANOVA analysis, that there was a difference between the Class I and both Class III groups (Figure 10). In addition, there was a significance in the anterior Maxillary Canine Root Apex to Mandibular Canine Root (CRA-CR) maxillo-mandibular width ratio. The difference, again, was between the Class I and both Class III groups (Figure 12). There were not any significant differences between the Class I and Class III patient groups for the Infraorbital Foramina to Mental Foramina (IF-MF) ratio (Figure 9) and the Maxillary Canine Root Apex to Mental Foramina (CRA-MF) ratio (Figure 11).

For the posterior maxillo-mandibular width ratios, there were no significant differences in the Greater Palatine Foramina to the Lingula (GPF-L) (Figure 13) and the Greater Palatine Foramina to the Alveolar Ridge at Mandibular First Molar (GPF-AvRM) (Figure 14). There was a noted significance in the Maxillary First Molar Palatal Root Apices to the Lingula (MRA-L) ratio (Figure 15). There was a difference between the Class I and the Class III due to a retrusive maxilla groups and between the Class III due to a retrusive maxilla and Class III due to a prognathic mandible groups.

There was also a significant difference between the Maxillary First Molar Root Apices and the Alveolar Ridge at Mandibular First Molar (MRA-AvRM) width ratio (Figure 16). The difference was between the Class III due to a retrusive maxilla and Class III due to a prognathic mandible.

In summary, in comparing the maxillo-mandibular discrepancies in the transverse dimension, it appears the discrepancies exist in the anterior maxillo-mandibular ratio of the infraorbital foramina to the mandibular canine root apices and in the area of the maxillary canine root apices to the mandibular canine root apices. The maxillo-mandibular transverse discrepancies in the posterior areas were present in the area of the maxillary first molar root apices to the lingula and the maxillary first molar root apices to the alveolar ridge at the mandibular first molar.

Table I. Class I Patient group measurement of bilateral landmarks in the Maxilla and Mandible and Ratios

CLASS I PATIENTS				
		Raw Average	**Standard Deviation**	**Intra-rater reliability**
ANTERIOR	IF-IF	50.93	0.29	0.56
	CRA-CRA	27.35	0.26	
	CR-CR	20.32	0.37	
	MF-MF	46.47	0.36	
POSTERIOR	GPF-GPF	29.32	0.18	
	MRA-MRA	33.35	0.33	
	L-L	78.52	0.33	
	AvRM-AvRM	52.59	0.24	

RATIOS (Anterior Maxillary/Mandibular Width Ratio)

	IF:MF	**IF: CR**	**CRA: MF**	**CRA:CR**
Average	1.08	2.55	0.60	1.37
Standard Deviation	0.13	0.43	0.08	0.24

RATIOS (Posterior Maxillary/Mandibular Width Ratio)

	GPF:L	**GPF:AvRM**	**MRA:L**	**MRA:AvRM**
Average	0.37	0.56	0.42	0.63
Standard Deviation	0.03	0.05	0.05	0.06

Table ii. Class iii due to a Retrusive Maxilla Patient Group measurement of bilateral landmarks in the Maxilla and Mandible and Ratios (Class iiiR)

CLASS III DUE TO RETRUSIVE MAXILLA PATIENTS				
		Raw Average	**Standard Deviation**	**Intra-rater reliability**
ANTERIOR	IF-IF	49.45	0.17	0.34
	CRA-CRA	29.33	0.15	
	CR-CR	25.09	0.18	
	MF-MF	45.90	0.16	
POSTERIOR	GPF-GPF	31.30	0.19	
	MRA-MRA	32.34	0.18	
	L-L	85.70	0.26	
	AvRM-AvRM	54.42	0.15	

RATIOS (Anterior Maxillary/Mandibular Width Ratio)

	IF:MF	**IF: CR**	**CRA: MF**	**CRA:CR**
Average	1.08	2.00	0.64	1.18
Standard Deviation	0.14	0.34	0.12	0.24

RATIOS (Posterior Maxillary/Mandibular Width Ratio)

	GPF:L	**GPF:AvRM**	**MRA:L**	**MRA:AvRM**
Average	0.36	0.58	0.38	0.60
Standard Deviation	0.06	0.10	0.04	0.06

Table iii. Class iii due to Prognathic Mandible Patient Group measurement of bilateral landmarks in the Maxilla and Mandible and Ratios (Class iiiP)

CLASS III DUE TO PROGNATHIC MANDIBLE PATIENTS				
		Raw Average	**Standard Deviation**	**Intra-rater reliability**
ANTERIOR	IF-IF	51.67	0.10	0.25
	CRA-CRA	30.13	0.14	
	CR-CR	25.95	0.12	
	MF-MF	47.01	0.11	
POSTERIOR	GPF-GPF	30.29	0.11	
	MRA-MRA	34.87	0.15	
	L-L	84.05	0.15	
	AvRM-AvRM	54.40	0.17	

RATIOS (Anterior Maxillary/Mandibular Width Ratio)

	IF:MF	**IF: CR**	**CRA: MF**	**CRA:CR**
Average	1.10	2.02	0.64	1.18
Standard Deviation	0.09	0.31	0.07	0.23

RATIOS (Posterior Maxillary/Mandibular Width Ratio)

	GPF:L	**GPF:AvRM**	**MRA:L**	**MRA:AvRM**
Average	0.36	0.56	0.42	0.64
Standard Deviation	0.03	0.06	0.05	0.09

