A 3D ANALALYSIS OF CLASS III CORRECTION WITH FIXED APPLIANCES

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Dedication

To my wonderful man, partner, friend and soul mate Bandar for all your support, understanding, patience and unconditional love over the last few years. I would not be here without you.

To my parents for their unparalleled support and for being my backbone throughout my life.

To my brother and sister for your companionship throughout my life and for making this journey a smooth one. I'm blessed to have you in my life.

To my Grandmother who has always been a blessing in my life. Her prayers for me keep me going everyday.

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Abstract

By

Sara Taher

INTRODUCTION: Our objective was to evaluate the dento-skeletal changes occurring during a comprehensive non-extraction orthodontic treatment of Class III malocclusion in the three planes of space and compare them to class I malocclusion subjects using cone-beam computed tomography (CBCT).

METHODS: The pre- (T1) and post-treatment (T2) CBCTs of 23 matched adolescent subjects from class I and class III were oriented using the cranial nerve canals to set the 3 planes of reference and 19 landmarks were registered on maxillary, mandibular and dental structures. The data consisted of 3-dimensional coordinates representing the distances to the reference planes. The data was analyzed using Wilcoxon rank sum test, Mann Whitney U test and the intra-observer reliability was tested by Interclass Correlation Coefficient.

RESULTS: The coordinate system is a reliable method to be used for longitudinal studies. Class I treatment resulted in significant dental changes in vertical and AP directions. Class I group showed significant changes in skeletal landmarks consistent with growth magnitude and direction. Class III

treatment showed significant dental changes mostly in transverse followed by vertical and AP directions. This study allows us to appreciate the third dimension of a 3D study utilizing CBCT. Dental changes were the most significant between the two groups. ANS and PNS showed minimal changes in both groups. Only Gonion and PNS showed a tendency to relocate backwards where all the other landmarks displayed a downward and forward movement, which is supported by the previous growth studies.

CONCLUSION: A collection of dental changes contributed to the correction of class III malocclusion. The coordinate method was found to be reliable for longitudinal studies in 3-Dimensions and allows the evaluation of amount and direction of treatment changes in the third dimension.

Keywords: Class III, Correction, Cone Beam Computed Tomography, Orientation, Coordinate.

TABLE OF CONTENTS

DEDICATION..... 2
ACKNOWLEDGEMENTS..... 3
ABSTRACT..... 4
LIST OF FIGURES..... 7
LIST OF TABLES..... 8
REVIEW OF THE LITERATURE..... 9
LITERATURE REFERENCES..... 23
STATEMENT OF THESIS..... 26
MANUSCRIPT FOR PUBLICATION..... 27
INTRODUCTION..... 29
MATERIAL AND METHODS..... 32
RESULTS 38
DISCUSSION..... 42
CONCLUSION 47
REFERENCES..... 48

APPENDICES

IRB Approval..... 51
Informed Consent..... 52
Orientation Method..... 54
Statistics..... 56
Scatterplots..... 85

List of Figures

Fig 1: Axial plane setting according to the Optical Foramina in the coronal view

Fig 2: Coronal plane setting according to the Foramina Ovale in the axial plane

Fig 3: Axial plane setting using Foramen Cecum and McRae's line in the sagittal plane

Fig 4: Setting coronal plane at Basion and saving as default orientation

Fig 5: Maxillary contact point scatterplot with table

Fig 6: Mandibular contact point scatterplot with table

Fig 7: Maxillary right canine scatterplot with table

Fig 8: Maxillary left canine scatterplot with table

Fig 9: Mandibular right canine scatterplot with table

Fig 10: Mandibular left canine scatterplot with table

Fig 11: Maxillary right molar scatterplot with table

Fig 12: Maxillary left molar scatterplot with table

Fig 13: Mandibular right molar scatterplot with table

Fig 14: Mandibular left molar scatterplot with table

Fig 15: Anterior Nasal Spine scatterplot with table

Fig 16: Posterior Nasal Spine scatterplot with table

Fig 17: Right orbitale scatterplot with table

Fig 18: Pogonion scatterplot with table

Fig 19: Menton scatterplot with table

Fig 20: Right gonion scatterplot with table

Fig 21: Left gonion scatterplot with table

Fig 22: Right condylion scatterplot with table

Fig 23: Left condylion scatterplot with table

List of Tables

Table 1: Sample Demographics

Table 2: Overall Reliability

Table 3: Subjects reliabilities

Table 4: Landmarks Reliabilities

Table 5: Descriptive Class I T1

Table 6: Descriptive Class I T2

Table 7: Descriptive Class III T1

Table 8: Descriptive Class III T2

Table 9: Class I subjects distribution

Table 10: Class III subjects distribution

Table 11: Class I Normality Testing

Table 12: Class III Normality Testing

Table 13: Treatment Changes of Cl III

Table 14: Treatment Changes of Cl I

Table 15: Comparing treatment changes of the two groups [(T2-T1)Cl III – (T2-T1)Cl I]

Table 16: Comparison of T1 of Cl I and Cl III

Table 17: Comparison of T2 of Cl I and Cl III

Review of Literature

Malocclusion and Class III

In 1890 Edward Angle, the father of modern orthodontics, defined malocclusion as the malrelationship between the upper and lower first molars where the mesiobuccal cusp of the upper first molar should occlude in the buccal groove of the lower first molar. He described the three classes of malocclusion as class I, class II and class III. Class III malocclusion results from the mesial position of the lower molar relative to the upper molar.

Staudt et al studied the different skeletal types underlying cl III malocclusion in a random population and found About 75% of the Class III malocclusion had skeletal origin, mainly due to mandibular prognathism or macrognathia. They concluded that different skeletal types proposed in the study can give guidance in treatment planning and the evaluation of treatment effects in Class III malocclusion and in genetic studies.

Kuramae1 et al conducted a cephalometric evaluation of class III malocclusion by a modified Tweed-Merrifield analysis on a sample of 20 White Brazilian subjects of 17-36 years old. Results showed statistically significant differences among genders for FMIA, SNA, SNB, 1.NB, PFH, AFH, 1-NB and mandibular length. Antero-posterior jaw relation, presented a normal upper jaw length and an augmented lower jaw length. A vertical growth

pattern prevailed, as evidenced by FMA, AFH, PHF and OCC.PL. Angle. The Z Angle, total chin and upper lip failed to clearly show any disturbance of facial esthetics and IMPA, 1.NA, 1-NA, 1.NB and 1-NB revealed dental compensation.

A study conducted by baccetti et al showed that there is a significant degree of sexual dismorphism in class III malocclusion starting from age 13 years. Male subjects showed significantly larger linear dimensions of the maxilla, mandible, and anterior facial heights when compared with female subjects during the circumpubertal and postpubertal periods.

Araujo et al investigated the Bolton anterior tooth size discrepancy among different groups of malocclusion and found that individuals with Angle Class I and Class III malocclusions had significantly greater prevalence of tooth size discrepancies than do individuals with Class II malocclusions; they also concluded that the mean anterior tooth size discrepancy for Angle Class III subjects was significantly greater than for Class I and Class II subjects.

Growth and Class III

Growth is an anatomic phenomenon defined as the increase in size or number (Proffit).

Alexander et al conducted a semi longitudinal cephalometric study of the craniofacial growth in untreated class III malocclusion subjects of white European or North American ancestry. It compromised the largest sample obtained

from class III white population. They measured incremental growth changes for each sex. The growth pattern of 3 fundamental cephalometric measurements (lower anterior face height, midfacial length, and mandibular length) exhibited differences between the male and female subjects in both the timing and the size of average growth increments in the adolescent growth spurt. The girls had their adolescent spurt in mandibular growth between 10 and 12 years. The boys had their adolescent mandibular growth spurt between 12 and 15 years. Adolescent peaks in midfacial growth were at prepubertal ages in both sexes. The approximated average increments of growth for the Class III girls from ages 6 to 16 years were 1 mm in lower anterior face height, 1 mm in midfacial length, and 3 mm in mandibular length. The approximated average increments of growth for the Class III boys in the same time interval were 0.5 mm greater than for the girls at every measurement from 6 to 16 years. Male subjects showed more than 3 mm of mandibular growth at 3 consecutive age intervals starting from 15 years. The average increments of change in several measurements indicated definite worsening of the relative mandibular prognathism and sagittal skeletal discrepancy between the jaws with growth. During childhood (5-7 years), much craniofacial growth occurred. Moreover, much mandibular growth relative to the maxilla still occurred in Class III subjects after the adolescent growth spurt. The dentoalveolar measurements demonstrated dental incremental movements consistent to

compensate for the worsening skeletal discrepancy

A study done by Reyes at al to estimate the craniofacial growth of cl III malocclusion showed increases in mandibular length were substantially larger in Class III subjects than in subjects with normal occlusion. Lower anterior facial height was significantly larger in Class III individuals during the late developmental stages.

Baccetti et al found in a study evaluating the Craniofacial changes in Class III malocclusion as related to skeletal and dental maturation Significant changes in total mandibular length occur until young adulthood (18 years on average), with increases between late maturation stages (4 through 6) that were twice as large as in subjects with normal occlusion for the Class III females, and 3 times as large as in subjects with normal occlusion for the Class III males. Growth trends toward accentuated Class III profile and increased vertical dimension of the face also become apparent at late developmental stages (corresponding with complete eruption of the second and third molars).

Wolfe et al found that the AP maxillomandibular relationship of Class III subjects worsens over time. They were primarily due to excessive mandibular growth, which produces a protrusive, hyperdivergent phenotype. The AP discrepancies of

males are larger than those of females, with differences increasing over time.

Singh et al conducted a splin analysis on the mandible of class III subjects and concluded that there is a difference in class III subjects than the class I mandibles. They found that moderate deformation in the condylar region of the ramus and significant alterations affecting the body of the mandible predominantly associated with symphaseal changes could be identified. The deformation of the mandible corpus is a significant component in the etiology of class III. The study supported that alteration in mandibular growth patters lead to shape changes associated with cl III appearance. It is possible that alterations include condylar proliferation allied with corpus and symphaseal remodeling.

Singh et al analyzed local shape and size differences in cranial base configurations of Class I and Class III subjects, employing finite element (FEM) analysis. They found that while the anterior cranial base was more homogeneous for shape-change, significant, localized anisotropy in the posterior regions of the cranial base and around sella turcica was evident. For size-change, areas of negative allometry were located posteriorly, but dilations in the mid- and anterior cranial base also were apparent. It is concluded that morphological alterations within the petro-occipital complex

accompanied by changes in the sphenoidal and ethmoidal regions induce deviation from a normal cranial base configuration to one associated with deficient orthocephalization and an appearance of Class III malocclusion.

Class III tx changes

Sonia et al conducted a study to test the reproducibility and validity of 3 sagittal reference planes in the assessment of class I and class III treatment with the use of the Wits analysis. Measurements made to the functional occlusal plane, the bisected occlusal plane, and the maxillomandibular bisector were compared with each other and with the angular measurement of the ANB angle. They also studied the angular relationship of these reference planes to the postmaxillary vertical reference plane. The data were collected from pretreatment (T1), posttreatment (T2), and 2-year postretention (T3) lateral cephalograms of Class I and Class III subjects. Subjects received nonextraction treatment with full fixed orthodontic appliances in the permanent dentition. The maxillomandibular bisector was determined to be an easily identifiable and reproducible reference plane that exhibited greater stability over time with both growth and treatment than either the functional occlusal plane or bisected occlusal plane.

A study conducted by *Ishikawa et al* on 44 adult females with normal incisor relationship and skeletal class I or class

III jaw relationships to investigate the dentoalveolar compensations for variations in sagittal jaw discrepancy showed that SN-AB is the most appropriate skeletal measure on cephalograms while SN-U1, SN-L1 and SN-OP were reliable dental measures. They concluded that lower incisor inclination was strongly influenced by the sagittal jaw relationship, which plays a role in achieving normal incisor relationship. They also mentioned that compensated occlusal cant is relatively slight.