Figure 9

Comparison of the IF-MF ratio between the Class I, Class IIIR, Class IIIP groups

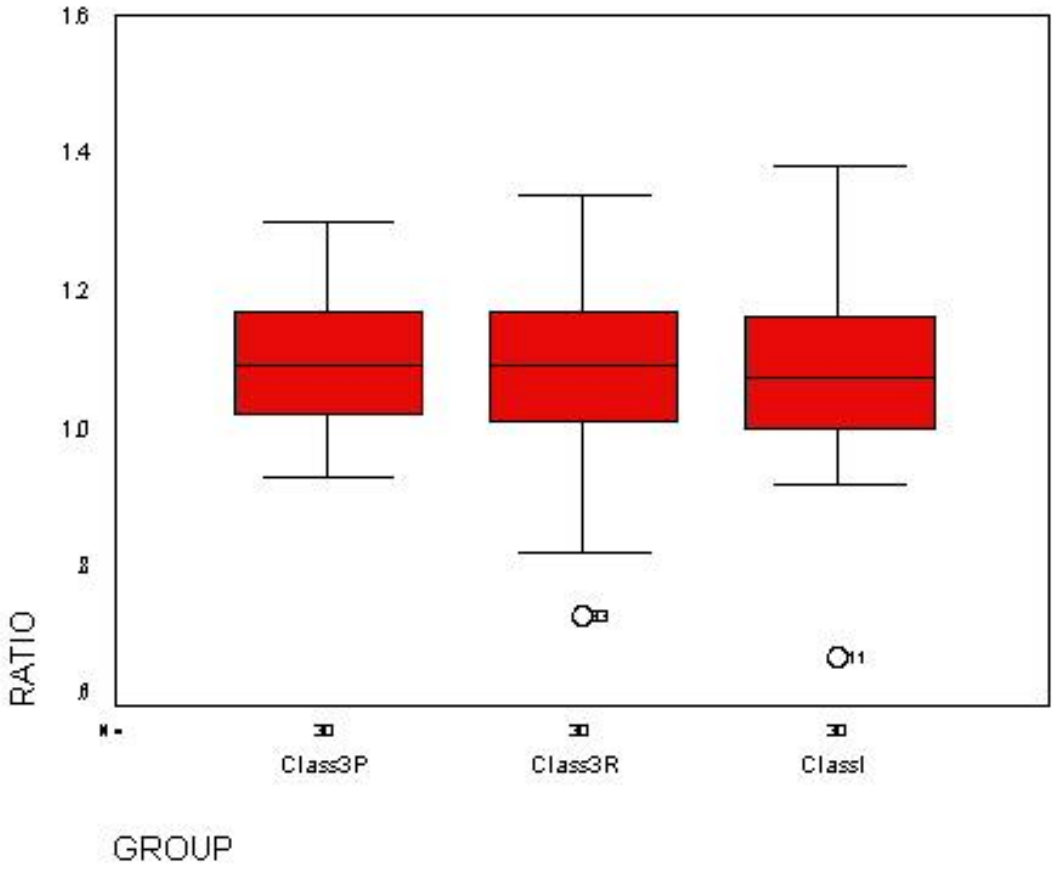


Figure 10

Comparison of the IF-CR ratio of the 3 patient groups

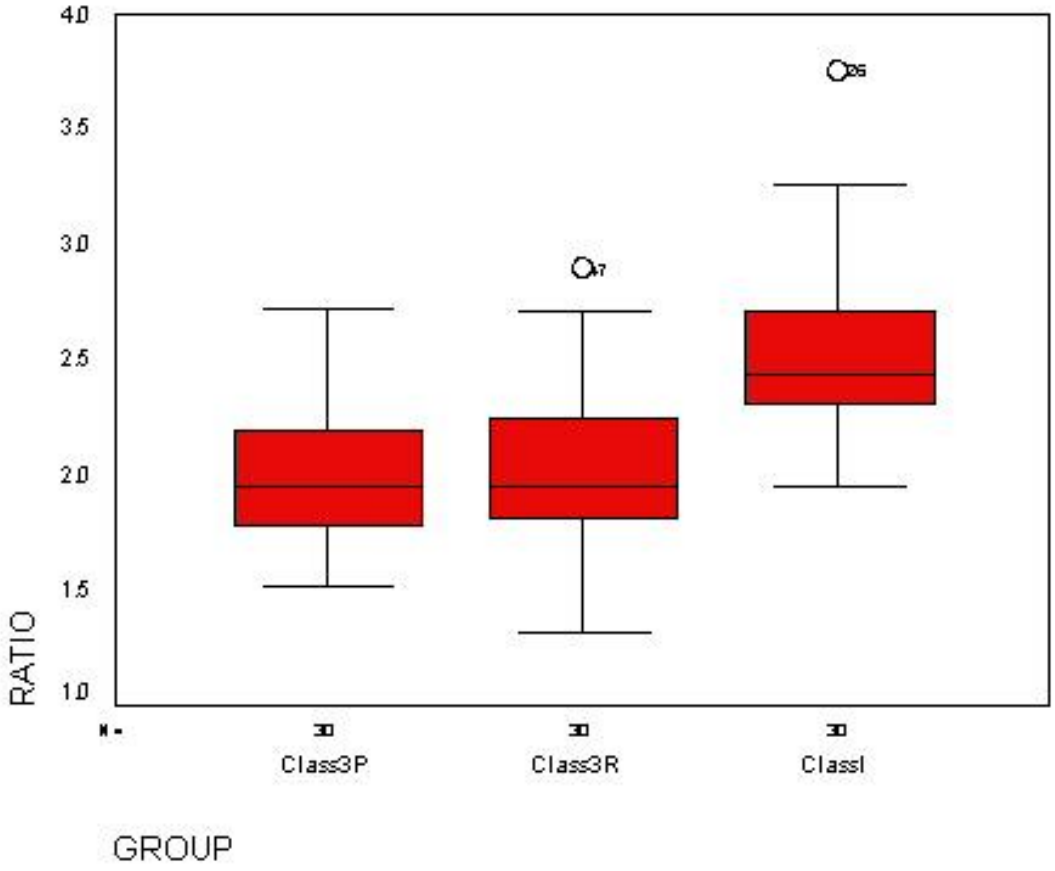


Figure 11

Comparison of the CRA-MF ratio between the 3 groups

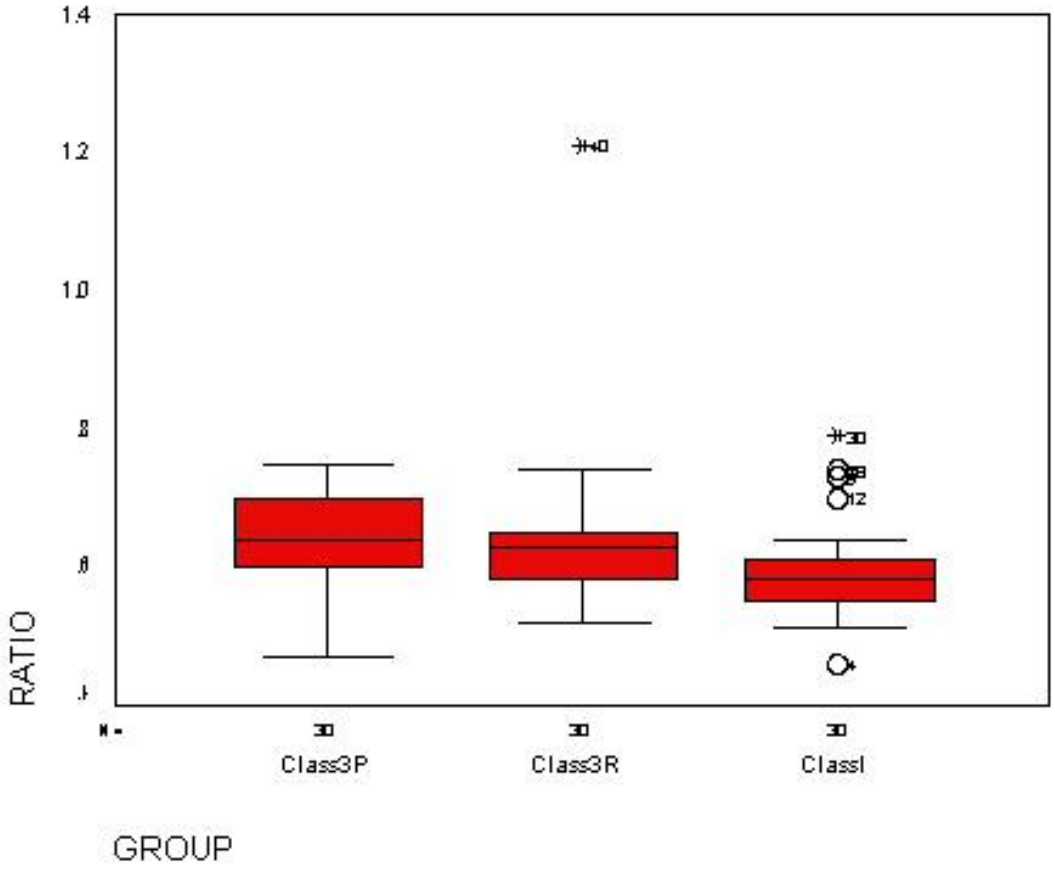


Figure 12

Comparison of the CRA-CR ratio between the 3 groups

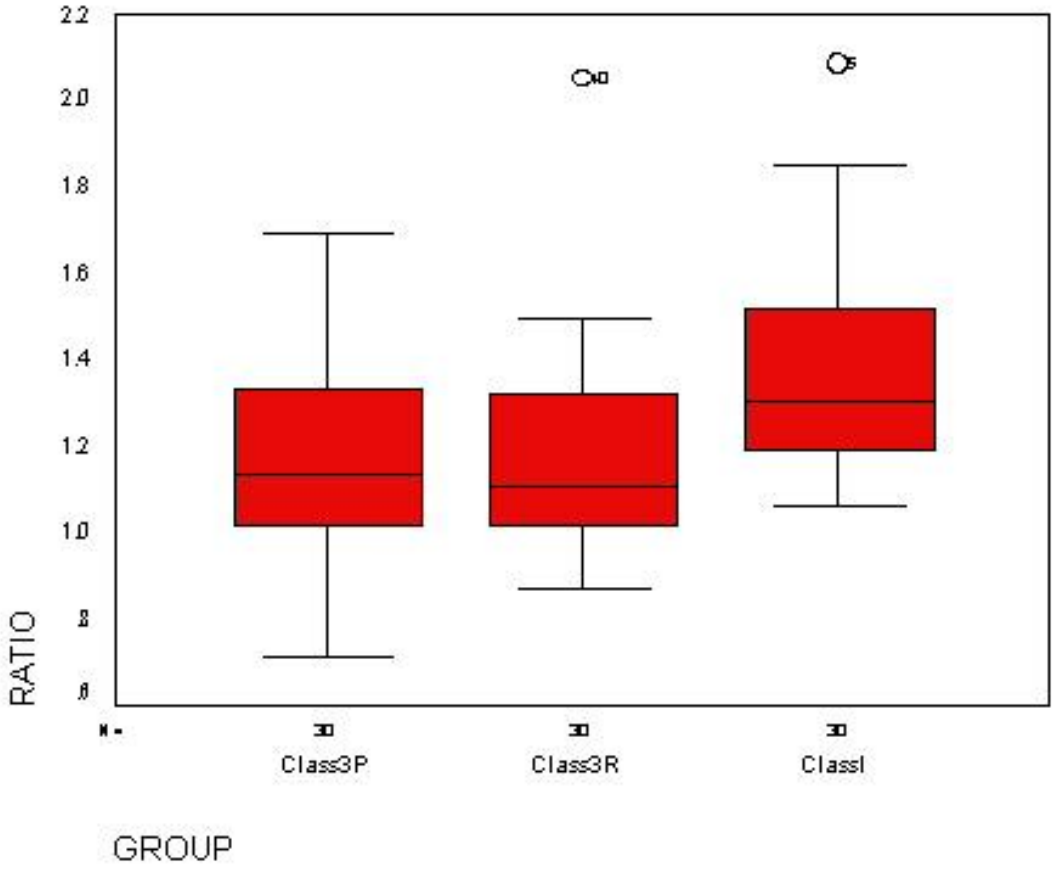


Figure 13

Comparison of the GPF-L ratio between groups

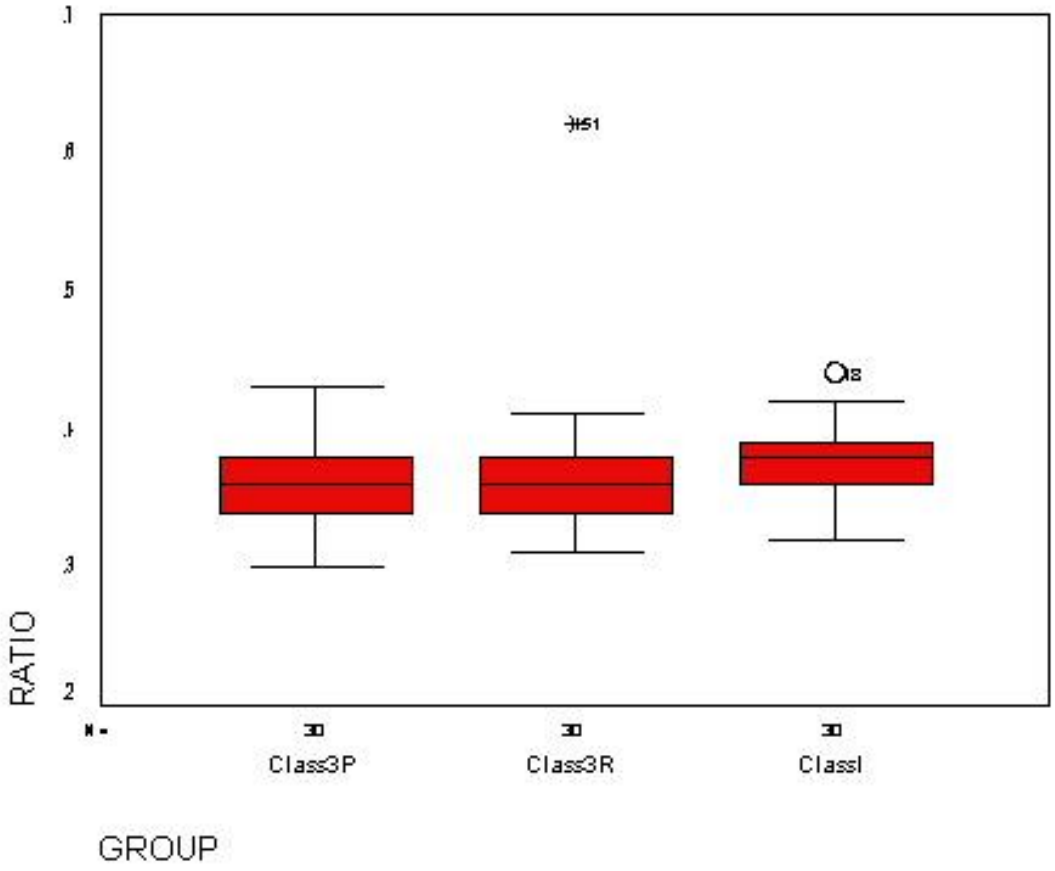


Figure 14

Comparison of the GPF-AVRM ratio between the 3 groups

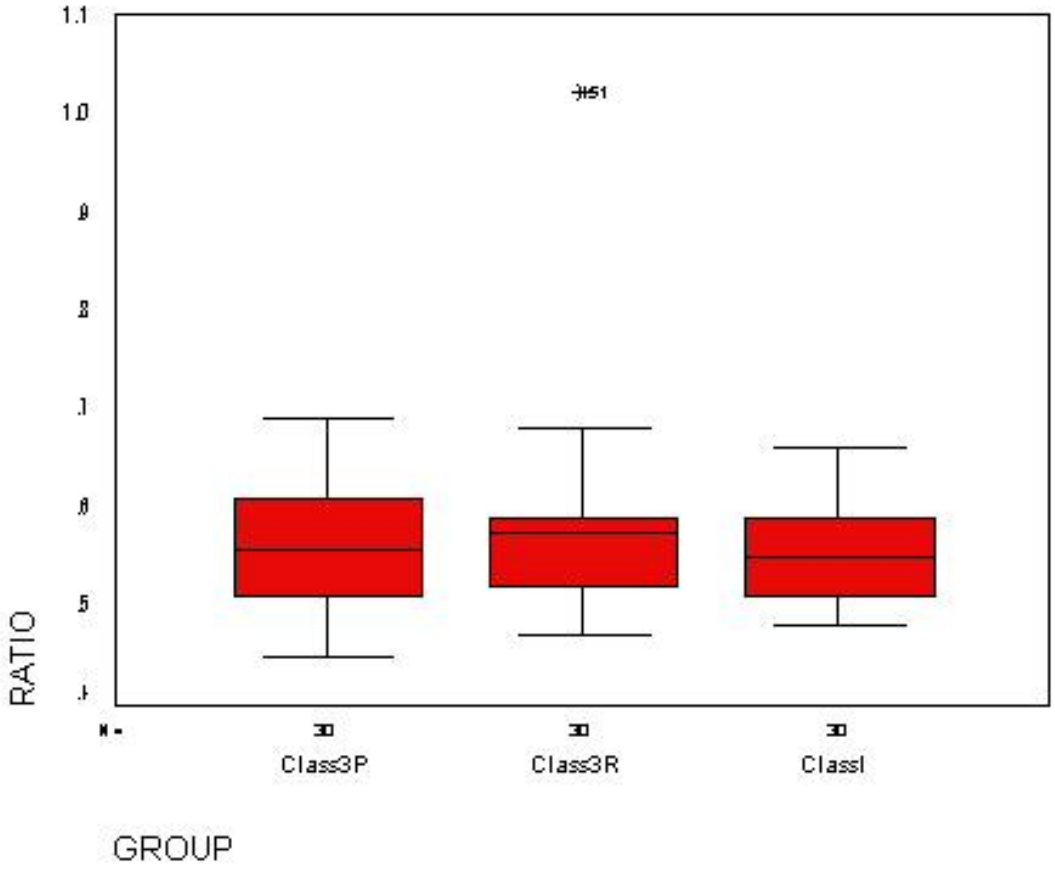


Figure 15

Comparison of the MRA-L ratio between the 3 groups

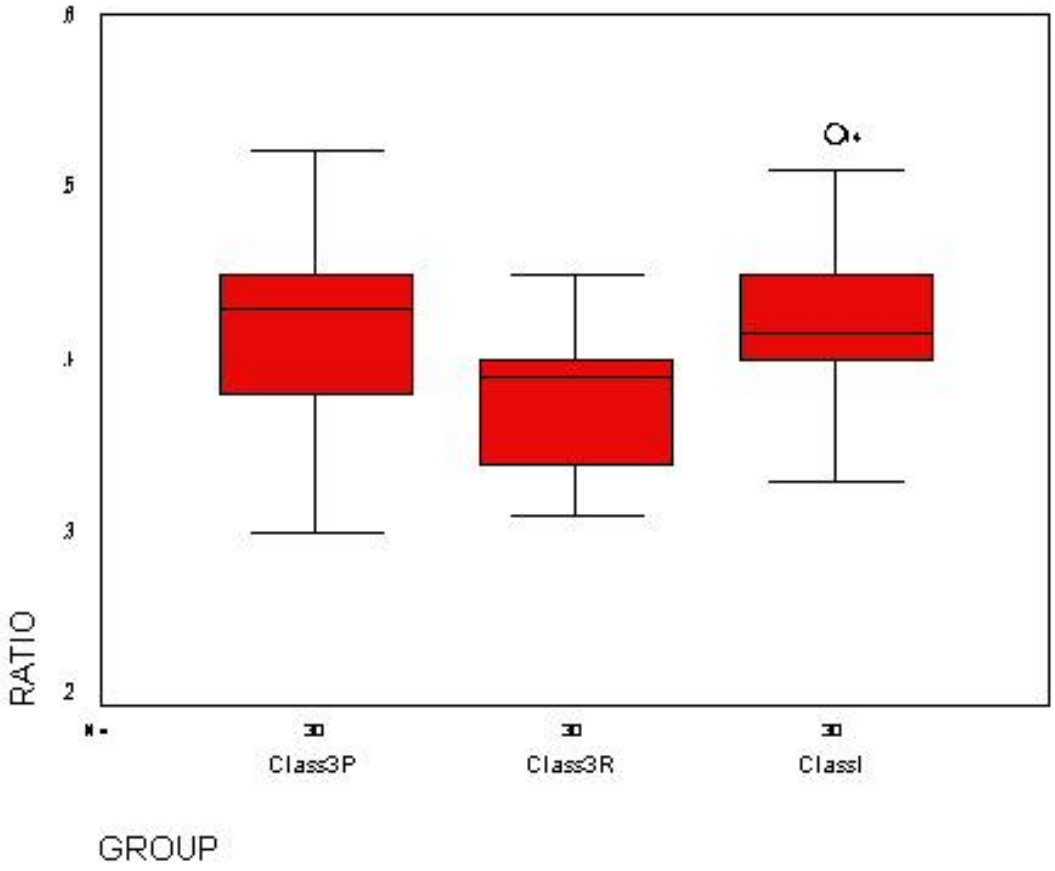
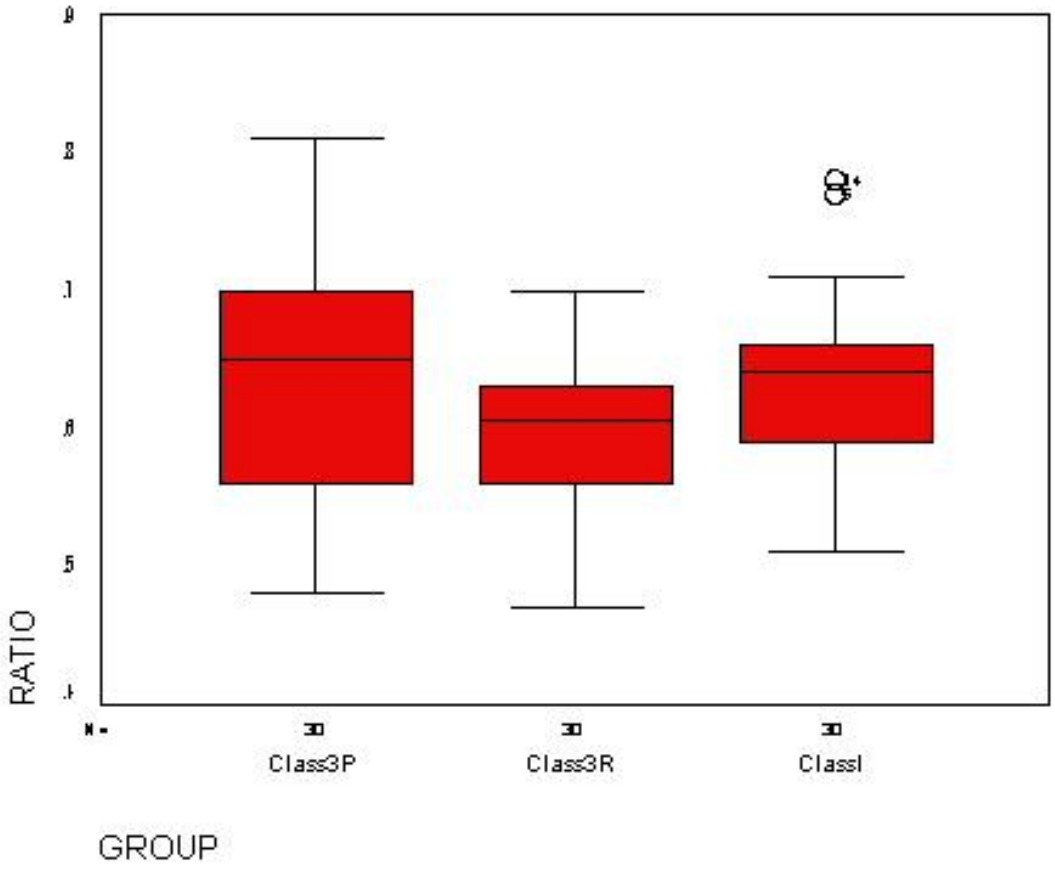


Figure 16

Comparison of the MRA-A ratio between the 3 groups



V. DISCUSSION

The transverse dimension is the least studied compared to the antero-posterior and vertical dimensions. With the advent of the CBCT, the transverse, antero-posterior, and vertical planes can all be evaluated therefore, it can be determined whether there is a concurrent transverse difference in the Class I and Class III patient populations. The objective of this study was to determine if the patient has an anteroposterior discrepancy, will he/she have a concurrent transverse discrepancy. This can enable practitioners to focus on where the treatment should be centered on for a Class III patient. For example, should the maxilla be expanded in a Class III patient? This will result in better treatment outcomes and increase patient satisfaction. The prevalence of a Class III malocclusion in the United States to be 14% (Uysal et al) so it would be beneficial to gain more information.

Another aim of this research was to specifically define where the transverse discrepancies were located and whether there were differences between the Class I and III groups. Braun et al reported that the mandibular dental arches in a Class III malocclusion to be wider than Class I mandibular arches beginning in the premolar region. Maxillary interpremolar, intermolar widths and all maxillary alveolar width measurements were significantly narrower in the Class III group (Uysal et al). Kuntz et al reported that researchers found that the maxillary intermolar width of Class III subjects to be slightly smaller than those with an ideal Class I occlusion. This can contribute to the explanation of why the posterior maxilla-mandibular ratios of MRA-L and MRA-AvRM showed statistical significance. In a study which compared arch widths in a large sample of Class III Turkish subjects conducted by Uysal et al, molar