Schoenwetter concluded that in selected class III malocclusions, orthodontic treatment can yield acceptable results without the need for surgical intervention. His observation resulted from six cases treated with different class III treatment protocols, including non-extraction, lower premolars extractions and lower incisor extraction. The results of nonsurgical Class III orthodontic treatment included: 1) Change in lower incisors angulation in extraction cases as a result of space closure and lingual tipping of the incisors. 2) Increased maxillary incisors angulation. 3) Maintained maxillary arch expansion. 4) Class III occlusion remained in the buccal segments. 5) Recovering of rotation of the mandible was evident in cephalometric superimpositions. 6) No improvement in facial profile. 7) Increase in dental compensations as the facial contour improved with persistent class III characteristics. 8) Acceptable periodontal tissue.

Ishikawa et al reported that compensatory changes for sagittal jaw discrepancies were statistically confirmed for both incisor inclination and occlusal plane angulation. However, the compensatory effects were weaker than with normal overjet cases. Discriminate analysis to separate normal and negative overjet cases confirmed that negative overjet results from insufficient dentoalveolar compensation, though there must be limits in sagittal jaw relationships where normal incisor relationships are obtained.

Treatment and Short-term Posttreatment Outcomes of MCH and Fixed Appliance Therapy by baccetti et al showed favorable skeletal effects consisted mainly of smaller increases in mandibular length and advancement with respect to the controls, with the final outcome of significant improvements in the sagittal skeletal and dental parameters. This treatment protocol also induced significant downward rotation of the mandible. Their long-term observation showed significant dentoskeletal outcomes in terms of improvement of mandibular prognathism, Wits appraisal, overjet, and molar relationship induced by MCH and fixed appliances remained stable in the long term. In the long term, the treatment protocol produced less anterior rotation of the mandibular plane than untreated Class III controls.

Jluxlang et al conducted a study to analyze the effects of nonsurgical treatment on subjects with a severe skeletal Class III deformity and to directly evaluate dental and facial profile changes. Twelve of the subjects were treated with extractions while 6 were treated with non-extraction. A mean reduction of 6.5 mm in the overjet was noted, with skeletal changes and dental changes contributing 20% and 80% to the overjet correction, respectively. The inclination of the upper incisors to the SN plane was increased 5.98. The inclination of the lower incisors to the mandibular plane was decreased 6.68. The difference between the distance of the upper lip and lower lip to Sn-Pg at the beginning of treatment changed from a negative value to a positive value with a significant difference. They concluded that successful treatment effects can be obtained with nonsurgical therapy in severe skeletal Class III malocclusions in the permanent dentition. A remarkable soft tissue change was noted after the treatment, and the concave facial profile changed to a straight profile.

Burns et al determined the skeletal, dental, and soft-tissue changes in response to camouflage Class III treatment. They included thirty patients (average age, 12.4± 1.0 years) with skeletal Class III malocclusions who completed comprehensive nonextraction orthodontic treatment. Skeletal, dental, and soft-tissue changes were determined by using published cephalometric analyses. The quality of orthodontic

treatment was standardized by registering the peer assessment rating index on the pretreatment and posttreatment study models. The change in the level of gingival attachment with treatment was determined on the study casts. The results were compared with a group of untreated subjects. Data were analyzed with repeated measures analysis and paired t tests. Results showed that average change in the Wits appraisal was greater in the treated group than in the control group. The average peer assessment rating index score improved. No significant differences were found for the level of gingival attachments between the treatment and control groups. The sagittal jaw relationship (ANB angle) did not improve with camouflage treatment. A wide range of tooth movements compensated for the skeletal changes in both groups. The upper and lower limits for incisal movement to compensate for Class III skeletal changes were 120 to the sella-nasion line and 80 to the mandibular plane, respectively. Greater increases in the angle of convexity were found in the treated group, indicating improved facial profiles. Greater increases in length of the upper lip were found in the treated group, corresponding to the changes in the hard tissues with treatment. Conclusions: Significant dental and soft-tissue changes can be expected in young Class III patients treated with camouflage orthodontic tooth movement. A wide range of skeletal dysplasias can be camouflaged with tooth movement without deleterious effects to the periodontium. However, proper diagnosis and realistic

treatment objectives are necessary to prevent undesirable sequelae.

Busato et al studied compensatory canine angulation in Angle Class II and III patients. The aim of their study was to evaluate the occurence of compensation in mesiodistal axial inclinations of canines in skeletal malocclusions patients. The sample consisted of 25 Angle Class II, division 1 malocclusion (group 1) and 19 Angle Class III malocclusion patients (group 2). After measurement of dental angulations through a method that associates plaster model photography and AutoCad software, comparisons between the groups were performed by T-test for independent samples. Results showed that there was no statistically significant difference between groups, when maxillary canine angulations were compared. Regarding the mandibular canines, there was a statistically
significant difference in dental angulation, expressed by 3.2° for group 1 and 0.15° for group 2. An upright position tendency for mandibular canines was observed in the Angle Class III sample. This configures a pattern of compensatory coronary positioning, since the angulation of these teeth makes them occupy less space in the dental arch and consequently mandibular incisors can be in a more retracted position in the sagittal plane.

Ngan developed a way to predict future growth in Class

III patients. The Growth Treatment Response Vector (GTRV) analysis was designed to predict excessive mandibular growth. Serial cephalometric radiographs of 40 Class III patients who were treated with maxillary protraction headgear were included in the study. Patient selection included an anterior crossbite with a skeletal Class III malocclusion, no previous orthodontic treatment other than protraction facemask to correct the anterior crossibte, and a 3 year minimum of patient follow-up post-facemask therapy. Treatment regimen included a Hyrax palatal expander, followed by a facemask, and one year of nighttime wear of a Frankel III appliance for retention. Cephalometric radiographs were taken at the initiation of treatment and six months after maxillary protraction. The horizontal growth changes of the maxilla and mandible between the post-treatment radiograph and the follow-up radiograph were determined by locating the A point and B point on the post-treatment radiograph. The occlusal plane was constructed by using the mesial buccal cusp of the maxillary molars and the incisal tip of the maxillary incisors as landmarks. The difference in distances between A point and B point were measured after superimposition. The GTRV ratio was calculated by using the following formula:

GTRV= Horizontal growth changes of the maxilla / Horizontal growth changes of the mandible

The mean GTRV ratio for the successful group was found to be 0.49 with a range of 0.33 to 0.88. Class III patients with a

mild to moderate Class III skeletal pattern and a GTRV ratio that falls within this range can be successfully camouflaged with orthodontic treatment. The mean ratio for the unsuccessful group was 0.22 with a range of 0.06 and 0.38. Class III patients with excessive mandibular growth together with a GTRV ratio below 0.38 should be warned of future need for orthognathic surgery.

2D and 3D imaging

Gribel et al assessed the accuracy and reliability of craniometric measurements on lateral cephalometry and 3D measurements on CBCT scans and found that CBCT craniometric measurements computed by a dedicated ‘‘3D Cephalometric module’’ are extremely accurate and can be used for craniofacial analysis. Lateral cephalograms have intrinsic limitations that result in distorted images, enlarged in some areas and reduced in others. A pattern seems to exist, and mathematical algorithms may correct these distortions in the future, so that 3D normal values for 3D quantitative assessment and diagnosis can be derived from previously known 2D norms, without exposing untreated patients to radiation.

Arat et al investigated the displacement of craniofacial reference landmarks during puberty in 2003 by Comparing three superimposition methods. They examined the

amount and direction of displacement of reference landmarks located on the cranial base and face and compared them according to the superimposition methods of Bjo¨rk (method A), Steiner (method B), and Ricketts (method C). The material consisted of cephalometric and hand-wrist films of 40 nontreated growing individuals obtained at the beginning (T1) and at the end of the observation period (T2). Hand-wrist films were used to evaluate the skeletal maturation of the subjects. The displacement of each landmark was measured according to each superimposition method, and the amounts of displacement in each method were evaluated by paired **t**-test. The repeated measurement analysis of variance test was used to compare the variances of the changes among the methods. Significant changes were observed in landmarks (sella, nasion, basion, pterygomaxillare), which used as references for superimpositions. The direction of displacement of sella and pterygomaxillare points was different among the methods. In the horizontal plane, although most landmarks were displaced in a similar manner in the Bjo¨rk and Ricketts methods, the vertical displacement of all the landmarks was different. The horizontal displacements of basion, condylion, and gonion were similar according to all three methods. These results indicate that differences regarding the superimposition methods should be taken into consideration in the evaluation of the changes due to growth or treatment.

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Statement of thesis

The aim of this retrospective study is to evaluate the tridimensional dento-skeletal changes taking place during Class III malocclusion correction.

It is hypothesized that: 1) There is no difference in the spatial position of dental and skeletal landmarks at T1 and at T2 of the class I and class III malocclusion subjects. 2) There is no difference in the spatial movement of dental and skeletal landmarks at T1 and T2 of the treated class I and class III malocclusions. 3) There is no difference in the spatial movement of skeletal and dental landmarks between treatment changes of the class I and class III malocclusions.

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Abstract

INTRODUCTION: Our objective was to evaluate the dento-skeletal changes occurring during a comprehensive non-extraction orthodontic treatment of Class III malocclusion in the three planes of space and compare them to class I malocclusion subjects using cone-beam computed tomography (CBCT).

METHODS: The pre- (T1) and post-treatment (T2) CBCTs of 23 matched adolescent subjects from class I and class III were oriented using the cranial nerve canals to set the 3 planes of reference and 19 landmarks were registered on maxillary, mandibular and dental structures. The data consisted of 3-dimensional coordinates representing the distances to the reference planes. The data was analyzed using Wilcoxon rank sum test, Mann Whitney U test and the intra-observer reliability was tested by Interclass Correlation Coefficient.

RESULTS: The coordinate system is a reliable method to be used for longitudinal studies. Class I treatment resulted in significant dental changes in vertical and AP directions. Class I group showed significant changes in skeletal landmarks consistent with growth magnitude and direction. Class III treatment showed significant dental changes mostly in transverse followed by vertical and AP directions. This study allows us to appreciate the third dimension of a 3D study utilizing CBCT. Dental changes were the most significant between the two groups. ANS and PNS showed minimal changes in both groups. Only Gonion and PNS showed a tendency to relocate backwards where all the other landmarks displayed a downward and forward movement, which is supported by the previous growth studies.

CONCLUSION: A collection of dental changes contributed to the correction of class III malocclusion. The coordinate method was found to be reliable for longitudinal studies in 3-Dimensions and allows the evaluation of amount and direction of treatment changes in the third dimension.

Keywords: Class III, Correction, Cone Beam Computed Tomography, Orientation, Coordinate.

Introduction

The developing skeletal Class III malocclusion is one of the most challenging problems confronting the practicing orthodontist. Early orthopedic intervention can be effective in normalizing skeletal Class III malocclusions if patients are treated in a timely manner. However, there are a significant group of patients who either do not have the opportunity to receive early treatment or are corrected during childhood and relapse during the adolescent growth spurt. In addition, there is a large number of skeletal Class III patients that either decline or cannot afford surgical treatment. The only alternative is orthodontic camouflage through comprehensive treatment with fixed appliances.

Class III malocclusion and anterior crossbite are common clinical problems in an orthodontic practice. It is the least prevalent when compared to other kinds of malocclusion. Some ethnicities express more Class III malocclusion tendencies than others. Descendants of Asian ancestries showed the highest incidents of approximately 12% [1], Saudi Arabian patients showed 9.4% of the cases [2], US African American showed a prevalence of 3-5% [3] while European descents showed 1.5% to 5.3% and North American Caucasians showed 1%-4% [1].

The etiology of Class III malocclusion can be genetic or environmental. The Habsburg family was one of the well known examples of inheritance as described by McGuigan [4]. Rakoski and Schilli described some environmental influences that result in excessive mandibular growth such as mandibular posture that act as a constant distraction of the mandibular condyle from the foassa may be a growth stimulus and functional shifts due to respiratory needs, tongue size or pharyngeal dimensions [5].