alveolar widths were smaller in Class III versus Class I occlusions. This supports the results of the MRA-AvRM ratio showing significance. It has also been shown in the literature that in the mandible, Class III malocclusions had larger intercanine widths (Kuntz et al). This can explain why 2 out of the 3 maxillo-mandibular width ratios involving the intercanine widths showed statistical significance. A possible explanation for the increased mandibular arch width in the Class III population is that the sum of all the mesiodistal widths of the dental units around the arch represents a specific dimension (Uysal et al 2005). In a study by Sperry et al, it was demonstrated the Class III group due to mandibular prognathism more commonly had mandibular tooth size excess for the overall ratio than Class I and Class II groups. Lavelle, Nie and Lin showed that the Class III cases had smaller maxillary tooth dimensions and larger mandibular teeth.

When comparing gender differences in the Class III malocclusion, it has been shown that there is a significant degree of sexual dimorphism especially after age 13 and female subjects with a Class III malocclusion present with smaller linear dimensions in the maxilla and mandible (Baccetti et al). A future research study can determine if there indeed is a difference in the transverse measurements in female and male subjects in a Class III sample population.

One change in this study as compared to the previous study conducted by Brewer was the criteria for the Class III population due to a retrusive maxilla. In the study by Brewer, a Sella-Nasion-A Point (SNA) angle of less than 82 degrees was used. A normal Caucasian population possesses a SNA of 82+/- 2 degrees so any of the

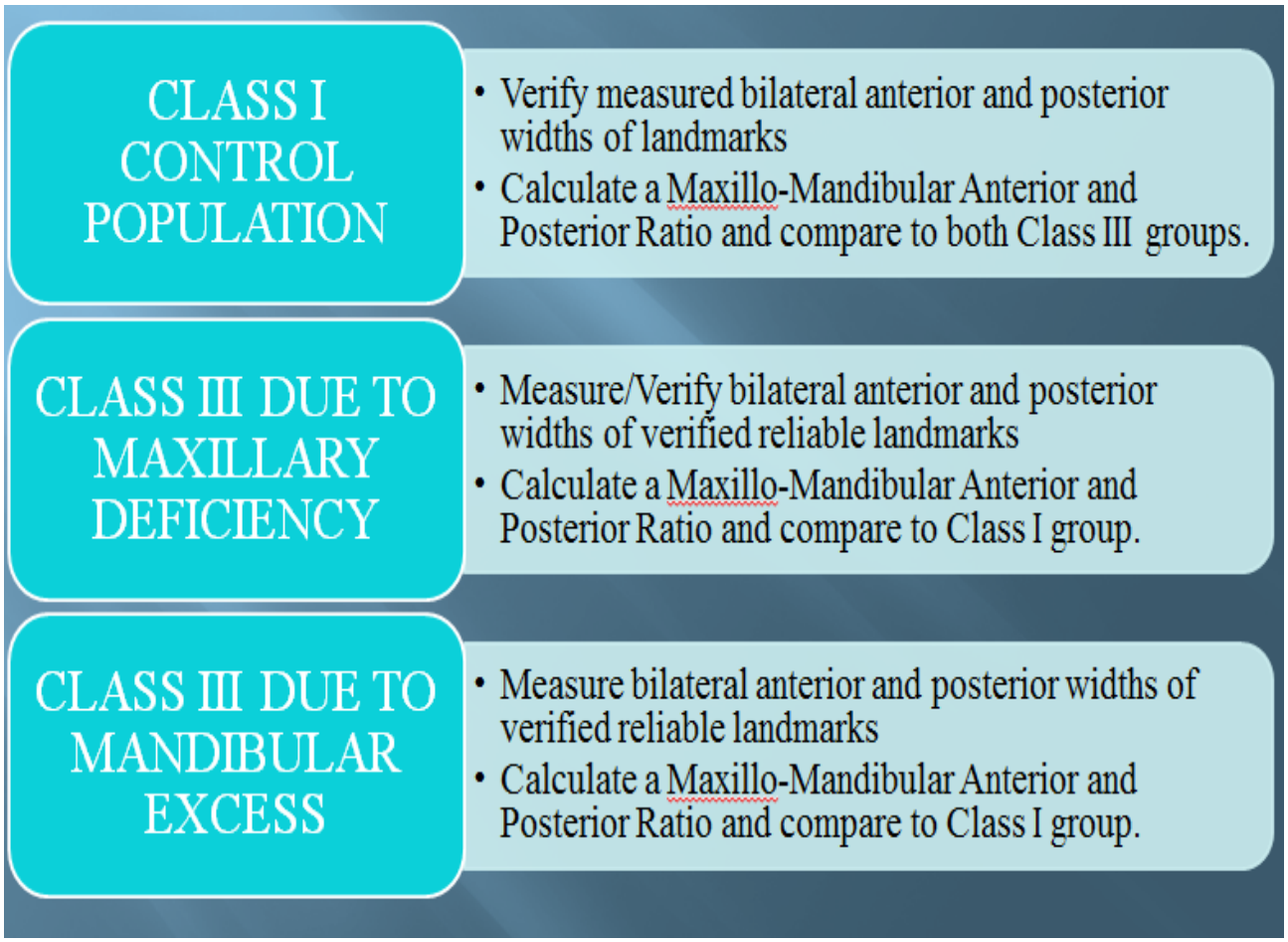
subjects used in that study could indeed have been considered to have normal maxillary antero-posterior growth. Because of this, in this study, the SNA angle for the Class III population due to a retrusive maxilla was set at equal or less than 78 degrees.

This study does have its limitations. Intra-rater reliability was calculated but there was no other examiner to verify the measurements therefore, inter-reliability could not be determined. Lagrevere et al and Goldenberg et al showed that inter-rater reliability is not as strong as intra-rater reliability but has fallen well within a range that is acceptable. The intra-rater reliability was shown to be statistically accurate therefore it was decided that inter-rater reliability would offer very little additional information.

VI. CONCLUSION

1. Bilateral transverse linear width measurements showed that the Class III due to a retrusive maxilla patient population showed narrower dimensions in both the anterior and posterior maxilla and mandible compared to the Class III due to a hyperplastic mandible patient population. The Class III due to a hyperplastic mandible patient population demonstrated larger intercanine and intermolar widths in the maxilla and mandible compared to the Class I and Class III due a retrusive maxilla patient populations.
2. In comparing the maxillo-mandibular ratios in the transverse dimension, there was a statistical significance in the anterior maxillo-mandibular ratio of the infraorbital foramina to the mandibular canine root apices and in the area of the maxillary canine root apices to the mandibular canine root apices between the Class I and both Class III groups. The maxillo-mandibular transverse ratios in the posterior areas demonstrated statistical significance in the area of the maxillary first molar root apices to the lingula and the maxillary first molar root apices to the alveolar ridge at the mandibular first molar in the Class III patient group due to a retrusive maxilla.

Appendix A: Schematic of Study Objectives



Appendix B: Class I Patients, Raw Data

		Timepoint 1	Timepoint 2	Timepoint 3	Mean	SD
1	IF-IF	44.3	44.7	43.6	44.20	0.56
	CRA-CRA	25.3	26.6	26.5	26.13	0.72
	GPF-GPF	25.6	26.1	26.4	26.03	0.40
	MRA-MRA	26.5	26.9	25.4	26.27	0.78
	CR-CR	17.3	17	17	17.10	0.17
	MF-MF	46.1	46.1	45.8	46.00	0.17
	L-L	78.5	78.8	78.4	78.57	0.21
	AvRM-AvRM	47.8	47.5	47.4	47.57	0.21
2	IF-IF	44.6	45.9	46.3	45.60	0.89
	CRA-CRA	27	27.1	27	27.03	0.06
	GPF-GPF	28.7	28.4	28.5	28.53	0.15
	MRA-MRA	32.6	30.5	31.3	31.47	1.06
	CR-CR	23.5	22.7	23.6	23.27	0.49
	MF-MF	47.2	49.3	48.4	48.30	1.05
	L-L	79.6	79	79.6	79.40	0.35
	AvRM-AvRM	55.9	55.4	55.3	55.53	0.32
3	IF-IF	50.7	50.2	51.6	50.83	0.71
	CRA-CRA	25	27.2	26.3	26.17	1.11
	GPF-GPF	29.3	29.6	30.3	29.73	0.51
	MRA-MRA	33	32.8	33	32.93	0.12
	CR-CR	24	24.1	23.8	23.97	0.15
	MF-MF	45.1	45	46.7	45.60	0.95
	L-L	84	83.5	83.7	83.73	0.25
	AvRM-AvRM	54.8	54.2	54.1	54.37	0.38
4	IF-IF	47.8	47.8	46.8	47.47	0.58
	CRA-CRA	22.9	23.5	23.5	23.30	0.35
	GPF-GPF	26.5	26.6	26.2	26.43	0.21
	MRA-MRA	28.5	28.3	28.4	28.40	0.10
	CR-CR	20.5	20.1	19.6	20.07	0.45
	MF-MF	50.7	50.1	52.1	50.97	1.03
	L-L	80.5	80.7	81.2	80.80	0.36

	AvRM-AvRM	54.4	53.7	53.9	54.00	0.36
5	IF-IF	54.5	54.1	52.8	53.80	0.89
	CRA-CRA	34.9	34.2	34.2	34.43	0.40
	GPF-GPF	32	31	31.2	31.40	0.53
	MRA-MRA	42	41.7	41.9	41.87	0.15
	CR-CR	16.3	15.9	17.3	16.50	0.72
	MF-MF	47	46.3	48.4	47.23	1.07
	L-L	84.6	82.4	82.1	83.03	1.37
	AvRM-AvRM	54.6	54.3	54.1	54.33	0.25
6	IF-IF	59.5	59.6	60	59.70	0.26
	CRA-CRA	28.5	27.9	29	28.47	0.55
	GPF-GPF	30.8	31	31.2	31.00	0.20
	MRA-MRA	34.2	36.1	37	35.77	1.43
	CR-CR	24	24	22.1	23.37	1.10
	MF-MF	51	51.3	52.2	51.50	0.62
	L-L	81.3	82.9	81.8	82.00	0.82
	AvRM-AvRM	53.3	51.3	52.6	52.40	1.01
7	IF-IF	45.4	45.2	44.5	45.03	0.47
	CRA-CRA	25.2	26	25	25.40	0.53
	GPF-GPF	26.6	26.2	26.2	26.33	0.23
	MRA-MRA	32.2	32.8	31.8	32.27	0.50
	CR-CR	19.5	18.2	19.3	19.00	0.70
	MF-MF	43.1	44.2	43.5	43.60	0.56
	L-L	67.2	67.9	67.5	67.53	0.35
	AvRM-AvRM	49.9	49.1	49.3	49.43	0.42
8	IF-IF	52.2	52.5	52.2	52.30	0.17
	CRA-CRA	27.4	27.8	27.6	27.60	0.20
	GPF-GPF	31	30.9	30.9	30.93	0.06
	MRA-MRA	32.5	32.3	33.8	32.87	0.81
	CR-CR	22.9	22.6	21.1	22.20	0.96
	MF-MF	48.9	48.2	48.6	48.57	0.35
	L-L	80.2	80.1	80	80.10	0.10
	AvRM-	54.5	55	54.3	54.60	0.36

	AvRM					
9	IF-IF	48.2	47.8	48.8	48.27	0.50
	CRA-CRA	30.2	28.3	28.9	29.13	0.97
	GPF-GPF	28.9	28.7	29.3	28.97	0.31
	MRA-MRA	31.3	31.9	32.5	31.90	0.60
	CR-CR	24.6	24.8	24.8	24.73	0.12
	MF-MF	50.2	50	50	50.07	0.12
	L-L	79.7	79.5	79.5	79.57	0.12
	AvRM-AvRM	53.9	53.7	54.6	54.07	0.47
10	IF-IF	48.8	48.6	48.4	48.60	0.20
	CRA-CRA	25.8	26.4	25.4	25.87	0.50
	GPF-GPF	28.6	28.6	28.9	28.70	0.17
	MRA-MRA	35.1	34.7	34.4	34.73	0.35
	CR-CR	21.4	21.5	20.4	21.10	0.61
	MF-MF	46.5	46	46.7	46.40	0.36
	L-L	75.8	75.3	76	75.70	0.36
	AvRM-AvRM	53.9	53	52.5	53.13	0.71
11	IF-IF	51.3	51.1	51.7	51.37	0.31
	CRA-CRA	28.8	29.6	30.2	29.53	0.70
	GPF-GPF	32	30.9	31.4	31.43	0.55
	MRA-MRA	30.6	31.5	31.2	31.10	0.46
	CR-CR	19.7	17.8	17.2	18.23	1.31
	MF-MF	49.3	49	48.4	48.90	0.46
	L-L	77.7	76.9	76.7	77.10	0.53
	AvRM-AvRM	50.4	50.8	50.6	50.60	0.20
12	IF-IF	53	53.1	53.2	53.10	0.10
	CRA-CRA	30.1	31.4	29.9	30.47	0.81
	GPF-GPF	29.2	29.2	28.8	29.07	0.23
	MRA-MRA	35.1	33.4	36.1	34.87	1.37
	CR-CR	21.4	21.6	21.4	21.47	0.12
	MF-MF	43.3	43.5	44	43.60	0.36
	L-L	82.7	82.5	82.5	82.57	0.12
	AvRM-AvRM	54.3	53.7	53.9	53.97	0.31

13	IF-IF	50.8	50.1	49.7	50.20	0.56
	CRA-CRA	23.3	24	23.8	23.70	0.36
	GPF-GPF	27	26.8	26.6	26.80	0.20
	MRA-MRA	31.3	30.7	31.4	31.13	0.38
	CR-CR	18.5	18	19.1	18.53	0.55
	MF-MF	45	43.5	43.5	44.00	0.87
	L-L	72.8	72.5	72.3	72.53	0.25
	AvRM-AvRM	50.3	49.8	49.4	49.83	0.45
14	IF-IF	52.2	52.3	52.7	52.40	0.26
	CRA-CRA	27	27.3	27.4	27.23	0.21
	GPF-GPF	32.9	32.4	32.2	32.50	0.36
	MRA-MRA	42.2	40.9	41.6	41.57	0.65
	CR-CR	19.8	19.4	19.6	19.60	0.20
	MF-MF	49.7	50.4	49.3	49.80	0.56
	L-L	78.8	78.1	78.1	78.33	0.40
	AvRM-AvRM	53.1	53.1	52.9	53.03	0.12
15	IF-IF	46.7	46.2	45.6	46.17	0.55
	CRA-CRA	27	27.2	27.4	27.20	0.20
	GPF-GPF	30	30	29.7	29.90	0.17
	MRA-MRA	37.8	38.5	38.7	38.33	0.47
	CR-CR	21.4	22.3	21.3	21.67	0.55
	MF-MF	46.7	45.5	45.7	45.97	0.64
	L-L	76.2	75.5	75.8	75.83	0.35
	AvRM-AvRM	53.7	54.1	53.2	53.67	0.45
16	IF-IF	60.1	59.3	58.4	59.27	0.85
	CRA-CRA	32	31.5	31.9	31.80	0.26
	GPF-GPF	32.2	31.3	32.1	31.87	0.49
	MRA-MRA	37.2	37	37.6	37.27	0.31
	CR-CR	22.9	21.6	21.4	21.97	0.81
	MF-MF	44	42.9	42.4	43.10	0.82
	L-L	81.5	81.3	80.9	81.23	0.31
	AvRM-AvRM	55.3	54.8	54.8	54.97	0.29

17	IF-IF	54.2	53.5	54.7	54.13	0.60
	CRA-CRA	27.8	27.5	27.5	27.60	0.17
	GPF-GPF	27.1	27.1	26.5	26.90	0.35
	MRA-MRA	29.5	30.2	30.8	30.17	0.65
	CR-CR	21.2	20.1	20.5	20.60	0.56
	MF-MF	45.1	45.2	44.9	45.07	0.15
	L-L	75.4	74.7	74.7	74.93	0.40
	AvRM-AvRM	53.8	54.2	54.2	54.07	0.23
18	IF-IF	49.8	49.9	49.3	49.67	0.32
	CRA-CRA	26.8	26.3	26.1	26.40	0.36
	GPF-GPF	32.3	32.5	32.5	32.43	0.12
	MRA-MRA	35	34.6	34.9	34.83	0.21
	CR-CR	20.4	19.3	19.5	19.73	0.59
	MF-MF	42.4	44.2	43.5	43.37	0.91
	L-L	74.5	73.8	74.3	74.20	0.36
	AvRM-AvRM	49.8	49.1	49.5	49.47	0.35
19	IF-IF	47.1	47.4	46.5	47.00	0.46
	CRA-CRA	23.4	23.2	23.3	23.30	0.10
	GPF-GPF	26.5	24.9	25.3	25.57	0.83
	MRA-MRA	28.9	28.4	28.8	28.70	0.26
	CR-CR	20.2	19.2	19.5	19.63	0.51
	MF-MF	43.6	44	44	43.87	0.23
	L-L	71.6	70.9	71.4	71.30	0.36
	AvRM-AvRM	50.9	50.5	50.9	50.77	0.23
20	IF-IF	51.4	50.9	51.8	51.37	0.45
	CRA-CRA	29	28.5	28.5	28.67	0.29
	GPF-GPF	28.8	29.5	29.1	29.13	0.35
	MRA-MRA	36.5	36.6	36.4	36.50	0.10
	CR-CR	21.8	22.6	22.2	22.20	0.40
	MF-MF	46.1	45.6	44.5	45.40	0.82
	L-L	74.6	74.6	74.8	74.67	0.12
	AvRM-AvRM	52.7	52.5	52.5	52.57	0.12
21	IF-IF	53.6	53.2	52.4	53.07	0.61