Cephalometric analysis may not be the most reliable tool to differentiate whether the maxilla or the mandible contribute to the skeletal disharmony. Dental characteristics including Angle's molar and canine relationships, retroclined mandibuar incisors and proclined maxillary incisors, an edge to edge bite or anterior crossbite are the most consistent findings [6].

Class III may have various combinations of underlying skeletal and dental components. Guyer et al studied 144 Michigan children between the ages of 5 and 15 years and found 20% had mandibular prognathism with normal maxillary anteroposterior relationship [7]. Maxillary skeletal retrusion with normal sagittal relationship of the mandible was found in 24%. A combination of maxillary retrusion and mandibular retrusion was found in 22%. Some of the Class III subjects did not show any skeletal imbalances. According to Broadbent et al, within the face other areas exhibited differences from Class I sample including larger mandibular plane angle, larger gonial angle, longer mandible, increased lower anterior facial height with dental compensations involving maxillary dentoalveolar protrusion and mandibular dentoalveolar protrusion [8].

Class III malocclusion with a significant skeletal component is an orthodontic challenge, especially when a conservative approach is requested. An important factor for the success of treatment is the facial growth pattern. The consequences that might result from an untreated Class III malocclusion might be harmful to the individual dentition, TMJ and have negative effects on function and psychology. With the current modalities of orthodontic treatment of Class III malocclusions, the resultant dentoskeletal changes that result in the correction of this type of malocclusion or camouflaging the underlying skeletal discrepancy is beneficial to understand in order to assess patients response to the treatment and the amount of correction that can be achieved nonsurgically. It is helpful to understand how these changes are different from the changes of a mild form of malocclusion in Class I patients.

Camouflage treatment is defined by Profitt as displacement of the teeth relative to their supporting bone to compensate for an underlying jaw discrepancy. Camouflage implies that growth modification to overcome the basic problem is not feasible [9]. The method of camouflaged treatment was developed as an extraction treatment and introduced into orthodontics in the 1930's and 1940's. During this era, extraction to camouflage became

popular because growth modification had been largely rejected as ineffective and surgical correction had barely begun to develop [9].

According to a study performed by Lin [10], the effects of Class III camouflage treatment can be broken down into 4 categories: dental changes, skeletal changes, vertical changes, and soft tissue changes. Other than Lin, few investigators have demonstrated the dramatic dental and soft tissue changes that can be obtained with orthodontic Class III camouflage treatment. Although the results obtained in these reported cases [11, 12, 13] are promising, the sample sizes are small and there is little data on the successfulness of camouflage treatment. There is also little information available on the range of tooth movements that are possible through orthodontic treatment.

The use of 3D imaging is a precious tool for the practitioner to diagnose the case accurately and assess post-treatment changes. CBCT being fairly recent, very few studies have been conducted on Class III in comparison to the 2D studies that started decades ago. The purpose of this study is to evaluate the changes on 3D images that took place during a comprehensive treatment in a specific patient population (Class III malocclusions), using pre- and post-treatment CBCT's and compare these changes to a group of treated Class I malocclusion.

Material and Methods

This retrospective study was approved by the Case Western Reserve University Institutional Review Board (IRB) (Appendix 1). A legal guardian signed the informed consent of the American Association of Orthodontists before the initiation of treatment, including a paragraph consenting the use of records for research purposes (Appendix 2).

Pre-existing records including clinical examination, intraoral and extraoral photos, dental casts trimmed in centric occlusion, CBCT and medical history charts of a sample of adolescent patients that presented in the Graduate Clinic of CWRU School of Dental Medicine for comprehensive orthodontic treatment age between 11-25 years old were used. The selection of eligible patients was done by initiating a search entering the inclusion criteria through the program Ortho II (View Point). Skeletal discrepancy was confirmed using profile photos, CBCT and cephalometric analysis. The anteroposterior molar and canine relationship was confirmed by intraoral photos, CBCT and dental casts examination. Data was derived from pre-treatment and post-treatment Cone Beam Computed Tomography (CBCT) scans. All scans were taken in the Craniofacial Imaging Center at Case Western Reserve University School of Dental Medicine during routine records appointments using the 2mA setting and the largest field of view (0.38mm Voxel size). The CBCT machine (CB MercuRay^{TM}, Hitachi Medical Systems America Co. – Twinsburg, OH) was Custom to CWRU with the following specifications: 2 mA, 120 kVp, 12 inch field of view (F) , 512 slices, 0.377 mm slice thickness, 1024x1024 pixels resolution, 12 bits per pixel , 4096 gray scale. The DICOM was read by the program Dolphin Imaging to obtain the 3D images.

The expected Effect Size (E) was set at 0.7mm that we considered to be more clinically relevant than the Voxel size (0.38mm). The standard deviation (SD) of 0.61 was taken from the subdivision study by Sanders et al[14] as we adopted the same methodology in our study. With a two-tailed α of 0.01 and 0.05 and a confidence level of 95%, a sample size

of 23 (E/S=0.82) was required to compare means of continuous variables, based on the sample size calculation table[15]. After reviewing the subjects that met the inclusion criteria for each group, 23 matched subjects by gender and age at T1 and T2 were included in the study.

The inclusion criteria of the Class III subjects included: 1) Patients from CWRU Department of Orthodontics, 2) Class III molar relationship bilateral, 3) Class III skeletal discrepancy detected based on ANB and/or Wits analysis, 4) Permanent teeth at least up to the first molar are clinically present, 5) Class I molar and canine bilaterally at the end of treatment and 6) Initial and final records available including; pictures, clinical exam report, CBCT, casts.

The exclusion criteria of the class III group were: 1) Significant medical history (e.g. syndrome, cranio-facial anomalies, trauma, growth disturbance), 2) Tooth size discrepancy, malformed, grossly decayed teeth, 3) Anterior functional shift, 4) Obvious asymmetry and 5) Extraction therapy during comprehensive orthodontic treatment.

The Inclusion criteria of the Class I subjects were: 1) Patients from CWRU Department of Orthodontics, 2) Class I molar and canine relationship bilateral, 3) ANB angle more than -2 and less than 2 degrees, 4) Permanent teeth at least up to the first molar are clinically present, 5) Mild Class I malocclusion, 6) Class I molar and canine bilaterally at the end of treatment and 7)Initial and final records available: pictures, clinical exam report, CBCT, casts.

The exclusion criteria of the Class I group were: 1) Previous orthodontic treatment whether phase I or II, 2) Significant medical history (e.g. syndrome, cranio-facial anomalies, trauma, growth disturbance), 3) Shift in the path of closure determined by clinical examination, 4) Severe vertical discrepancies, 5) Tooth size discrepancy, malformed , grossly decayed teeth, 6) Crossbite at the incisors or first molars and 7) Extraction therapy during comprehensive orthodontic treatment.

Nineteen landmarks were chosen to reflect the dento-skeletal changes for each subject with treatment. Ten are dental and nine are skeletal.

The dental landmarks are described as follows:

- MaxC: Most incisal point of contact between the maxillary central incisors.
- MandC: Most incisal point of contact between the mandibular central incisors.
- UR3 and UL3: Cusp tip of the maxillary canines.
- LR3 and LL3: Cusp tip of the mandibular canines.
- UR6 and UL6: Mesiobuccal cusp tip of the maxillary first molars.
- LR6 and LL6: Central fossa of the mandibular first molars.

The maxillary landmarks were:

- ANS: Most anterior point of the anterior nasal spine of the maxilla.
- PNS: Most posterior point of the posterior nasal spine of the maxilla.
- RtOr: Right Orbitale, most inferior point of the right infraorbital rim of the maxilla.

The mandibular landmarks consisted of:

- Pg: Pogonion, most anterior midpoint on the mandibular symphysis.
- Me: Most inferior midpoint of the chin on the outline of the mandibular symphysis.
- RGo and LGo: Gonion, point of maximal convexity of the mandibular angle.
- RCo and LCo: Condylion, most superior point of the condylar head.

Method of 3-D image orientation: The slice thickness was set at 0.38 mm as a standard Voxel size. When the bilateral nerve canals were not simultaneously visible on one slice, the slice thickness was increased until they were. The method followed in this study was described by Wu et al[16] in 2011 to orient each one of the pre- and post-treatment 3-D images:

In the coronal view, the axial plane was aligned with the center of the left and right optical foramina by tilting the head to avoid head roll, (Figure1). In the axial view the coronal

plane was aligned with the center of the left and right foramina ovale by rotating the head to avoid head yaw and then the axial plane was scrolled to the level of Foramen cecum. The sagittal plane was positioned to pass through Foramen cecum. (Figure2). Finally, in the sagittal view, the pitch of the head was adjusted so that the axial plane overlapped McRae's line (Basion to Opisthion) (Figure 3). This process allowed the image to be fixed in the 3 planes of space and without rotating the image in any direction; the axial plane overlapping McRae's line and the sagittal plane overlapping Foramen Cecum, the coronal plane was dragged back to Basion (Fig. 4). The Origin, or (0,0,0) coordinate, was estimated around the Basion area because this is where all 3 planes intersect. This orientation and coordinate system was saved as default orientation, allowing the operator to reset it between every landmark registration.

The reliability of this orientation was tested by Wu et al[16]. They found that all the landmarks illustrated circular envelopes of error, which means that the variation was evenly distributed along all three planes. This result is consistent with Baumrind's[17] philosophy about mental averaging process. All landmarks selected by Wu et al[16] had circle-like features, which allows the visual estimation of the center of a structure to be applied and each measure of dispersion was less than 0.3mm.

All the dento-skeletal landmarks were registered by one operator on the volume slices and the 3-D image was used only as a general overview of the registration, never for landmark placement. The slice thickness was 1 voxel for more precise placement of the landmarks. The orientation was reset to initial between each landmark registration and all the pre-treatment (T1) registrations were done first, followed by all the post-treatment (T2) images. No coordinate value was visible or even accessible during the registration process until it was exported. Once all the landmarks were registered, the volume was reset to the original default

orientation and the data was exported directly to an Excel file in millimeters without the need to transcript any measurement manually to minimize errors.

Intra-examiner reliability was tested on 10 randomly selected subjects from both groups, either from T1 or T2. The same operator reoriented and re-registered all 19 landmarks on these 10 images at least 2 weeks after the end of the previous registration. The first measurements were not visible to the operator during the second measurement for the intra-observer reliability testing since the raw volume was downloaded again into the computer program and the first measurement landmarks were deleted from the volume.

The software JMP Pro 10 3D was used to construct 3D scatterplots to represent the mean change of each landmark in all planes in each group and to provide comparison between the two groups using the software. Distribution of landmarks movement in each plane of space was analyzed.

Data analysis was done with Microsoft Excel and The Statistical Package for the Social Sciences (SPSS 20.0, Inc. – Chicago, IL). The tests included: 1) Descriptive statistics (mean, min, max, SD) of each group including gender distribution, ethnicity, age at T1, age at T2, treatment time, type of malocclusion, phase I treatment and expansions, types of elastics used. T test was used to test differences in age at T1 and age at T2 between the 2 groups. 2) Intraclass correlation coefficient was used for intraexmaner reliability. 3) Intraclass correlation coefficient was used to test landmarks reliability of the 10 randomly selected subjects. 4) Descriptive statistics (mean, range, standard deviation) of each landmark in each plane of space for each group was tested at T1 and T2. 5) Descriptive statistics on the distribution of subjects according to landmarks directional changes in each group. 6) Shapiro-Wilk normality test was used to test normal distribution of each landmark for each group at T1 and T2. 7) Wilcoxon rank sum test was used to compare treatment changes within each group, T2-T1 of Class III and T2-T1 of Class I. 8) Mann Whitney U test was used to compare

the differences between treatment changes between Class III and Class I groups. 9) Mann Whitney U test was used to compare T1 of Class III and T1 of Class I. 10) Mann Whitney U test was used to compare T2 of Class III and T2 of Class I.