	CRA-CRA	26.7	26.4	26.4	26.50	0.17
	GPF-GPF	27	26.4	26.2	26.53	0.42
	MRA-MRA	32.4	33.5	33.5	33.13	0.64
	CR-CR	15.7	16.7	16.4	16.27	0.51
	MF-MF	41.8	43.9	45	43.57	1.63
	L-L	84	83.2	84	83.73	0.46
	AvRM-AvRM	52.3	52.3	51.9	52.17	0.23
22	IF-IF	52.8	53.7	53	53.17	0.47
	CRA-CRA	27.2	28.2	27.1	27.50	0.61
	GPF-GPF	28.8	29	29.1	28.97	0.15
	MRA-MRA	30.7	30	30.4	30.37	0.35
	CR-CR	23	22.7	23.3	23.00	0.30
	MF-MF	46.1	46.7	47.3	46.70	0.60
	L-L	81.3	82.6	81.7	81.87	0.67
	AvRM-AvRM	60.7	58.6	59.5	59.60	1.05
23	IF-IF	51.7	51.7	52.3	51.90	0.35
	CRA-CRA	31.9	31.7	30.8	31.47	0.59
	GPF-GPF	27.8	28.6	28.2	28.20	0.40
	MRA-MRA	29.2	29.3	30.4	29.63	0.67
	CR-CR	18	17.4	17.9	17.77	0.32
	MF-MF	42.6	42.4	42.1	42.37	0.25
	L-L	78.5	78.9	78.9	78.77	0.23
	AvRM-AvRM	46.3	45.7	46.4	46.13	0.38
24	IF-IF	43.1	42.9	42.9	42.97	0.12
	CRA-CRA	26.7	28.1	26.8	27.20	0.78
	GPF-GPF	26	26.2	26	26.07	0.12
	MRA-MRA	31.4	30.4	31.2	31.00	0.53
	CR-CR	22.5	20.1	19.8	20.80	1.48
	MF-MF	47.6	46.6	46.5	46.90	0.61
	L-L	79.7	79.8	80.1	79.87	0.21
	AvRM-AvRM	54	52.7	53	53.23	0.68
25	IF-IF	47	49.4	49.6	48.67	1.45
	CRA-CRA	25.2	24.4	24.8	24.80	0.40

	GPF-GPF	26.1	26.3	25.9	26.10	0.20
	MRA-MRA	32.3	32.5	33.6	32.80	0.70
	CR-CR	24.9	23.3	22.3	23.50	1.31
	MF-MF	48.7	48.8	48.4	48.63	0.21
	L-L	76.6	78	78.5	77.70	0.98
	AvRM-AvRM	53.9	54.1	53.9	53.97	0.12
26	IF-IF	57.6	57.4	57	57.33	0.31
	CRA-CRA	27.9	28.4	28.6	28.30	0.36
	GPF-GPF	33.7	33.5	32.9	33.37	0.42
	MRA-MRA	35.7	35	35.3	35.33	0.35
	CR-CR	15.4	15.6	14.8	15.27	0.42
	MF-MF	52.6	55	53.5	53.70	1.21
	L-L	88	88.2	88.5	88.23	0.25
	AvRM-AvRM	52.8	53.7	53	53.17	0.47
27	IF-IF	48.1	47.9	48.1	48.03	0.12
	CRA-CRA	22.8	23.5	23	23.10	0.36
	GPF-GPF	28	28	27.5	27.83	0.29
	MRA-MRA	32.3	32.1	31.9	32.10	0.20
	CR-CR	21.4	20	20	20.47	0.81
	MF-MF	44.3	42.9	43.4	43.53	0.71
	L-L	73.5	71.2	71.2	71.97	1.33
	AvRM-AvRM	48.5	48	48.5	48.33	0.29
28	IF-IF	55.2	55	55.4	55.20	0.20
	CRA-CRA	29.3	29.9	29.7	29.63	0.31
	GPF-GPF	32.4	32.4	32.4	32.40	0.00
	MRA-MRA	35.6	35.8	35	35.47	0.42
	CR-CR	18.1	18	18.9	18.33	0.49
	MF-MF	51	51.5	51.9	51.47	0.45
	L-L	83	82.3	82.7	82.67	0.35
	AvRM-AvRM	55.4	55.7	54.6	55.23	0.57
29	IF-IF	52.7	51.8	51.8	52.10	0.52
	CRA-CRA	25.9	26.1	26.3	26.10	0.20
	GPF-GPF	34.3	34.7	34.5	34.50	0.20

	MRA-MRA	34.4	33.2	34.7	34.10	0.79
	CR-CR	23.3	21.5	21.1	21.97	1.17
	MF-MF	40.1	41.5	40.9	40.83	0.70
	L-L	81	82.2	81	81.40	0.69
	AvRM-AvRM	52.1	52.2	52.1	52.13	0.06
30	IF-IF	55.4	55	55	55.13	0.23
	CRA-CRA	25.9	26.6	26.8	26.43	0.47
	GPF-GPF	31.9	32.2	32.1	32.07	0.15
	MRA-MRA	33.2	34.1	33.3	33.53	0.49
	CR-CR	17.4	17.1	17.6	17.37	0.25
	MF-MF	45.2	45.3	44.6	45.03	0.38
	L-L	76.3	76.5	76.3	76.37	0.12
	AvRM-AvRM	51.4	51.7	51	51.37	0.35

Appendix C: Class I Patients Anterior Width Ratio

	RATIOS (Anterior Width Ratio)			
	IF:MF	IF:CR	CRA:MF	CRA:CR
1	0.9608696	2.5847953	0.5681159	1.5282651
2	0.9440994	1.9598854	0.5596963	1.1618911
3	1.1147661	2.1210014	0.5738304	1.0917942
4	0.9313277	2.3654485	0.4571615	1.1611296
5	1.1390261	3.2606061	0.7290049	2.0868687
6	1.1592233	2.5549215	0.5527508	1.2182596
7	1.0328746	2.3701754	0.5825688	1.3368421
8	1.0768703	2.3558559	0.568291	1.2432432
9	0.9640479	1.9514825	0.5818908	1.1778976
10	1.0474138	2.3033175	0.5574713	1.2259084
11	0.6662343	2.8171846	0.6039536	1.6197441
12	1.2178899	2.4736025	0.6987768	1.4192547
13	1.0522088	2.7086331	0.5386364	1.278777
14	1.0522088	2.6734694	0.5468541	1.3894558
15	1.004351	2.1307692	0.5917331	1.2553846
16	1.3750967	2.6980273	0.737819	1.447648
17	1.2011834	2.6278317	0.612426	1.3398058
18	1.1452729	2.5168919	0.6087625	1.3398058
19	1.0714286	2.3938879	0.531155	1.1867572
20	1.1314244	2.3138138	0.6314244	1.2912913
21	1.2180566	3.2622951	0.6082632	1.6290984
22	1.1384725	2.3115942	0.5888651	1.1956522
23	1.2250197	2.9212008	0.7427223	1.7711069
24	0.9161336	2.0657051	0.5799574	1.3076923
25	1.0006854	2.070922	0.5099383	1.0553191
26	1.0676598	3.7554585	0.5270019	1.8537118
27	1.1033691	2.3469055	0.5306279	1.1286645
28	1.0725389	3.0109091	0.5757772	1.6163636
29	1.2759184	2.3717754	0.6391837	1.1881639
30	1.2242783	3.1746641	0.7882704	1.5220729

Appendix D: Class I Patients Posterior Width Ratio

	RATIOS (Posterior Width Ratio)			
	GPF:L	GPF:AvRM	MRA:L	MRA:AvRM
1	0.3313534	0.547302	0.3343233	0.5522074
2	0.3593619	0.5138055	0.3963056	0.5666267
3	0.3550955	0.5469037	0.3933121	0.6057633
4	0.3271452	0.4895062	0.3514851	0.5259259
5	0.3781614	0.5779141	0.5042152	0.7705521
6	0.3780488	0.5916031	0.4361789	0.68257
7	0.3899309	0.532704	0.4777887	0.652731
8	0.3861839	0.5665446	0.4103204	0.6019536
9	0.3640553	0.5357583	0.4009217	0.5900123
10	0.3791281	0.5401506	0.3859259	0.6537014
11	0.4076956	0.6212121	0.4033722	0.6146245
12	0.3520388	0.5386041	0.422285	0.6460778
13	0.3694853	0.5377926	0.4292279	0.6247492
14	0.4148936	0.6128221	0.5306383	0.7837838
15	0.3942857	0.5571429	0.5054945	0.7142857
16	0.3922856	0.5797453	0.4587608	0.6779867
17	0.3589858	0.4975339	0.4025801	0.5579531
18	0.4371069	0.6556604	0.4694519	0.7041779
19	0.3585788	0.5036113	0.4025245	0.5653316
20	0.3901786	0.5542169	0.4888393	0.6943564
21	0.316879	0.5086262	0.3957006	0.6351438
22	0.3538274	0.4860179	0.3709283	0.5095078
23	0.3580195	0.6112717	0.3762167	0.642341
24	0.3263773	0.4896681	0.3881469	0.5823419
25	0.3359073	0.4836319	0.4221364	0.6077826
26	0.378164	0.6275862	0.4004533	0.6645768
27	0.3867531	0.5758621	0.4460398	0.6641379
28	0.3919355	0.5866023	0.4290323	0.6421243
29	0.4238329	0.6617647	0.4189189	0.6540921
30	0.419904	0.62427	0.4391096	0.6528228

Appendix E: Class III Patients due to Retrusive Maxilla Raw Data

		Timepoint 1	Timepoint 2	Timepoint 3	Mean	SD
RET- 1	IF-IF	46	46.5	46.3	46.27	0.25
	CRA-CRA	27.3	27.8	27.5	27.53	0.25
	GPF-GPF	28.1	28.1	28.1	28.10	0.00
	MRA-MRA	30.8	30.1	30.5	30.47	0.35
	CR-CR	23.2	23.6	23.3	23.37	0.21
	MF-MF	43	43	43	43.00	0.00
	L-L	79.2	78.8	79	79.00	0.20
	AvRM-AvRM	56.6	57.2	57	56.93	0.31
RET-2	IF-IF	47.7	48.7	48	48.13	0.51
	CRA-CRA	26.1	25.8	25.7	25.87	0.21
	GPF-GPF	30.4	30.1	30.4	30.30	0.17
	MRA-MRA	31.8	32.1	32.1	32.00	0.17
	CR-CR	24.7	24.4	24.4	24.50	0.17
	MF-MF	45	45.3	44.4	44.90	0.46
	L-L	80.9	79.1	79.2	79.73	1.01
	AvRM-AvRM	52.1	52	52	52.03	0.06
RET-3	IF-IF	35.7	36.5	35.8	36.00	0.44
	CRA-CRA	28	27.3	27.3	27.53	0.40
	GPF-GPF	27	27	27.3	27.10	0.17
	MRA-MRA	30.2	29.4	29.4	29.67	0.46
	CR-CR	26.8	27.6	28.2	27.53	0.70
	MF-MF	49.7	50	49	49.57	0.51
	L-L	87	84.9	86	85.97	1.05
	AvRM-AvRM	52.8	53.6	52.7	53.03	0.49
RET-4	IF-IF	56	55.7	55.3	55.67	0.35
	CRA-CRA	34.3	34.7	34.3	34.43	0.23
	GPF-GPF	32	32.3	33.7	32.67	0.91
	MRA-MRA	34	34.5	34.5	34.33	0.29
	CR-CR	23.4	23.9	23.9	23.73	0.29
	MF-MF	47.7	47.7	48.1	47.83	0.23

	L-L	89.3	88.8	89.8	89.30	0.50
	AvRM-AvRM	56.8	56.3	56.2	56.43	0.32
RET-5	IF-IF	50.8	50.4	50	50.40	0.40
	CRA-CRA	31.4	30.9	31.3	31.20	0.26
	GPF-GPF	30	30.4	30	30.13	0.23
	MRA-MRA	35.5	35.4	34.4	35.10	0.61
	CR-CR	30	29.7	29.6	29.77	0.21
	MF-MF	43.8	44.2	43.8	43.93	0.23
	L-L	82.9	83.8	83.7	83.47	0.49
	AvRM-AvRM	55.2	55.8	55.8	55.60	0.35
RET-6	IF-IF	45.7	46	45.7	45.80	0.17
	CRA-CRA	25.3	25.3	24.6	25.07	0.40
	GPF-GPF	34	34.5	33.6	34.03	0.45
	MRA-MRA	32.2	32.6	31.9	32.23	0.35
	CR-CR	26.3	26.8	26.3	26.47	0.29
	MF-MF	44.2	43.7	44.7	44.20	0.50
	L-L	89.6	89.2	89.2	89.33	0.23
	AvRM-AvRM	51.2	51.6	51.6	51.47	0.23
RET-7	IF-IF	49.7	49.7	48.6	49.33	0.64
	CRA-CRA	24.7	24.2	24.8	24.57	0.32
	GPF-GPF	29.4	29.4	29	29.27	0.23
	MRA-MRA	32.5	33.2	33.6	33.10	0.56
	CR-CR	24.9	25.4	26.1	25.47	0.60
	MF-MF	46.5	46.9	47.2	46.87	0.35
	L-L	77.7	78.7	78.7	78.37	0.58
	AvRM-AvRM	49	49.5	49	49.17	0.29
RET-8	IF-IF	53.1	52.8	52.5	52.80	0.30
	CRA-CRA	30	29.7	29.5	29.73	0.25
	GPF-GPF	32.2	32.3	32.7	32.40	0.26
	MRA-MRA	37.7	37.6	36.9	37.40	0.44
	CR-CR	27.8	28.3	27.3	27.80	0.50
	MF-MF	47.6	47.7	47.7	47.67	0.06
	L-L	83.6	84	84	83.87	0.23

	AvRM-AvRM	56.6	55.9	55.9	56.13	0.40
RET-9	IF-IF	46.3	46.7	46.5	46.50	0.20
	CRA-CRA	22.9	22.4	22.7	22.67	0.25
	GPF-GPF	26.3	26.4	26.2	26.30	0.10
	MRA-MRA	26.8	26.8	26.8	26.80	0.00
	CR-CR	26.2	25.7	26	25.97	0.25
	MF-MF	43.1	43.7	43.5	43.43	0.31
	L-L	85.7	85.5	85.4	85.53	0.15
	AvRM-AvRM	56.2	55.8	56	56.00	0.20
RET-10	IF-IF	61.4	60.8	61.2	61.13	0.31
	CRA-CRA	55.5	55.6	55.6	55.57	0.06
	GPF-GPF	37.2	37.4	37.6	37.40	0.20
	MRA-MRA	37.8	38.6	38.2	38.20	0.40
	CR-CR	27.1	27.2	27.1	27.13	0.06
	MF-MF	46.3	45.5	45.5	45.77	0.46
	L-L	90.6	91.4	90.6	90.87	0.46
	AvRM-AvRM	55.2	55.3	55.3	55.27	0.06
RET-11	IF-IF	55.5	55.8	55.6	55.63	0.15
	CRA-CRA	29.3	29.3	29.3	29.30	0.00
	GPF-GPF	33.8	33.7	33.6	33.70	0.10
	MRA-MRA	29.9	31.3	30	30.40	0.78
	CR-CR	29.4	29	29.2	29.20	0.20
	MF-MF	46.5	46	46.2	46.23	0.25
	L-L	94	94.3	94	94.10	0.17
	AvRM-AvRM	56.5	57	56.7	56.73	0.25
RET-12	IF-IF	44.6	44.6	44.6	44.60	0.00
	CRA-CRA	25.8	25.8	25.8	25.80	0.00
	GPF-GPF	27.2	27.2	27.2	27.20	0.00
	MRA-MRA	25.5	25.2	25.4	25.37	0.15
	CR-CR	23.1	23.2	23.1	23.13	0.06
	MF-MF	39.5	40.2	40	39.90	0.36
	L-L	81.1	81.1	81.1	81.10	0.00

	AvRM-AvRM	54.6	54.1	54.4	54.37	0.25
RET-13	IF-IF	62.2	61.5	62.9	62.20	0.70
	CRA-CRA	30.3	30.9	29.8	30.33	0.55
	GPF-GPF	27.1	27.3	26.8	27.07	0.25
	MRA-MRA	30.4	29.7	30.4	30.17	0.40
	CR-CR	22.8	23.2	22.8	22.93	0.23
	MF-MF	47.9	47.9	47.2	47.67	0.40
	L-L	87.8	86.9	87.8	87.50	0.52
	AvRM-AvRM	50.6	50.6	51	50.73	0.23
RET-14	IF-IF	45.6	45.6	45.3	45.50	0.17
	CRA-CRA	25.3	25.6	25.3	25.40	0.17
	GPF-GPF	31.1	30.7	30.8	30.87	0.21
	MRA-MRA	29.5	29.2	29.5	29.40	0.17
	CR-CR	24.8	24.2	25.4	24.80	0.60
	MF-MF	38.5	39	39.5	39.00	0.50
	L-L	78	78.5	78.5	78.33	0.29
	AvRM-AvRM	50.2	50.6	50.5	50.43	0.21
RET-15	IF-IF	38.6	38.7	39.2	38.83	0.32
	CRA-CRA	27.2	28.1	28.1	27.80	0.52
	GPF-GPF	32.7	32	32.2	32.30	0.36
	MRA-MRA	39	38.4	38	38.47	0.50
	CR-CR	23.9	23.3	23.6	23.60	0.30
	MF-MF	43.9	43.5	44.3	43.90	0.40
	L-L	91.1	91.2	91.2	91.17	0.06
	AvRM-AvRM	55.3	54.9	54.6	54.93	0.35
RET-16	IF-IF	46	46	46	46.00	0.00
	CRA-CRA	29	29.4	29.2	29.20	0.20
	GPF-GPF	28.4	28.4	28.4	28.40	0.00
	MRA-MRA	32	31.7	31.9	31.87	0.15
	CR-CR	24.4	24.4	24.4	24.40	0.00
	MF-MF	45.9	45.9	45.9	45.90	0.00
	L-L	81.9	82	82	81.97	0.06

	AvRM-AvRM	55.4	55.4	55.4	55.40	0.00
RET-17	IF-IF	51.3	51.3	51.3	51.30	0.00
	CRA-CRA	25.3	25.1	25.3	25.23	0.12
	GPF-GPF	28.3	28.6	28.4	28.43	0.15
	MRA-MRA	32.1	32.1	32.1	32.10	0.00
	CR-CR	17.7	17.7	17.7	17.70	0.00
	MF-MF	43.5	43	43.3	43.27	0.25
	L-L	75.9	75.6	75.8	75.77	0.15
	AvRM-AvRM	57	56.5	56.8	56.77	0.25
RET-18	IF-IF	52.2	51.8	51.3	51.77	0.45
	CRA-CRA	26.6	27.4	27	27.00	0.40
	GPF-GPF	29.7	29.7	29.2	29.53	0.29
	MRA-MRA	30.1	30.1	30.6	30.27	0.29
	CR-CR	25.8	25.9	26.2	25.97	0.21
	MF-MF	46.6	47	47.4	47.00	0.40
	L-L	74.9	74.4	75.4	74.90	0.50
	AvRM-AvRM	48.9	48.4	48.9	48.73	0.29
RET-19	IF-IF	47.9	48.2	48	48.03	0.15
	CRA-CRA	28.9	28.5	28.7	28.70	0.20
	GPF-GPF	33.9	34.6	34	34.17	0.38
	MRA-MRA	36.2	36.6	36.4	36.40	0.20
	CR-CR	23.2	23.5	23.3	23.33	0.15
	MF-MF	47.5	47.6	47.6	47.57	0.06
	L-L	90.1	90.5	90.3	90.30	0.20
	AvRM-AvRM	54	54.6	54.4	54.33	0.31
RET-20	IF-IF	53	52.7	52.9	52.87	0.15
	CRA-CRA	26.2	26.2	26.2	26.20	0.00
	GPF-GPF	27.8	27.3	27.5	27.53	0.25
	MRA-MRA	28	27.4	27.8	27.73	0.31
	CR-CR	25.7	25.7	25.7	25.70	0.00
	MF-MF	43.2	43.2	43.2	43.20	0.00
	L-L	87.2	87.2	87.2	87.20	0.00

	AvRM-AvRM	52.6	52	52.4	52.33	0.31
RET-21	IF-IF	57.9	57.2	57.7	57.60	0.36
	CRA-CRA	36.2	35.8	35.9	35.97	0.21
	GPF-GPF	58.5	58.2	57.8	58.17	0.35
	MRA-MRA	36.3	36.3	35.9	36.17	0.23
	CR-CR	31.9	31.3	31.9	31.70	0.35
	MF-MF	48.4	48.9	48.4	48.57	0.29
	L-L	93.1	93.1	93.1	93.10	0.00
	AvRM-AvRM	57.1	57.1	57.2	57.13	0.06
RET-22	IF-IF	47.9	47.6	47.1	47.53	0.40
	CRA-CRA	35.2	34.7	34.2	34.70	0.50
	GPF-GPF	30	29.4	29.4	29.60	0.35
	MRA-MRA	35.7	35.3	35.3	35.43	0.23
	CR-CR	23.8	24.1	23.6	23.83	0.25
	MF-MF	51.1	51	51	51.03	0.06
	L-L	90.9	90.1	90.1	90.37	0.46
	AvRM-AvRM	56.9	57.4	56.9	57.07	0.29
RET-23	IF-IF	46	46	46.3	46.10	0.17
	CRA-CRA	29.7	29.6	29.2	29.50	0.26
	GPF-GPF	26.4	25.8	27	26.40	0.60
	MRA-MRA	32.7	31.8	32.7	32.40	0.52
	CR-CR	28.8	28.5	28.8	28.70	0.17
	MF-MF	41.9	41.9	41	41.60	0.52
	L-L	81.5	81.9	81.5	81.63	0.23
	AvRM-AvRM	52.4	52.6	52.6	52.53	0.12
RET-24	IF-IF	47.7	46.9	47.3	47.30	0.40
	CRA-CRA	28.5	27.9	27.9	28.10	0.35
	GPF-GPF	30.4	29.9	29.4	29.90	0.50
	MRA-MRA	28.9	28.9	29.4	29.07	0.29
	CR-CR	25.7	25.2	25.2	25.37	0.29
	MF-MF	49.5	49	49	49.17	0.29
	L-L	88.8	89.3	88.8	88.97	0.29

	AvRM-AvRM	57.2	57.8	56.6	57.20	0.60
RET-25	IF-IF	41.5	40.9	40.9	41.10	0.35
	CRA-CRA	26.2	26.2	25.8	26.07	0.23
	GPF-GPF	28.2	28.6	28.6	28.47	0.23
	MRA-MRA	35.4	35	34.6	35.00	0.40
	CR-CR	17.2	18	17.2	17.47	0.46
	MF-MF	44.4	44.8	44.9	44.70	0.26
	L-L	80.8	81.3	81.3	81.13	0.29
	AvRM-AvRM	53.6	54.2	53.6	53.80	0.35
RET-26	IF-IF	48.9	48.5	48.9	48.77	0.23
	CRA-CRA	29.5	29.3	29.7	29.50	0.20
	GPF-GPF	31.5	31.7	31.3	31.50	0.20
	MRA-MRA	30.4	30.3	29.9	30.20	0.26
	CR-CR	20.4	20.8	20	20.40	0.40
	MF-MF	46.2	46.2	46.6	46.33	0.23
	L-L	90.6	90.1	90.5	90.40	0.26
	AvRM-AvRM	54.5	55.3	55.8	55.20	0.66
RET-27	IF-IF	56	56.7	56	56.23	0.40
	CRA-CRA	32.3	32.8	32.3	32.47	0.29
	GPF-GPF	32.9	33.3	32.6	32.93	0.35
	MRA-MRA	33.9	33.9	33	33.60	0.52
	CR-CR	23.4	23.5	23.5	23.47	0.06
	MF-MF	51.6	51	51	51.20	0.35
	L-L	87.1	87.7	87.1	87.30	0.35
	AvRM-AvRM	60.6	60.6	60.2	60.47	0.23
RET-28	IF-IF	56.3	56.8	56.8	56.63	0.29
	CRA-CRA	27.5	27.5	28.1	27.70	0.35
	GPF-GPF	30.9	30.9	31	30.93	0.06
	MRA-MRA	31.4	31.7	31.7	31.60	0.17
	CR-CR	25.3	25	25.6	25.30	0.30
	MF-MF	44.6	45.2	44.9	44.90	0.30
	L-L	90.6	90.6	90.6	90.60	0.00

	AvRM-AvRM	52.8	52.8	52.1	52.57	0.40
RET-29	IF-IF	50.8	51.3	51.1	51.07	0.25
	CRA-CRA	25.9	25.1	25.9	25.63	0.46
	GPF-GPF	32.3	32.7	32.1	32.37	0.31
	MRA-MRA	32.6	31.8	32.3	32.23	0.40
	CR-CR	25.2	25.7	25.9	25.60	0.36
	MF-MF	47.4	46.8	47.1	47.10	0.30
	L-L	94.4	93.9	93.9	94.07	0.29
	AvRM-AvRM	54.8	55.1	55.8	55.23	0.51
RET-30	IF-IF	42.9	42.4	42.3	42.53	0.32
	CRA-CRA	31.1	31.1	31.5	31.23	0.23
	GPF-GPF	31.8	32	31.8	31.87	0.12
	MRA-MRA	33.2	32.9	33.3	33.13	0.21
	CR-CR	28.2	28.5	28.4	28.37	0.15
	MF-MF	51.3	51.7	51.7	51.57	0.23
	L-L	85.8	85.8	85.7	85.77	0.06
	AvRM-AvRM	54.2	54.9	54.5	54.53	0.35