Results

The Class III and Class I groups included matched subjects in gender, age at T1 and age at T2 (Table 1). The 2 groups included 18 females and 5 males (N=23). Most of the subjects were Caucasians. The Class III group had 18 Caucasians and 5 from other ethnicities while the Class I included 22 Caucasians and 1 from other ethnicity. Age at T1 was 13.98± 1.56 in the Class III group and 13.82 ± 1.66 in the Class I group. Age at T2 was 16.01± 1.62 in the Class III and 15.59± 1.67 in the Class I group. T test showed no significant differences at T1 (P=0.74) and at T2 (P=0.40). Treatment time was 24.17± 3.63 in the Class III group and 21.22± 3.66 in the Class I subjects. When the Class III group was analyzed it included most of the subjects (N=17) with a combination of skeletal and dental Class III malocclusion, while only 3 were more skeletal and the 3 subjects had more dental Class III representation in the form of an anterior crossbite. Regarding phase I treatment, 5 out of the 23 subjects had phase I treatment. Expanders were used with 9 Class III subjects between phase I and phase II treatments, one of the subjects had expansion twice between the two phases. Class I malocclusions ranged from mild crowding, mild spacing and slightly increased overbites. For both groups all kinds of elastics were used except for crossbite elastics in some of the Class III.

Intraclass correlation coefficient tested intraexaminer reliability on 10 randomly selected subjects after 2 weeks interval. Overall reliability on all subjects was as high as 0.997 (Table 2). When each of the 10 subjects was tested individually, the reliability ranged between 0.980 and 1.0 (Table 3). Moreover, reliability on each landmark was tested on the 10 individuals (Table 4). Dental landmarks showed high reliability in the Y and Z planes when compared to the X plane, which was still considered highly reliable. Maxillary landmarks showed high reliability with the least reliable was orbitale in the X plane. On the other hand, this landmark showed consistency of measurement among all subjects. The most reliable point

in the maxilla was ANS in the Z plane. Mandibular landmarks Showed higher reliability in the Y and Z planes when compared to the X plane which was still highly reliable. Pogonion and menton were the most reliable landmarks in the mandible.

Landmarks descriptive statistics including range, minimum, maximum, mean and standard deviation for each group variables are shown in Table 5 for Class I at T1, Table 6 for Class I at T2, Table 7 for Class III at T1 and Table 8 for Class III at T2. For the all landmarks, measurements in the Y plane were the most variable between all patients represented by high standard deviation followed by the Z plane and the least was in X plane for most of the variables. Condylion was the only landmark to show the second high variability in the X plane instead of the Z plane following the Y plane. Orbitale showed the most consistent measurements in the X plane among all the subjects with a constant standard deviation.

Subjects distribution according to landmarks movement in each plane is shown in Table 9 for Class I and Table 10 for Class III. In the vertical dimension (Y plane), there was a general tendency towards downward relocation in both groups, condylion displayed a greater tendency than others to relocate upward. In the anteroposterir direction (Z plane), there was a general tendency towards forward relocation except PNS and left Go. In the transverse direction (X plane), there was a marked tendency for Go, Co, Mx6 and Md6 to move laterally. The class III group showed more consistent tendency for right relocation, which might be due to orientation.

Test for normality showed normal distribution of all variables in the class I group except for RGo and LGo in the Z plane at T1and T2 and PNS in the X plane at T2 with $P<0.05$ (Table 11). Normality test showed less than normal distribution of most of the variables in the Class III group (Table 12).

Treatment changes of the Class III subjects (T2-T1) are shown in Table 13. According to $P<0.05$, there were significant changes after treatment in the following landmarks: maxc in

Y and Z, mandc in X and Z, UR3 in all planes, UL3 in Y and Z, LR3 in X, LL3 in Y, UR6, UL6, LR6 in all planes, LL6 in Y. Skeletal landmarks showed significant changes in PNS in X, Rt Or in X and Z, Pg in Y and Z, Me in Y, RGo in X, LGo in Y and Z, right and left Co in X and Y. Less changes were detected with when $P<0.01$.

Treatment Changes Class I subjets (T2-T1) are shown in Table 14. With P value of 0.05, there were a significant changes in: Maxc in X, mandc in Y and Z, all canines and molars in Y and Z. Skeletal landmarks showed significant changes in PNS in Y, RtOr in Z, Pg in X and Y, Me in Y and Z, right and left Go in Y and RCo in Z. Less changes were detected with when $P<0.01$

Treatment Changes between the 2 groups [(T2-T1) of the Class III subjects- (T2-T1) of the Class I subjects] are shown in Table 15. Scatterplots figures were used to represent differences between the 2 groups. Significant differences between the 2 groups were found in: LR3 in Y, LL3 in X and Y, Pg in X, RGo in X and Y, LGo in X, LCo in X and Z.

Dental landmarks showed the following changes: Maxillary contact point (Fig. 5) showed downward and forward movement with no significant differences between the 2 groups. Significant vertical movement within each group and AP in Class III. Mandibular contact point (Fig. 6) showed downward and forward movement with no significant differences between the 2 groups. There was less vertical and AP in Class III compared to Class I. Maxillary canines (fig. 7 & 8) in both groups showed downward and forward movement without significant differences. They showed significant vertical and AP movement within each group. The maxillary right canine in Class III showed .97mm in transverse but not statistically significant when compared to Class I subjects. Mandibular right canine (Fig. 9) in both groups showed downward and forward. It showed significant differences in vertical. Significant transverse changes within Class III subjects while significant vertical and AP within Class I subjects. Mandibular left canine (Fig. 10) in both

groups showed downward and forward movements. There were significant differences in vertical and transvers in the Class III group while significant vertical and AP within Class I group. Maxillary first molars (Fig. 11 & 12) showed downward and forward movements with no sig difference between the 2 groups. The Class III group showed significant changes in all 3 planes while Class I only showed in the vertical and AP. Mandibular first molars (Fig 13 & 14) showed downward and forward movement with no significant differences between the 2 groups. There were significant changes in the right molar within Class III in all planes while only in vertical and AP within Class I.

Skeletal landmarks showed the following results: ANS and PNS (Fig. 15 &16) showed minimal changes with no significant differences between the 2 groups. Right orbitale (Fig. 17) showed no significant differences between the 2 groups. Pogonion and menton (Fig. 18 & 19) showed downward and forward movements. Pg showed significant differences in transverse between the 2 groups. Both showed vertical significance within each group. Right gonion (Fig. 20) showed backward relocation with significant differences in the transverse and vertical. Left gonion (Fig. 21) showed the same as the right side except for more vertical changes within each group. Right condylion (Fig. 22) showed upward and anterior relocation with no significant differences between the 2 groups. Significant transverse and vertical changes were noted within Class III subjects. Left condylion (Fig. 23) showed upward and anterior relocation with significant differences in transverse and AP. There were significant transverse and vertical changes within Class III subjects.

The Class III group was compared to the Class I group before treatment (table 16) and after treatment (Table 17) to see how much differences they had before and after treatment. There was a significant difference between the 2 groups at T1 in the X plane in mandibular contact point, mandibular left canine, pogonion and menton. At T2 Class III and Class I did not show any statistical differences between all variables.

Discussion

The three dimensional analysis has provided clear and valuable answers to research question as the third dimension plays an important role in the results obtained. Ballrick et[18] all in 2008 proved that CBCT can be used to make clinically accurate measurements and has acceptable resolution. The orientation method found by Wu et al.[16] in 2011 that was used in this study was based on cranial nerve canals, which are considered the most constant and symmetrical in the cranial base. Frequently we observed some volumes to appear off centered after we followed the orientation, which might draw attention to the presence of cranial base asymmetry. This might play a role in the patient malocclusion and occlusal asymmetries. This could also explain the slight generalized tendency of the Class III landmarks to appear shifted to the right. As we found more variation in the Class III subjects than the class I subjects after orientation following the cranial base. These observations prove that the cranial base is variable among all kinds of malocclusion and has an etiologic factor in it according to Hopkin et al 1968 [19].

We have to note that our decision in selecting subjects for Class III group that were treated and camouflaged successfully resulted in selection bias in our study as we had to allocate patients that had favorable growth during treatment or no growth to fit our criteria.

Most of our subjects were females (18 out of 23), these could contribute to the none significant skeletal changes that took place between the two groups as females complete growth earlier than males even in the class III group. A study done by Jenny Zwei-Chieng Chang[20] in 2006 showed that females displayed little growth increments after 14 years of age, which was our mean age at T1.

Test of normality with Shapiro-Wilk test revealed deviation from the normal distribution of the class III variables, which indicate more variability of the measurement obtained and orientation might have played a role. The high standard deviation noted in all

landmarks in the Y plane shows the variability of the sagittal orientation between subjects and the different head pitch obtained when following the McRae's line explains this.

The generalized tendency of downward and forward movement of most of the landmarks supports growth studies and orthodontic extrusive forces. It is represented in our study by Go relocating backward in both of our groups. (Enlow et al). [21]

Ricketts in 1960[22] mentioned that treatment effects are minimal on ANS as it grows 1mm per year in adolescent subjects. Our study showed minimal movement of 0.7mm in Class I subjects and 0.62mm in Class III subjects. Baumrind et al[17] in 1987 reported a downward remodeling of the palate during the mixed dentition and adolescent growth periods with a mean downward displacement at PNS for the time interval between 8.5 and 15.5 years of age lying between 1.81 and 3.19 mm. The authors found strong evidence that the palate elongates anteroposteriorly mainly by distal extension in its posterior region, this assertion being based on Björk's implant superimposition showing that the posterior displacement at PNS is much greater than at ANS. Our results supports this by seeing more of our subjects showing PNS relocate posterior and ANS moves anterior [23].

Baumrind and Frantz [17] stated that landmarks that are placed on anatomically formed edges or crests are easy to identify, but those on curves with wide radii show greater errors of measurement. Although these 2 statements were made with respect to 2D imaging, they also apply to 3D imaging. This will explain our reduced reliability in right orbitale in the X plane. On the other hand, the consistency of the transverse values of right Orbitale is to be found in anthropometry. N.A.Dodgson[23] (2004) studied the variation of human interpupillary distance (IPD) and stated that it is known to vary with respect to age, gender and race, with its range being 50-75mm for the majority of adults. Since our subjects are in the same age range and mostly Caucasian, they display similar measurements from Orbitale to the X plane. If the distance between Orbitale and the sagittal plane in our study was roughly 33 to 40 mm and if

we double this value, a distance of 60 to 70 mm would fall in the range stated in Dodgson's article. This distance was not expected to increase over the course of treatment in our sample, which explains that the changes observed in the X plane registration were errors as it was the least reliable among all the variables [25,23].

Our Class I sample displayed significant changes in the vertical and antero-posterior direction and that is explained by the significant growth of some these subjects. That same observation was also seen in the Class III subjects with more transverse changes which is explained by the expansion treatment they received, 9 out of the 23 subjects either in phase I or phase II. One of the subjects received expansion twice in the two phases of treatment.

Some of our landmark changes can be justified and explained clinically. Looking at the dental and skeletal landmarks: the maxillary contact point showed significant vertical movement within each group representing growth in both groups while the significant AP in Class III represents protraction of maxillary incisors for crossbites corrections and dental compensation. In the mandibular contact point there was less vertical and AP in Class III due to maintaining COS and trying not to flare the lower incisors in this group. In the maxillary right canine, Class III showed .97mm in transverse due to expansion but not statistically significant when compared to Class I. The more vertical in Class III results from more extrusion to help enhance a convex profile while more AP in Class III for correction of canine relationship. The same vertical explanation applies to the maxillary left canine. Mandibular canines showed significant changes in the vertical direction due to the use of Class III elastics in Class III subjects. Maxillary first molars in Class III subjects showed significant changes in all 3 planes while Class I only in the vertical and AP but not significant in the transverse and this is explained by the expansion these subjects received. In the mandibular first molars there was less AP in in the Class III due to molar maintenance in this group. Gonion and condylion differences between the 2 groups shows the difference in the growth potential and

direction between the Class I and Class III subjects.

We decided to explain not finding significant differences between the two groups by testing T1 of both groups and we didn't find significant differences between the two groups. This is explained by presence of sufficient dental compensations of the class III subjects and some successful phase I treatment. Both groups received treatment with different kinds of elastics, even the Class I subjects which might cancel out any significant changes between the two groups.

Ning et al[24] in 2009 looked at camouflage treatment of Class III cases and found no significant changes in the skeletal parameters. Dental parameters and soft tissue parameters showed significant favorable changes. This cannot be compared to our results as it included patients with severe crowding and required extractions. Our study included patients treated without extractions. This adds to the explanation that treatment non-extraction would yield favorable results but not significantly different from the Class I as it did not involve extraction that would result in significant dental movements.

Studies show that facemask/palatal expansion therapy is an effective method for treatment, and although earlier intervention may provide a better orthopedic response, treatment in the late mixed or early permanent dentition can produce positive results. Turley et al 2007[25] and this supports our finding of favorable results in the Class III subjects with expansion treatment they received.

Orbitale displayed different movements in the AP direction between the two groups. The Class I moved forward with the expected direction of maxillary growth while In the Class III subjects it showed a minor movement backwards. This could be explained with an association with a failed phase I therapy that required these patients to seek phase II to correct it [23].

Burn's et al[26] in 2007 conducted a 2D study on nonextrcation Class III and found

similar results to ours. A wide range of skeletal dysplasias can be camouflaged with tooth movement without deleterious effects to the periodontium. However, proper diagnosis and realistic treatment objectives are necessary to prevent undesirable sequelae. This study did not significant sagittal changes in the treated Class III subjects which supports our findings.

Conclusion

- The coordinate system is a reliable method to be used for longitudinal studies.
- Treatment of both Class I and Class III groups resulted in significant dental changes in vertical and AP directions.
- Both groups showed significant changes in skeletal landmarks consistent with growth magnitude and direction.
- Class III treatment showed significant dental changes specially in the transverse, followed by vertical and AP directions.
- Dental changes were the most significant between the two groups.
- ANS and PNS showed minimal changes in both groups.
- Only Gonion and PNS showed a tendency to relocate backwards where all the other landmarks displayed a downward and forward movement, which is supported by the previous growth studies.
- The current data suggests that the transverse dimension played the most important role in the Class III orthodontic correction.
- Further studies may be needed to confirm the present findings.

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Appendix 1: IRB Approval

NOTICE OF APPROVAL

CWRU IRB Protocol Number:	**IRB-2013-380**
Protocol Title:	***Class III malocclusions: Description of the Dentoskeletal Changes that Lead to the Correction of the Class III Malocclusion to Class I molar relationship.***
Responsible Investigator (RI):	**Juan Palomo**
Co-Investigator (CI):	**Sara Taher**
RI Department:	**Orthodontics**
Type of Review:	**Expedited**
Risk Level:	**Minimal**
Vulnerable Population(s):	**Children**
Approval Date:	**02/25/2013**
CONTINUING REVIEW DEADLINE:	**02/10/2014**
EXPIRATION DATE:	**02/24/2014**

The CWRU Institutional Review Board (IRB) has approved the above new protocol through the **EXPEDITED** review process.

When conducting Human Subjects' Research, your responsibilities include the following:

1. 1. Report all adverse events and unanticipated problems involving human subjects to the IRB Office, located in the Office of Research Administration (ORA), within three (3) business days of your knowledge of the occurrence.
2. 2. Provide the IRB with a complete Continuing Review form (available in our electronic application system at http://sberirb-app.case.edu, or from the ORA) by the continuing review deadline noted above, and when the study is to be terminated.
3. 3. Submit all proposed changes to the protocol to the IRB and wait for IRB approval before implementing any protocol change or modification.
4. 4. Keep all research data and original consent documents in your possession for at least three (3) years after the study is terminated.
5. 5. Note that completely de-identified data can be kept and used for research indefinitely. The IRB is primarily concerned about identifiers/identifiable data. If you want to terminate your study, identifiers/identifiable data must be destroyed. This includes paper or electronic master lists, contact lists, codes/codebooks, transcripts containing identifiers and video and audio recordings.
6. 6. If applicable, please use the most current IRB-approved consent forms. Feel free to use copies of these forms as long as they are identical to what was originally IRB approved. If you wish to change the forms or any other part of the study, you must submit an addendum request/protocol modification with revised copy(ies) of the relevant document(s) and wait for IRB approval before a modification can be implemented.
7. 7. ***Discontinue all work pertaining to this protocol if a continuing review approval is NOT finalized by the expiration date noted above.*** No further work on this protocol is allowable until the proper continuing review materials or required revisions are approved by the IRB.
    a. a. Please note that, if the continuing review materials or required revisions are not received by the expiration date, the RI and this study would be automatically placed on Administrative Hold for 30 days. This means that the RI loses their IRB privileges and research from this study must cease.
    b. b. If after 30 days, the Case IRB still does not have the protocol for processing, this protocol will be administratively terminated and your IRB privileges will be revoked for all your protocols.

Thank you for your attention to this matter. Please contact the IRB office at 216-368-6993 if we can be of further assistance.

Appendix 2: Informed Consent

INFORMED CONSENT

for the Orthodontic Patient

Risks and Limitations of Orthodontic Treatment

Successful orthodontic treatment is a partnership between the orthodontist and the patient. The doctor and staff are dedicated to achieving the best possible result for each patient. As a general rule, informed and cooperative patients can achieve positive orthodontic results. While recognizing the benefits of a beautiful healthy smile, you should also be aware that, as with all healing arts, orthodontic treatment has limitations and potential risks. These are seldom serious enough to indicate that you should not have treatment; however, all patients should seriously consider the option of no orthodontic treatment at all by accepting their present oral condition. Alternatives to orthodontic treatment vary with the individual's specific problem, and prosthetic solutions or limited orthodontic treatment may be considerations. You are encouraged to discuss alternatives with the doctor prior to beginning treatment.

Orthodontics and Dentofacial Orthopedics is the dental specialty that includes the diagnosis, prevention, interception and correction of malocclusion, as well as neuromuscular and skeletal abnormalities of the developing or mature orofacial structures.

An orthodontist is a dental specialist who has completed at least two additional years of graduate training in orthodontics at an accredited program after graduation from dental school.

American Association of Orthodontists

Patient _____ Date _____

Allergies
Occasionally, patients can be allergic to some of the component materials of their orthodontic appliances. This may require a change in treatment plan or discontinuance of treatment prior to completion. Although very uncommon, medical management of dental material allergies may be necessary.

General Health Problems
General health problems such as bone, blood or endocrine disorders, and many prescription and non-prescription drugs (including bisphosphonates) can affect your orthodontic treatment. It is imperative that you inform your orthodontist of any changes in your general health status.

Use of Tobacco Products
Smoking or chewing tobacco has been shown to increase the risk of gum disease and interferes with healing after oral surgery. Tobacco users are also more prone to oral cancer, gum recession, and delayed tooth movement during orthodontic treatment. If you use tobacco, you must carefully consider the possibility of a compromised orthodontic result.

Temporary Anchorage Devices
Your treatment may include the use of a temporary anchorage device(s) (i.e. metal screw or plate attached to the bone.) There are specific risks associated with them.

It is possible that the screw(s) could become loose which would require its/their removal and possibly relocation or replacement with a larger screw. The screw and related material may be accidentally swallowed. If the device cannot be stabilized for an adequate length of time, an alternate treatment plan may be necessary.

It is possible that the tissue around the device could become inflamed or infected, or the soft tissue could grow over the device, which could also require its removal, surgical excision of the tissue and/or the use of antibiotics or antimicrobial rinses.

It is possible that the screws could break (i.e. upon insertion or removal.) If this occurs, the broken piece may be left in your mouth or may be surgically removed. This may require referral to another dental specialist.

When inserting the device(s), it is possible to damage the root of a tooth, a nerve, or to perforate the maxillary sinus. Usually these problems are not significant; however, additional dental or medical treatment may be necessary.

Local anesthetic may be used when these devices are inserted or removed, which also has risks. Please advise the doctor placing the device if you have had any difficulties with dental anesthetics in the past.

If any of the complications mentioned above do occur, a referral may be necessary to your family dentist or another dental or medical specialist for further treatment. Fees for these services are not included in the cost for orthodontic treatment.

Patient or Parent/Guardian Initials _____

ACKNOWLEDGEMENT

I hereby acknowledge that I have read and fully understand the treatment considerations and risks presented in this form. I also understand that there may be other problems that occur less frequently than those presented, and that actual results may differ from the anticipated results. I also acknowledge that I have discussed this form with the undersigned orthodontist(s) and have been given the opportunity to ask any questions. I have been asked to make a choice about my treatment. I hereby consent to the treatment proposed and authorize the orthodontist(s) indicated below to provide the treatment. I also authorize the orthodontist(s) to provide my health care information to my other health care providers. I understand that my treatment fee covers only treatment provided by the orthodontist(s), and that treatment provided by other dental or medical professionals is not included in the fee for my orthodontic treatment.

Signature of Patient/Parent/Guardian Date

Signature of Orthodontist/Group Name Date

Witness Date

CONSENT TO UNDERGO ORTHODONTIC TREATMENT

I hereby consent to the making of diagnostic records, including x-rays, before, during and following orthodontic treatment, and to the above doctor(s) and, where appropriate, staff providing orthodontic treatment prescribed by the above doctor(s) for the above individual. I fully understand all of the risks associated with the treatment.

AUTHORIZATION FOR RELEASE OF PATIENT INFORMATION

I hereby authorize the above doctor(s) to provide other health care providers with information regarding the above individual's orthodontic care as deemed appropriate. I understand that once released, the above doctor(s) and staff has(have) no responsibility for any further release by the individual receiving this information.

CONSENT TO USE OF RECORDS

I hereby give my permission for the use of orthodontic records, including photographs, made in the process of examinations, treatment, and retention for purposes of professional consultations, research, education, or publication in professional journals.