Appendix F: Class III due to a Retrusive Maxilla Anterior Width Ratio

	RATIOS (Anterior Width Ratio)			
	IF:MF	IF: CR	CRA: MF	CRA:CR
1	1.075968992	1.980028531	0.640310078	1.17831669
2	1.072011878	1.96462585	0.576095026	1.055782313
3	0.726294553	1.307506053	0.555480834	1
4	1.163763066	2.345505618	0.719860627	1.450842697
5	1.147192716	1.693169093	0.71016692	1.048152296
6	1.036199095	1.730478589	0.567119155	0.947103275
7	1.052631579	1.937172775	0.524182077	0.964659686
8	1.107692308	1.899280576	0.623776224	1.069544365
9	1.070606293	1.790757381	0.521872602	0.872913992
10	1.335761107	2.253071253	1.214129643	2.047911548
11	1.20331651	1.905251142	0.633741889	1.003424658
12	1.117794486	1.92795389	0.646616541	1.115273775
13	1.304895105	2.712209302	0.636363636	1.322674419
14	1.166666667	1.834677419	0.651282051	1.024193548
15	0.884586181	1.645480226	0.633257403	1.177966102
16	1.002178649	1.885245902	0.636165577	1.196721311
17	1.185670262	2.898305085	0.583204931	1.425612053
18	1.10141844	1.993581515	0.574468085	1.039794608
19	1.009810792	2.058571429	0.6033637	1.23
20	1.223765432	2.057068742	0.606481481	1.019455253
21	1.185998627	1.8170347	0.7405628	1.134595163
22	0.931417374	1.994405594	0.679947747	1.455944056
23	1.108173077	1.606271777	0.709134615	1.027874564
24	0.962033898	1.864651774	0.571525424	1.107752957
25	0.919463087	2.353053435	0.583146905	1.492366412
26	1.052517986	2.390522876	0.636690647	1.446078431
27	1.098307292	2.396306818	0.634114583	1.383522727
28	1.261321455	2.238471673	0.616926503	1.09486166
29	1.084217976	1.994791667	0.54423213	1.001302083
30	0.824822237	1.499412456	0.605688429	1.101057579

Appendix G: Class III due to a Retrusive Maxilla Posterior Width Ratio

	RATIOS (Posterior Width Ratio)			
	GPF:L	GPF:AvRM	MRA:L	MRA:AvRM
1	0.355696203	0.493559719	0.385654008	0.535128806
2	0.380016722	0.582319026	0.401337793	0.614990391
3	0.315238465	0.510999371	0.345094998	0.559396606
4	0.365808137	0.578854105	0.384471818	0.608387478
5	0.361022364	0.541966427	0.420527157	0.631294964
6	0.380970149	0.66126943	0.360820896	0.626295337
7	0.373458103	0.595254237	0.422373458	0.673220339
8	0.386327504	0.57719715	0.445945946	0.666270784
9	0.307482463	0.469642857	0.313328137	0.478571429
10	0.411592076	0.676718938	0.420396185	0.69119421
11	0.358129649	0.594007051	0.323060574	0.535840188
12	0.335388409	0.50030656	0.312782573	0.466584917
13	0.309333333	0.533508541	0.344761905	0.594612352
14	0.394042553	0.612029081	0.375319149	0.582947786
15	0.354296161	0.587985437	0.421937843	0.700242718
16	0.34648231	0.512635379	0.388775925	0.57521059
17	0.375274967	0.500880799	0.42366916	0.565472695
18	0.394303516	0.606019152	0.404094348	0.621067031
19	0.378368402	0.628834356	0.403100775	0.66993865
20	0.315749235	0.52611465	0.318042813	0.529936306
21	0.624776226	1.018086348	0.388471178	0.63302217
22	0.327554408	0.518691589	0.392106234	0.620911215
23	0.323397305	0.502538071	0.396896693	0.616751269
24	0.336080929	0.522727273	0.326714125	0.508158508
25	0.350862777	0.529120198	0.431388661	0.650557621
26	0.348451327	0.570652174	0.334070796	0.547101449
27	0.377243223	0.544652701	0.384879725	0.55567806
28	0.34142752	0.5884591	0.348785872	0.601141408
29	0.344082211	0.585998793	0.342664777	0.583584792
30	0.371550719	0.584352078	0.386319471	0.607579462

Appendix H: Class III due to a Prognathic Mandible Raw Data

		Timepoint 1	Timepoint 2	Timepoint 3	Mean	SD
PROG-1	IF-IF	48.4	48.9	48.7	48.67	0.25
	CRA-CRA	29.7	29.1	29.1	29.30	0.35
	GPF-GPF	29.3	29.3	29.9	29.50	0.35
	MRA-MRA	38.2	38.6	38.2	38.33	0.23
	CR-CR	28.8	29.5	29.1	29.13	0.35
	MF-MF	41.3	41.7	41.7	41.57	0.23
	L-L	87.2	87.8	87.9	87.63	0.38
	AvRM-AvRM	55.3	54.7	55.2	55.07	0.32
PROG-2	IF-IF	54.2	54.2	54.5	54.30	0.17
	CRA-CRA	32.5	33.1	32.5	32.70	0.35
	GPF-GPF	30.9	31.2	30.9	31.00	0.17
	MRA-MRA	37.3	37.7	37.5	37.50	0.20
	CR-CR	28.7	28.3	28.5	28.50	0.20
	MF-MF	46.6	46.2	46.4	46.40	0.20
	L-L	83.9	83.5	83.7	83.70	0.20
	AvRM-AvRM	55.3	55.8	55.5	55.53	0.25
PROG-3	IF-IF	55.5	55	55.3	55.27	0.25
	CRA-CRA	26.8	26.1	26.5	26.47	0.35
	GPF-GPF	29	29.5	28.8	29.10	0.36
	MRA-MRA	26.3	26.8	26.5	26.53	0.25
	CR-CR	20.7	20.7	20.7	20.70	0.00
	MF-MF	44.7	44.3	43.9	44.30	0.40
	L-L	87.5	87.5	87.1	87.37	0.23
	AvRM-AvRM	52.9	52.9	52.3	52.70	0.35

PROG-4	IF-IF	53.8	53.2	53.5	53.50	0.30
	CRA-CRA	31.1	29.9	31.1	30.70	0.69
	GPF-GPF	33.9	33.5	33.5	33.63	0.23
	MRA-MRA	29.1	29.7	30.3	29.70	0.60
	CR-CR	20.5	21.2	20.9	20.87	0.35
	MF-MF	48.8	48.4	48.1	48.43	0.35
	L-L	85.2	85.6	86.3	85.70	0.56
	AvRM-AvRM	54.9	55.5	55.4	55.27	0.32
PROG-5	IF-IF	51.7	51.4	51.7	51.60	0.17
	CRA-CRA	30.4	30.1	30.4	30.30	0.17
	GPF-GPF	32.9	32.5	32.5	32.63	0.23
	MRA-MRA	39.9	39	39.5	39.47	0.45
	CR-CR	25.9	25.2	25.3	25.47	0.38
	MF-MF	45.6	46.2	46.2	46.00	0.35
	L-L	92.5	92.8	93.1	92.80	0.30
	AvRM-AvRM	55.6	54.8	54.3	54.90	0.66
PROG-6	IF-IF	48.4	48.6	48.6	48.53	0.12
	CRA-CRA	28.8	28.4	28.2	28.47	0.31
	GPF-GPF	31.9	31.6	31.9	31.80	0.17
	MRA-MRA	36	36.2	36	36.07	0.12
	CR-CR	23.1	22.7	23.1	22.97	0.23
	MF-MF	45.6	45	45	45.20	0.35
	L-L	73.1	73.8	73.1	73.33	0.40
	AvRM-AvRM	51.3	51.2	51.5	51.33	0.15
PROG-7	IF-IF	45.8	45.8	46.4	46.00	0.35
	CRA-CRA	27.4	27.7	27.4	27.50	0.17
	GPF-GPF	27.5	27.8	27.8	27.70	0.17
	MRA-MRA	35.4	35.2	34.9	35.17	0.25
	CR-CR	27.1	27	27.6	27.23	0.32
	MF-MF	42.6	42.6	43	42.73	0.23
	L-L	80	80	79.6	79.87	0.23

	AvRM-AvRM	50.4	50.9	50.4	50.57	0.29
PROG-8	IF-IF	46.8	46.2	46.9	46.63	0.38
	CRA-CRA	29	28.8	29	28.93	0.12
	GPF-GPF	27.9	27.9	28.2	28.00	0.17
	MRA-MRA	33.4	33.1	33.4	33.30	0.17
	CR-CR	24.3	24.3	23.7	24.10	0.35
	MF-MF	48.2	48.1	48.1	48.13	0.06
	L-L	68.3	68.5	68.2	68.33	0.15
	AvRM-AvRM	52.6	52.6	52.1	52.43	0.29
PROG-9	IF-IF	48.7	48	48	48.23	0.40
	CRA-CRA	27.6	27.3	27.6	27.50	0.17
	GPF-GPF	30.2	29.9	30.2	30.10	0.17
	MRA-MRA	40.2	40.5	40.1	40.27	0.21
	CR-CR	24.3	24.4	24.7	24.47	0.21
	MF-MF	47.7	47.4	47.4	47.50	0.17
	L-L	83.4	83.7	83	83.37	0.35
	AvRM-AvRM	54.1	54.5	54.1	54.23	0.23
PROG-10	IF-IF	45.3	45.5	45.5	45.43	0.12
	CRA-CRA	34.3	34	34.3	34.20	0.17
	GPF-GPF	25.2	25.6	25.6	25.47	0.23
	MRA-MRA	26.9	26.1	26.1	26.37	0.46
	CR-CR	21	20.5	20.7	20.73	0.25
	MF-MF	45.5	45.2	45.2	45.30	0.17
	L-L	78.6	78.6	78.6	78.60	0.00
	AvRM-AvRM	51.3	50.9	50.7	50.97	0.31
PROG-11	IF-IF	52	52.6	52.4	52.33	0.31
	CRA-CRA	26.1	26.6	26.1	26.27	0.29
	GPF-GPF	26.4	26.4	26.4	26.40	0.00
	MRA-MRA	33.8	33.3	33.5	33.53	0.25
	CR-CR	27.7	27.4	27.3	27.47	0.21
	MF-MF	49.3	48.9	49.1	49.10	0.20

	L-L	79.3	80.4	80.1	79.93	0.57
	AvRM-AvRM	56.2	56.7	56.5	56.47	0.25
PROG-12	IF-IF	45	44.7	44.9	44.87	0.15
	CRA-CRA	30.5	31	30.7	30.73	0.25
	GPF-GPF	31.9	31.3	31.7	31.63	0.31
	MRA-MRA	37.1	36.8	36.9	36.93	0.15
	CR-CR	23.1	23.1	23	23.07	0.06
	MF-MF	41.5	42.1	41.8	41.80	0.30
	L-L	83.6	83	83.4	83.33	0.31
	AvRM-AvRM	45.9	45.7	45.8	45.80	0.10
PROG-13	IF-IF	47	47.9	47.5	47.47	0.45
	CRA-CRA	27.8	27.2	27.4	27.47	0.31
	GPF-GPF	30.6	30.3	30.4	30.43	0.15
	MRA-MRA	30.5	30	30.3	30.27	0.25
	CR-CR	26.7	26.7	26.5	26.63	0.12
	MF-MF	45.1	45.2	45.1	45.13	0.06
	L-L	87	87	86.8	86.93	0.12
	AvRM-AvRM	57.4	56.9	57.2	57.17	0.25
PROG-14	IF-IF	46.5	47.1	46.9	46.83	0.31
	CRA-CRA	27.1	26.5	26.7	26.77	0.31
	GPF-GPF	26.8	26.5	26.7	26.67	0.15
	MRA-MRA	31.7	31.7	31.5	31.63	0.12
	CR-CR	27.7	27	27.4	27.37	0.35
	MF-MF	46.5	46.7	46.5	46.57	0.12
	L-L	76	76.8	76.5	76.43	0.40
	AvRM-AvRM	48.4	48.8	48.5	48.57	0.21
PROG-15	IF-IF	49	49.6	49.4	49.33	0.31
	CRA-CRA	22.9	23.3	23.1	23.10	0.20
	GPF-GPF	25.7	25.3	25.5	25.50	0.20
	MRA-MRA	31.8	31.2	31.1	31.37	0.38