Signature Date

Witness Date

I have the legal authority to sign this on behalf of

Name of Patient

Relationship to Patient

Notes

Fig 1: Axial plane setting according to the Optical Foramina in the coronal view

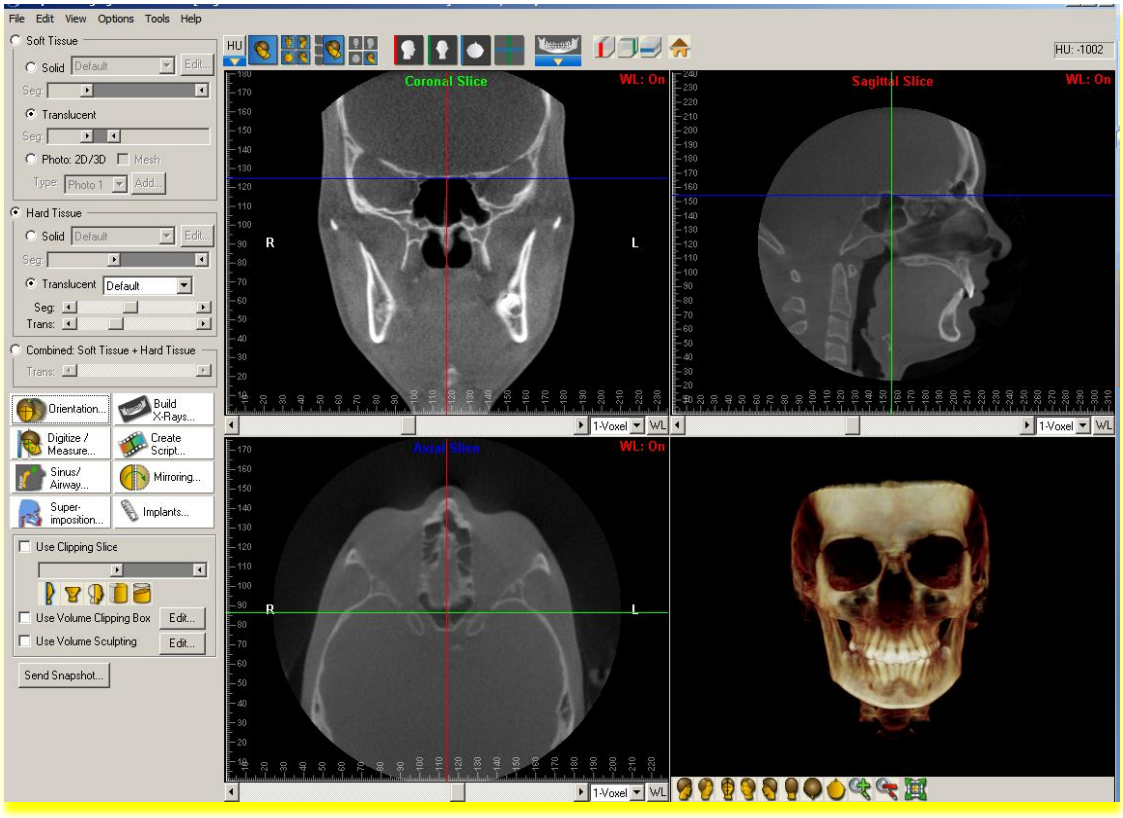


Fig 2: Coronal plane setting according to the Foramina Ovale in the axial plane

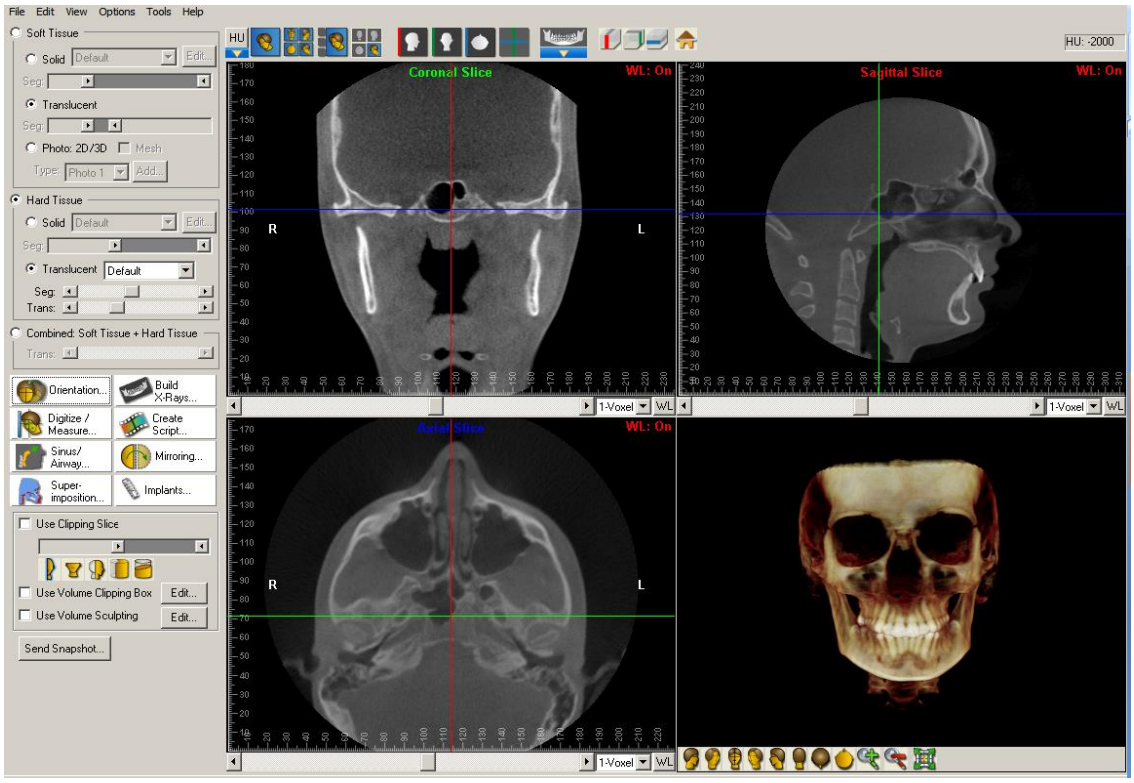


Fig 3: Axial plane setting using Foramen Cecum and McRae's line in the sagittal plane

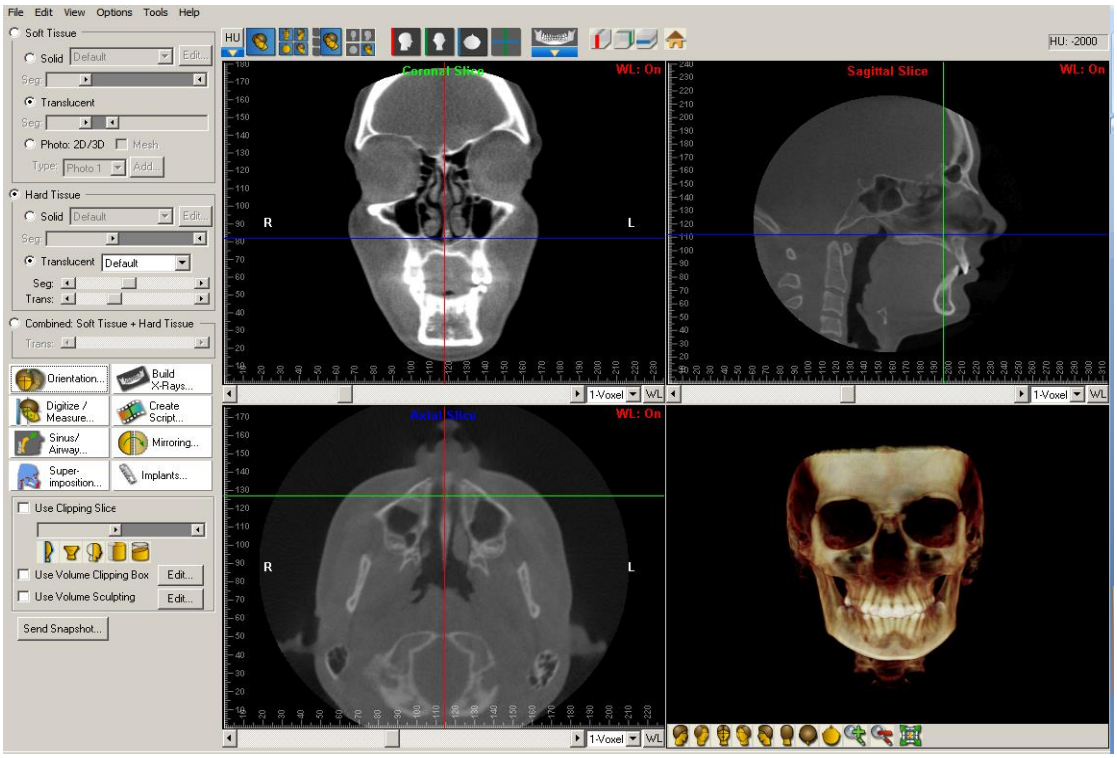


Fig 4: Setting coronal plane at Basion and saving as default orientation.

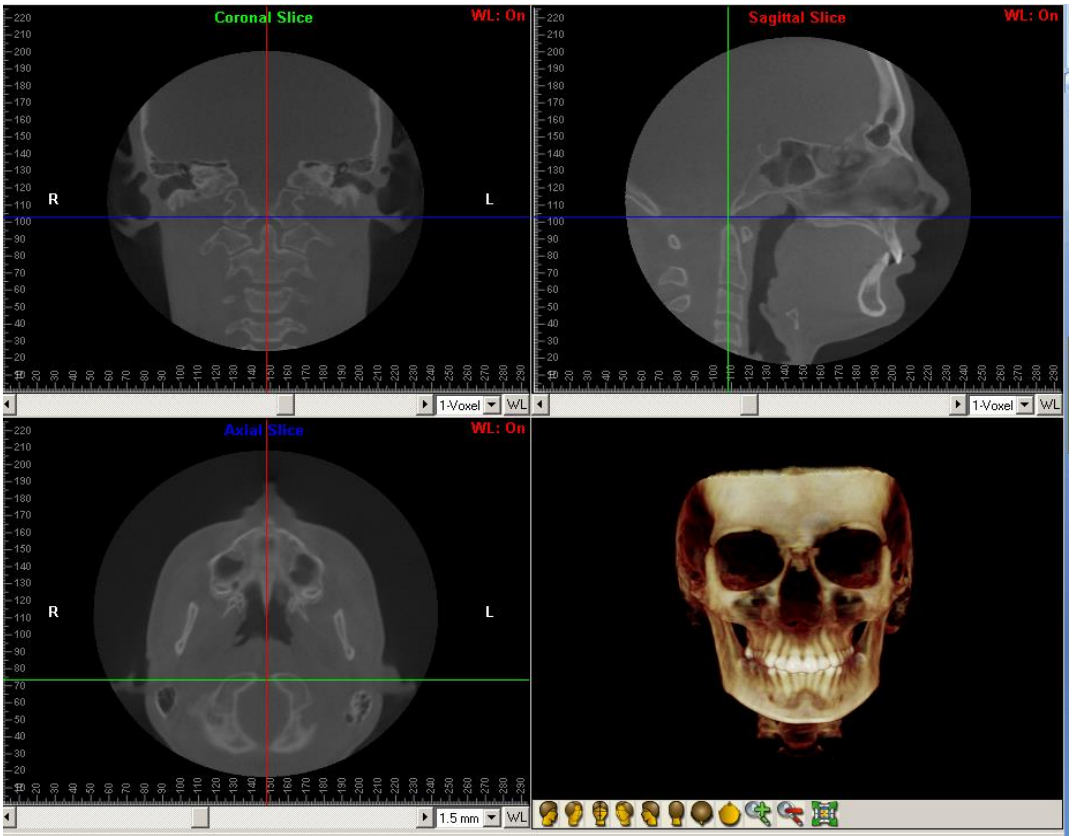


Table 1: Sample Demographics

Gp	Gender	Ethnicity	Age at T1	Age at T2	Tx time	Classification	PH I Expansion	Elastics
CL I	5 M 18 F	22 Caucasians 1 other	13.82 ± 1.66	15.59 ± 1.67	21.22 ± 3.66	Mild spacing Mild crowding Mild OB	None	None Cl II Cl III Verticals Triangles
CL III	5 M 18 F	18 Caucasians 5 other	13.98 ± 1.56	16.01 ± 1.62	24.17 ± 3. 63	17 combination 3 skeletal 3 dental	PH I: 5 Exp: 9	None Cl II Cl III Verticals Triangles Cross elastics

T test of age at T1= 0.74

T test of age at T2= 0.40

Table 2: Overall Reliability

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	.948[a]	.928	.965	365.350	56	1064
Average Measures	.997[c]	.996	.998	365.350	56	1064

Table 3: Subjects reliabilities

```
RELIABILITY
  /VARIABLES=WA234T1 WA234T1_A
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
```

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	12981.654	56	56
Average Measures	1.000[c]	1.000	1.000	12981.654	56	56

```
RELIABILITY
  /VARIABLES=WI312T2 WI312T2_A
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
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Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	7272.969	56	56
Average Measures	1.000[c]	1.000	1.000	7272.969	56	56

```
RELIABILITY
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  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
```

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2

Single Measures	1.000[a]	1.000	1.000	7759.455	56	56
Average Measures	1.000[c]	1.000	1.000	7759.455	56	56

```
RELIABILITY
  /VARIABLES=AD39T2 AD39T2_A
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
```

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	.970[a]	.949	.982	65.078	56	56
Average Measures	.985[c]	.974	.991	65.078	56	56

```
RELIABILITY
  /VARIABLES=BA209T2 BA209T2_A
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
```

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	23894.372	56	56
Average Measures	1.000[c]	1.000	1.000	23894.372	56	56

```
RELIABILITY
  /VARIABLES=BE212T2 BE212T2_A
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.
```

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	14434.824	56	56
Average Measures	1.000[c]	1.000	1.000	14434.824	56	56

RELIABILITY
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/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA
/ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	14006.064	56	56
Average Measures	1.000[c]	1.000	1.000	14006.064	56	56

RELIABILITY
/VARIABLES=**DO111T1 DO111T1_A**
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA
/ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	17158.236	56	56
Average Measures	1.000[c]	1.000	1.000	17158.236	56	56

RELIABILITY
/VARIABLES=**WA225T1 WA225T1_A**
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA
/ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	1.000[a]	1.000	1.000	20709.151	56	56
Average Measures	1.000[c]	1.000	1.000	20709.151	56	56

RELIABILITY

/VARIABLES=**SH118T1 SH118T1_A**
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA
/ICC=MODEL(MIXED) TYPE(CONSISTENCY) CIN=95 TESTVAL=0.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0		
		Lower Bound	Upper Bound	Value	df1	df2
Single Measures	.961[a]	.935	.977	50.793	56	56
Average Measures	.980[c]	.967	.988	50.793	56	56

Table 4: Landmarks Reliabilities

Land mark	X	Y	Z
MAX CONTACT	**.996**	**1.000**	**1.000**
MAND CONTACT	**.994**	**1.000**	**.999**
UR3	**.998**	**1.000**	**1.000**
UL3	**.989**	**1.000**	**1.000**
LR3	**.988**	**1.000**	**1.000**
LL3	**.995**	**1.000**	**1.000**
UR6	**.991**	**1.000**	**1.000**
UL6	**.997**	**1.000**	**1.000**
LR6	**.991**	**1.000**	**1.000**
LL6	**.997**	**1.000**	**1.000**

ANS	**.980**	**.969**	**.993**
PNS	**.971**	**.845**	**.887**
Rt OR	**.638**	**.893**	**.979**
Pg	**.997**	**1.000**	**1.000**
Me	**.997**	**1.000**	**1.000**
RtGo	**.978**	**.992**	**.997**
LtGo	**.995**	**.995**	**.999**
RtCo	**.969**	**1.000**	**.996**
LtCo	**.968**	**1.000**	**.988**

Table 5: Descriptive Class I T1

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
MaxcXT1	23	10.1	-4.3	5.8	.82	2.65
MaxcYT1	23	33.6	-50.4	-16.8	-34.10	8.54
MaxcZT1	23	23.9	77.2	101.1	89.00	6.15
MandcXT1	23	9.0	-4.1	4.9	.71	2.37
MandcYT1	23	36.2	-49.3	-13.1	-32.38	8.67
MandcZT1	23	22.7	75.8	98.5	85.92	5.73
UR3XT1	23	12.4	-23.0	-10.6	-16.34	2.94
UR3YT1	23	33.7	-49.9	-16.2	-33.27	8.03
UR3ZT1	23	21.1	71.6	92.7	80.52	5.57
UL3XT1	23	8.5	12.9	21.4	17.52	2.38
UL3YT1	23	32.2	-48.9	-16.7	-32.90	7.83
UL3ZT1	23	20.5	71.3	91.8	80.60	5.63
LR3XT1	23	8.9	-17.2	-8.3	-12.37	2.38
LR3YT1	23	34.0	-46.9	-12.9	-30.80	8.18

LR3ZT1	23	21.1	72.0	93.1	81.43	5.72
LL3XT1	23	7.4	9.9	17.3	13.50	2.28
LL3YT1	23	34.3	-47.1	-12.8	-30.48	8.24
LL3ZT1	23	21.0	71.4	92.4	81.14	5.50
UR6XT1	23	8.7	-29.0	-20.3	-24.87	2.24
UR6YT1	23	27.4	-42.0	-14.6	-28.41	6.94
UR6ZT1	23	20.1	53.5	73.6	61.27	5.50
UL6XT1	23	10.3	20.2	30.5	26.27	2.58
UL6YT1	23	26.5	-41.0	-14.5	-28.07	6.80
UL6ZT1	23	18.4	53.3	71.7	61.13	5.24
LR6XT1	23	7.8	-23.9	-16.1	-19.50	2.09
LR6YT1	23	27.0	-42.5	-15.5	-29.48	6.81
LR6ZT1	23	21.4	51.1	72.5	58.58	5.85
LL6XT1	23	11.1	15.0	26.1	21.17	2.58
LL6YT1	23	26.1	-41.9	-15.8	-29.07	6.58
LL6ZT1	23	21.4	50.1	71.5	58.37	5.52
ANSXT1	23	7.6	-3.0	4.6	.84	2.14
ANSYT1	23	34.8	-27.3	7.5	-8.97	8.99
ANSZT1	23	18.2	84.2	102.4	91.96	4.89
PNSXT1	23	6.1	-2.4	3.7	.60	1.58
PNSYT1	23	20.5	-15.8	4.7	-4.96	5.35
PNSZT1	23	12.0	35.3	47.3	41.03	2.93
OrRtXT1	23	7.7	-39.5	-31.8	-35.62	2.33
OrRtYT1	23	26.1	1.0	27.1	13.20	7.14
OrRtZT1	23	15.9	69.5	85.4	75.93	3.44
PgXT1	23	10.8	-5.1	5.7	1.05	2.96
PgYT1	23	40.1	-82.4	-42.3	-60.42	8.86
PgZT1	23	34.1	65.2	99.3	80.87	8.17
MeXT1	23	11.3	-5.1	6.2	1.07	3.02
MeYT1	23	35.2	-84.1	-48.9	-66.36	8.90
MeZT1	23	36.5	57.4	93.9	74.30	9.08
RGoXT1	23	14.1	-49.9	-35.8	-42.59	3.16
RGoYT1	23	18.7	-38.0	-19.3	-27.41	4.99
RGoZT1	23	18.7	7.2	25.9	13.51	5.26
LGoXT1	23	13.3	36.9	50.2	43.75	3.60
LGoYT1	23	16.6	-36.9	-20.3	-27.17	5.28
LGoZT1	23	20.0	5.3	25.3	13.17	4.51
RCoXT1	23	11.8	-54.5	-42.7	-46.98	3.01
RCoYT1	23	12.4	11.7	24.1	18.93	3.44
RCoZT1	23	10.4	7.9	18.3	13.50	2.57
LCoXT1	23	10.7	42.3	53.0	47.58	3.30
LCoYT1	23	14.7	11.8	26.5	19.58	3.72
LCoZT1	23	9.7	8.4	18.1	13.56	2.32

Valid N (listwise)	23					

Table 6: Descriptive Class I T2

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
MaxcX	23	9.8	-5.0	4.8	.44	2.93
MaxcY	23	35.5	-53.2	-17.7	-35.47	8.54
MaxcZ	23	23.6	79.4	103.0	89.85	5.91
MandcX	23	9.8	-5.2	4.6	.43	2.72
MandcY	23	32.7	-51.6	-18.9	-34.81	8.27
MandcZ	23	23.1	77.0	100.1	87.60	6.08
UR3X	23	12.1	-24.6	-12.5	-16.80	3.30
UR3Y	23	31.5	-51.2	-19.7	-34.88	7.94
UR3Z	23	23.2	71.7	94.9	81.95	5.88
UL3X	23	11.2	10.4	21.6	17.34	2.94
UL3Y	23	32.3	-51.5	-19.2	-34.93	7.78
UL3Z	23	23.1	71.0	94.1	82.03	5.81
LR3X	23	10.3	-18.9	-8.6	-12.78	3.01
LR3Y	23	32.2	-49.4	-17.2	-33.09	8.09
LR3Z	23	22.2	73.7	95.9	83.16	5.90
LL3X	23	9.0	8.6	17.6	13.59	2.68
LL3Y	23	32.6	-49.9	-17.3	-33.07	8.02
LL3Z	23	22.6	72.5	95.1	83.03	5.74
UR6X	23	9.4	-30.6	-21.2	-25.42	3.02
UR6Y	23	25.0	-43.0	-18.0	-29.81	6.80
UR6Z	23	21.7	54.1	75.8	62.56	5.66
UL6X	23	10.2	20.5	30.7	26.12	2.83
UL6Y	23	27.0	-43.3	-16.3	-29.77	6.60
UL6Z	23	21.4	53.4	74.8	62.47	5.44
LR6X	23	8.7	-24.4	-15.7	-19.95	2.75
LR6Y	23	24.5	-43.9	-19.4	-31.10	6.54
LR6Z	23	23.2	51.7	74.9	60.34	6.00
LL6X	23	10.8	14.4	25.2	20.80	2.76
LL6Y	23	25.9	-44.5	-18.6	-31.10	6.42
LL6Z	23	22.5	51.4	73.9	60.14	5.61

ANSX	23	9.0	-3.8	5.2	.58	2.50
ANSY	23	35.3	-28.9	6.4	-9.60	8.85
ANSZ	23	21.2	83.2	104.4	92.66	5.08
PNSX	23	7.0	-1.6	5.4	.54	1.86
PNSY	23	20.9	-17.1	3.8	-5.52	5.21
PNSZ	23	13.8	34.9	48.7	41.14	3.33
OrRtX	23	9.5	-40.0	-30.5	-35.61	2.27
OrRtY	23	29.1	-.1	29.0	13.46	7.25
OrRtZ	23	14.8	71.0	85.8	76.79	3.40
PgX	23	8.9	-5.8	3.1	-.77	2.54
PgY	23	31.5	-80.1	-48.6	-63.18	8.23
PgZ	23	36.7	65.8	102.5	81.74	8.34
MeX	23	11.3	-5.8	5.5	.54	3.58
MeY	23	32.1	-85.3	-53.2	-69.52	8.50
MeZ	23	39.1	58.0	97.1	75.42	9.03
RGoX	23	14.3	-51.1	-36.8	-43.33	3.56
RGoY	23	15.5	-37.8	-22.3	-29.30	4.92
RGoZ	23	18.3	7.3	25.6	12.94	5.02
LGoX	23	12.3	39.3	51.6	44.59	3.73
LGoY	23	13.8	-36.8	-23.0	-28.50	4.47
LGoZ	23	20.2	4.9	25.1	12.40	4.82
RCoX	23	17.1	-55.4	-38.3	-47.25	3.87
RCoY	23	11.0	13.2	24.2	19.38	3.49
RCoZ	23	6.5	10.4	16.9	14.23	1.86
LCoX	23	10.7	42.3	53.0	48.08	3.07
LCoY	23	14.5	12.9	27.4	19.76	3.81
LCoZ	23	9.6	10.1	19.7	14.19	2.53
Valid N (listwise)	23					

Table 7: Descriptive Class III T1

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Max. c X	23	9.8	-5.1	4.7	1.674	2.5207
Max. c Y	23	78.2	-93.7	-15.5	-36.491	15.0529
Max. c Z	23	48.8	55.3	104.1	87.935	10.4768
Mand. c. X	23	11.3	-5.7	5.6	2.187	2.8318
Mand. c Y	23	80.1	-93.7	-13.6	-36.243	15.1542

Mand. c Z	23	44.6	54.2	98.8	86.374	10.0873
UR3 X	23	12.2	-22.4	-10.2	-15.165	2.9026
UR3 Y	23	77.2	-89.2	-12.0	-35.296	14.4503
UR3 Z	23	42.9	49.4	92.3	80.296	9.5664
UL3 X	23	9.6	12.8	22.4	18.487	2.5315
UL3 Y	23	75.3	-87.0	-11.7	-34.678	14.0799
UL3 Z	23	45.2	48.8	94.0	80.526	9.9030
LR3 X	23	11.6	-18.8	-7.2	-11.165	2.9681
LR3 Y	23	77.2	-91.6	-14.4	-35.530	14.8005
LR3 Z	23	45.8	50.6	96.4	82.526	9.8271
LL3 X	23	10.6	7.9	18.5	15.322	2.6411