	CR-CR	32.6	32.9	32.7	32.73	0.15
	MF-MF	49.3	49.3	49.5	49.37	0.12
	L-L	83.8	84.2	84	84.00	0.20
	AvRM-AvRM	57.2	57.2	57	57.13	0.12
PROG-16	IF-IF	52.6	52.2	52.4	52.40	0.20
	CRA-CRA	35.4	35	35.2	35.20	0.20
	GPF-GPF	30.9	30.2	30.5	30.53	0.35
	MRA-MRA	40.6	40.6	40.6	40.60	0.00
	CR-CR	25.3	25.7	25.5	25.50	0.20
	MF-MF	48.6	48.1	48.4	48.37	0.25
	L-L	84.5	84.5	84.8	84.60	0.17
	AvRM-AvRM	53.1	53.6	53.3	53.33	0.25
PROG-17	IF-IF	53.3	53.7	53.5	53.50	0.20
	CRA-CRA	34.4	34.1	34.3	34.27	0.15
	GPF-GPF	29.5	29.5	29.5	29.50	0.00
	MRA-MRA	33.1	33	33	33.03	0.06
	CR-CR	27.8	27.8	27.8	27.80	0.00
	MF-MF	48.4	49	48.7	48.70	0.30
	L-L	87.5	88.1	87.8	87.80	0.30
	AvRM-AvRM	59.8	59.8	59.8	59.80	0.00
PROG-18	IF-IF	53.8	54	53.7	53.83	0.15
	CRA-CRA	27.5	27.8	27.7	27.67	0.15
	GPF-GPF	33.4	33.6	33.3	33.43	0.15
	MRA-MRA	35.2	36.1	35.7	35.67	0.45
	CR-CR	30.9	30.9	30.9	30.90	0.00
	MF-MF	44.3	44.3	44.5	44.37	0.12
	L-L	92.2	91.8	92	92.00	0.20
	AvRM-AvRM	54.5	54.5	54.5	54.50	0.00
PROG-19	IF-IF	53.9	54	54	53.97	0.06
	CRA-CRA	32.4	32.7	32.5	32.53	0.15

	GPF-GPF	27.7	27.2	27.5	27.47	0.25
	MRA-MRA	28.3	27.7	28	28.00	0.30
	CR-CR	29.6	29.6	29.4	29.53	0.12
	MF-MF	50.9	50.5	50.7	50.70	0.20
	L-L	91	91.5	91.3	91.27	0.25
	AvRM-AvRM	58	57.5	57.7	57.73	0.25
PROG-20	IF-IF	52.2	52.2	52	52.13	0.12
	CRA-CRA	31.7	31.1	31.5	31.43	0.31
	GPF-GPF	27.7	27.1	27.4	27.40	0.30
	MRA-MRA	35	34.5	34.7	34.73	0.25
	CR-CR	21.4	21.1	21.1	21.20	0.17
	MF-MF	46.2	46.3	46	46.17	0.15
	L-L	78.1	77.7	77.9	77.90	0.20
	AvRM-AvRM	55.5	55.5	55.3	55.43	0.12
PROG-21	IF-IF	58.5	58.3	58.5	58.43	0.12
	CRA-CRA	36.7	37	36.9	36.87	0.15
	GPF-GPF	30.3	30.3	30.5	30.37	0.12
	MRA-MRA	34.8	34.8	34.8	34.80	0.00
	CR-CR	24.6	24.2	24.4	24.40	0.20
	MF-MF	51.6	51	51.4	51.33	0.31
	L-L	90.5	90.1	90.3	90.30	0.20
	AvRM-AvRM	60.2	59.7	60	59.97	0.25
PROG-22	IF-IF	50.5	50.2	50.3	50.33	0.15
	CRA-CRA	26.4	26.1	26.2	26.23	0.15
	GPF-GPF	31.7	31.7	31.7	31.70	0.00
	MRA-MRA	37.5	37.3	37.1	37.30	0.20
	CR-CR	25.6	26	25.8	25.80	0.20
	MF-MF	43.8	44.6	44.1	44.17	0.40
	L-L	83.2	83.2	83.2	83.20	0.00
	AvRM-AvRM	54.5	54	54.3	54.27	0.25

PROG-23	IF-IF	54.4	54.8	54.6	54.60	0.20
	CRA-CRA	32.9	32.9	32.9	32.90	0.00
	GPF-GPF	33.9	34.4	34.2	34.17	0.25
	MRA-MRA	37	36.8	37.1	36.97	0.15
	CR-CR	32.3	32.6	32.4	32.43	0.15
	MF-MF	46.7	46.3	46.5	46.50	0.20
	L-L	90.6	91	90.8	90.80	0.20
	AvRM-AvRM	56.6	56.1	56.3	56.33	0.25
PROG-24	IF-IF	61.9	62.1	61.9	61.97	0.12
	CRA-CRA	26.9	27.3	27.1	27.10	0.20
	GPF-GPF	31.5	31.3	31.3	31.37	0.12
	MRA-MRA	36.3	36.9	36.6	36.60	0.30
	CR-CR	26.7	26.5	26.5	26.57	0.12
	MF-MF	49	49.3	49.1	49.13	0.15
	L-L	84.5	83.8	84.1	84.13	0.35
	AvRM-AvRM	53	53.5	53.4	53.30	0.26
PROG-25	IF-IF	52.1	52.2	52	52.10	0.10
	CRA-CRA	32.3	31.6	31.9	31.93	0.35
	GPF-GPF	30.5	30.5	30.5	30.50	0.00
	MRA-MRA	37.2	36.6	36.9	36.90	0.30
	CR-CR	29.8	29.8	29.8	29.80	0.00
	MF-MF	51.5	51.9	51.7	51.70	0.20
	L-L	85.7	85.7	85.7	85.70	0.00
	AvRM-AvRM	57.1	57.1	57.1	57.10	0.00
PROG-26	IF-IF	57.5	57.8	57.7	57.67	0.15
	CRA-CRA	35.8	35.8	35.8	35.80	0.00
	GPF-GPF	32	32.3	32.1	32.13	0.15
	MRA-MRA	35.6	35.2	35.4	35.40	0.20
	CR-CR	21.1	21.4	21.2	21.23	0.15
	MF-MF	51.4	52	51.7	51.70	0.30
	L-L	86.6	87.2	86.9	86.90	0.30

	AvRM-AvRM	55.8	55.1	55.4	55.43	0.35
PROG-27	IF-IF	54.7	54.7	55	54.80	0.17
	CRA-CRA	28.9	28.5	28.7	28.70	0.20
	GPF-GPF	31.4	31.4	31.4	31.40	0.00
	MRA-MRA	38.1	38.3	38.4	38.27	0.15
	CR-CR	26.7	27.5	27.3	27.17	0.42
	MF-MF	42.3	42.3	42.3	42.30	0.00
	L-L	83.5	84.1	84.3	83.97	0.42
	AvRM-AvRM	49.2	50.9	50.3	50.13	0.86
PROG-28	IF-IF	60.8	61.1	61	60.97	0.15
	CRA-CRA	35	35	35	35.00	0.00
	GPF-GPF	33.6	33.6	33.6	33.60	0.00
	MRA-MRA	41.7	41.7	41.7	41.70	0.00
	CR-CR	26.8	27.3	27	27.03	0.25
	MF-MF	49.4	49	49.2	49.20	0.20
	L-L	79.7	80.2	80	79.97	0.25
	AvRM-AvRM	53.6	53.1	53.4	53.37	0.25
PROG-29	IF-IF	48.8	49	49.2	49.00	0.20
	CRA-CRA	31.7	31.7	31.7	31.70	0.00
	GPF-GPF	31.3	31.1	30.9	31.10	0.20
	MRA-MRA	34.1	34.3	33.9	34.10	0.20
	CR-CR	23.2	23.3	23.5	23.33	0.15
	MF-MF	50.1	49.6	49.8	49.83	0.25
	L-L	90.9	90.3	90.6	90.60	0.30
	AvRM-AvRM	60.8	61.1	60.9	60.93	0.15
PROG-30	IF-IF	45.3	45.5	45.2	45.33	0.15
	CRA-CRA	26.6	25.9	26.3	26.27	0.35
	GPF-GPF	34.3	34.7	34.5	34.50	0.20
	MRA-MRA	35.7	35.7	35.7	35.70	0.00
	CR-CR	24.3	24.3	24.3	24.30	0.00

	MF-MF	48.9	48.1	48.5	48.50	0.40
	L-L	80.9	80.9	80.9	80.90	0.00
	AvRM-AvRM	52.5	51.9	52	52.13	0.32

Appendix I: Class III due to a Prognathic Mandible Anterior Width Ratio

	RATIOS (Anterior Width Ratio)			
	IF:MF	IF: CR	CRA: MF	CRA:CR
1	1.170809944	1.670480549	0.70489174	1.005720824
2	1.170258621	1.905263158	0.704741379	1.147368421
3	1.247554552	2.669887279	0.597441685	1.278582931
4	1.104611149	2.563897764	0.633860977	1.471246006
5	1.12173913	2.02617801	0.658695652	1.189790576
6	1.073746313	2.113207547	0.62979351	1.239477504
7	1.076443058	1.689106487	0.643525741	1.009791922
8	0.968836565	1.934993084	0.601108033	1.20055325
9	1.015438596	1.971389646	0.578947368	1.123978202
10	1.002943341	2.191318328	0.754966887	1.649517685
11	1.065852003	1.905339806	0.534962661	0.95631068
12	1.073365231	1.945086705	0.735247209	1.332369942
13	1.051698671	1.782227785	0.608567208	1.031289111
14	1.005726557	1.711327649	0.57480315	0.978075518
15	0.999324781	1.50712831	0.467927076	0.705702648
16	1.083390765	2.054901961	0.727773949	1.380392157
17	1.098562628	1.924460432	0.703627652	1.232613909
18	1.213373403	1.742179072	0.623591285	0.895361381
19	1.064431295	1.82731377	0.641683103	1.101580135
20	1.129241877	2.459119497	0.680866426	1.482704403
21	1.138311688	2.394808743	0.718181818	1.510928962
22	1.139622642	1.950904393	0.593962264	1.016795866
23	1.174193548	1.683453237	0.707526882	1.014388489
24	1.26119403	2.332496863	0.55156038	1.020075282
25	1.007736944	1.748322148	0.617666022	1.071588367
26	1.115409413	2.715855573	0.69245648	1.686028257
27	1.295508274	2.017177914	0.678486998	1.056441718
28	1.239159892	2.255240444	0.711382114	1.294697904
29	0.983277592	2.1	0.636120401	1.358571429
30	0.934707904	1.865569273	0.541580756	1.080932785

Appendix J: Class III due to a Prognathic Mandible Posterior Width Ratio

	RATIOS (Posterior Width Ratio)			
	GPF:L	GPF:AvRM	MRA:L	MRA:AvRM
1	0.336629897	0.535714286	0.43742868	0.696125908
2	0.37037037	0.558223289	0.448028674	0.675270108
3	0.333078977	0.552182163	0.303700878	0.503478811
4	0.392454298	0.608564536	0.34655776	0.537394451
5	0.351652299	0.594414086	0.425287356	0.718882817
6	0.433636364	0.619480519	0.491818182	0.702597403
7	0.346828047	0.547791694	0.440317195	0.695451549
8	0.409756098	0.534011443	0.487317073	0.635092181
9	0.361055578	0.555009219	0.483006797	0.742470805
10	0.324003393	0.499672989	0.335453774	0.517331589
11	0.330275229	0.467532468	0.419516264	0.593860685
12	0.3796	0.690684134	0.4432	0.806404658
13	0.350076687	0.532361516	0.348159509	0.529446064
14	0.34888792	0.549073439	0.413868295	0.651338367
15	0.303571429	0.446324387	0.373412698	0.549008168
16	0.360914106	0.5725	0.479905437	0.76125
17	0.335990888	0.493311037	0.376233865	0.552396878
18	0.363405797	0.613455657	0.387681159	0.654434251
19	0.300949598	0.475750577	0.30679328	0.484988453
20	0.351732991	0.494287432	0.445870774	0.626578473
21	0.336286453	0.50639244	0.38538206	0.580322401
22	0.381009615	0.584152334	0.448317308	0.687346437
23	0.376284875	0.606508876	0.40712188	0.656213018
24	0.372820919	0.588492808	0.435023772	0.686679174
25	0.355892649	0.534150613	0.430571762	0.646234676
26	0.369773686	0.579675286	0.407364787	0.638604931
27	0.37395792	0.626329787	0.455736403	0.763297872
28	0.420175073	0.629606496	0.521467278	0.781386633
29	0.343267108	0.510393873	0.376379691	0.559628009
30	0.42645241	0.661764706	0.441285538	0.684782609

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