LL3 Y	23	75.4	-89.7	-14.3	-34.422	14.4741
LL3 Z	23	44.8	50.0	94.8	82.352	10.1428
UR6 X	23	10.4	-30.1	-19.7	-23.883	2.6758
UR6 Y	23	63.5	-76.0	-12.5	-31.317	12.3069
UR6 Z	23	40.4	31.7	72.1	60.370	8.8945
UL6 X	23	9.5	22.2	31.7	26.983	2.2364
UL6 Y	23	61.9	-75.3	-13.4	-29.991	12.0743
UL6 Z	23	40.7	32.3	73.0	60.461	9.0734
LR6 X	23	9.9	-24.1	-14.2	-18.743	2.7860
LR6 Y	23	63.9	-78.9	-15.0	-33.265	12.2426
LR6 Z	23	40.6	31.3	71.9	59.491	8.9832
LL6 X	23	9.6	17.0	26.6	22.143	2.6462
LL6 Y	23	61.8	-77.2	-15.4	-32.052	12.0085
LL6 Z	23	40.0	31.4	71.4	59.196	8.8976
ANS X	23	8.4	-3.8	4.6	.948	1.9551
ANS Y	23	88.1	-78.9	9.2	-11.748	17.0832
ANS Z	23	41.0	65.6	106.6	90.835	7.8800
PNS X	23	8.0	-2.8	5.2	.709	1.9264
PNS Y	23	48.3	-45.0	3.3	-7.261	9.5515
PNS Z	23	19.9	26.8	46.7	39.557	4.8716
Or Rt X	23	7.6	-38.9	-31.3	-35.522	2.0066
Or Rt Y	23	79.0	-52.9	26.1	9.326	15.5433
Or Rt Z	23	17.4	66.1	83.5	75.717	5.2494
Pg X	23	12.0	-4.6	7.4	3.039	3.1677
Pg Y	23	79.7	-118.2	-38.5	-64.361	14.8109
Pg Z	23	56.9	39.0	95.9	81.961	12.2288
Me X	23	12.0	-4.6	7.4	3.061	3.1641
Me Y	23	74.7	-120.3	-45.6	-70.943	13.7911
Me Z	23	56.5	32.1	88.6	75.161	12.2566
R Go X	23	16.8	-50.3	-33.5	-41.483	4.1341
R Go Y	23	40.0	-54.2	-14.2	-30.357	7.8118
R Go Z	23	26.7	-2.5	24.2	13.783	6.1896

L Go X	23	17.0	37.3	54.3	44.900	4.0176
L Go Y	23	31.3	-48.0	-16.7	-28.587	6.4277
L Go Z	23	20.9	.4	21.3	13.326	6.2383
R Co X	23	11.9	-52.5	-40.6	-47.409	3.4244
R Co Y	23	36.4	-11.7	24.7	17.461	7.1460
R Co Z	23	14.3	8.9	23.2	13.922	3.0415
L Co X	23	15.9	41.8	57.7	48.039	3.9676
L Co Y	23	32.5	-6.5	26.0	19.409	6.8733
L Co Z	23	17.0	5.8	22.8	13.448	3.7824
Valid N (listwise)	23					

Table 8: Descriptive Class III T2

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Max. c X	23	10.8	-4.9	5.9	.87	2.88
Max. c Y	23	77.7	-94.5	-16.8	-37.65	15.29
Max. c Z	23	48.5	54.2	102.7	89.49	10.54
Mand. c. X	23	10.1	-5.0	5.1	.90	2.84
Mand. c Y	23	77.4	-93.7	-16.3	-37.36	15.18
Mand. c Z	23	47.8	53.2	101.0	87.58	10.20
UR3 X	23	11.0	-22.8	-11.8	-16.59	2.91
UR3 Y	23	75.3	-92.3	-17.0	-37.73	14.71
UR3 Z	23	45.3	47.9	93.2	81.83	9.89
UL3 X	23	11.7	12.3	24.0	17.89	2.96
UL3 Y	23	72.4	-90.6	-18.2	-37.10	14.32
UL3 Z	23	46.1	49.1	95.2	81.57	9.84
LR3 X	23	9.5	-18.3	-8.8	-12.20	2.74
LR3 Y	23	76.6	-92.0	-15.4	-35.96	15.05
LR3 Z	23	45.5	50.5	96.0	83.52	9.82
LL3 X	23	11.6	7.6	19.2	14.00	2.88
LL3 Y	23	73.5	-90.0	-16.5	-35.54	14.54
LL3 Z	23	45.7	50.5	96.2	83.01	9.82
UR6 X	23	8.2	-29.5	-21.3	-25.30	2.49
UR6 Y	23	64.9	-80.4	-15.5	-32.81	12.99
UR6 Z	23	42.3	32.8	75.1	62.02	8.87
UL6 X	23	10.1	21.4	31.5	26.09	2.88
UL6 Y	23	61.4	-77.9	-16.5	-32.22	12.31

UL6 Z	23	41.6	33.9	75.5	61.67	8.74
LR6 X	23	9.6	-25.4	-15.8	-20.30	2.64
LR6 Y	23	65.6	-82.6	-17.0	-34.54	12.88
LR6 Z	23	40.7	33.0	73.7	60.47	8.63
LL6 X	23	10.9	16.0	26.9	21.43	3.27
LL6 Y	23	61.6	-79.4	-17.8	-33.87	12.20
LL6 Z	23	41.4	32.2	73.6	59.77	8.72
ANS X	23	8.3	-3.2	5.1	.55	2.11
ANS Y	23	89.4	-78.4	11.0	-12.35	17.07
ANS Z	23	43.5	66.1	109.6	91.46	7.92
PNS X	23	7.5	-3.2	4.3	-.21	2.21
PNS Y	23	49.8	-46.2	3.6	-7.74	9.78
PNS Z	23	22.0	26.5	48.5	39.66	5.03
Or Rt X	23	9.4	-40.2	-30.8	-36.15	2.39
Or Rt Y	23	79.3	-53.0	26.3	9.71	15.64
Or Rt Z	23	19.9	64.4	84.3	76.81	5.21
Pg X	23	11.7	-3.6	8.1	2.07	3.72
Pg Y	23	80.2	-123.2	-43.0	-67.07	15.47
Pg Z	23	54.8	40.8	95.6	82.80	11.95
Me X	23	11.7	-3.6	8.1	2.08	3.73
Me Y	23	74.4	-124.2	-49.8	-73.64	14.35
Me Z	23	54.0	35.0	89.0	75.89	11.89
R Go X	23	16.4	-51.8	-35.4	-43.70	4.26
R Go Y	23	41.1	-57.5	-16.4	-30.44	8.40
R Go Z	23	26.7	-3.0	23.7	13.23	6.42
L Go X	23	15.6	37.9	53.5	44.38	4.24
L Go Y	23	34.0	-52.1	-18.1	-30.21	7.52
L Go Z	23	23.5	-1.1	22.4	12.40	6.52
R Co X	23	13.4	-57.2	-43.8	-48.78	3.59
R Co Y	23	38.9	-13.5	25.4	18.38	7.90
R Co Z	23	16.7	6.4	23.1	14.50	3.14
L Co X	23	15.4	41.6	57.0	47.31	3.77
L Co Y	23	32.5	-6.0	26.5	18.89	6.69
L Co Z	23	17.8	5.6	23.4	13.04	3.56
Valid N (listwise)	23					

Table 9: Class I subjects distribution

Landmark	Rt	Lt	NC	Sup	Inf	NC	Ant	Post	NC
MAXC	10	12	1	10	13	0	17	6	0
MANDC	10	13	0	20	3	0	17	6	0
UR3	13	9	1	2	21	0	18	4	1
UL3	12	11	0	4	19	0	18	5	0
LR3	11	12	0	2	21	0	18	4	1
LL3	10	13	0	2	20	1	18	3	2
UR6	12	11	0	2	19	2	18	5	0
UL6	12	11	0	4	18	1	14	8	1
LR6	12	11	0	3	20	0	17	6	0
LL6	11	10	2	1	22	0	18	5	0
ANS	13	10	0	11	12	0	15	7	1
PNS	11	10	2	6	17	0	11	10	2
Rt OR	11	11	1	13	9	1	17	6	0
Pg	12	11	0	1	22	0	15	8	0
Me	13	10	0	0	23	0	15	8	0
RtGo	13	10	0	5	18	0	15	8	0

LtGo	**7**	**16**	**0**	**7**	**16**	**0**	**7**	**16**	**0**
RtCo	**13**	**8**	**2**	**12**	**10**	**1**	**16**	**7**	**0**
LtCo	**10**	**13**	**0**	**12**	**11**	**0**	**12**	**11**	**0**

Table 10: Class III subjects distribution

Landmark	**Rt**	**Lt**	**NC**	**Sup**	**Inf**	**NC**	**Ant**	**Post**	**NC**
MAXC	**13**	**9**	**1**	**4**	**19**	**0**	**18**	**5**	**0**
MANDC	**16**	**7**	**0**	**6**	**15**	**2**	**16**	**7**	**0**
UR3	**18**	**5**	**0**	**6**	**17**	**0**	**18**	**5**	**0**
UL3	**12**	**11**	**0**	**4**	**19**	**0**	**16**	**7**	**0**
LR3	**14**	**9**	**0**	**10**	**13**	**0**	**13**	**9**	**1**
LL3	**18**	**5**	**0**	**6**	**16**	**1**	**15**	**7**	**1**
UR6	**18**	**5**	**0**	**6**	**17**	**0**	**19**	**3**	**1**
UL6	**16**	**7**	**0**	**2**	**21**	**0**	**17**	**6**	**0**
LR6	**19**	**4**	**0**	**4**	**18**	**1**	**18**	**5**	**0**
LL6	**12**	**11**	**0**	**1**	**21**	**1**	**14**	**9**	**0**
ANS	**13**	**9**	**1**	**10**	**12**	**1**	**13**	**8**	**2**
PNS	**18**	**4**	**1**	**7**	**16**	**0**	**7**	**16**	**0**
Rt OR	**14**	**9**	**0**	**14**	**9**	**0**	**17**	**4**	**2**

Pg	**13**	**10**	**0**	**3**	**20**	**0**	**15**	**8**	**0**
Me	**13**	**10**	**0**	**3**	**20**	**0**	**15**	**8**	**0**
RtGo	**18**	**4**	**1**	**10**	**12**	**1**	**15**	**8**	**0**
LtGo	**11**	**12**	**0**	**6**	**17**	**0**	**6**	**16**	**1**
RtCo	**17**	**6**	**0**	**15**	**7**	**1**	**15**	**8**	**0**
LtCo	**17**	**6**	**0**	**6**	**16**	**1**	**8**	**15**	**0**

Table 11: Class I Normality Testing

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
MaxcXT1	.097	23	.200*	.984	23	.96
MaxcYT1	.091	23	.200*	.978	23	.87
MaxcZT1	.117	23	.200*	.974	23	.78
MandcXT1	.112	23	.200*	.968	23	.64
MandcYT1	.089	23	.200*	.977	23	.86
MandcZT1	.104	23	.200*	.978	23	.87
UR3XT1	.157	23	.146	.948	23	.27
UR3YT1	.089	23	.200*	.986	23	.98
UR3ZT1	.109	23	.200*	.954	23	.36
UL3XT1	.102	23	.200*	.966	23	.58
UL3YT1	.101	23	.200*	.978	23	.88
UL3ZT1	.114	23	.200*	.963	23	.53
LR3XT1	.089	23	.200*	.973	23	.75
LR3YT1	.117	23	.200*	.971	23	.71
LR3ZT1	.087	23	.200*	.976	23	.82
LL3XT1	.136	23	.200*	.941	23	.19
LL3YT1	.110	23	.200*	.965	23	.57
LL3ZT1	.093	23	.200*	.968	23	.64
UR6XT1	.106	23	.200*	.985	23	.97

UR6YT1	.080	23	.200*	.985	23	.97
UR6ZT1	.112	23	.200*	.942	23	.20
UL6XT1	.124	23	.200*	.957	23	.41
UL6YT1	.079	23	.200*	.982	23	.94
UL6ZT1	.124	23	.200*	.953	23	.34
LR6XT1	.114	23	.200*	.969	23	.67
LR6YT1	.092	23	.200*	.982	23	.94
LR6ZT1	.122	23	.200*	.923	23	.08
LL6XT1	.101	23	.200*	.973	23	.77
LL6YT1	.081	23	.200*	.983	23	.95
LL6ZT1	.111	23	.200*	.947	23	.25
ANSXT1	.097	23	.200*	.974	23	.79
ANSYT1	.130	23	.200*	.970	23	.69
ANSZT1	.139	23	.200*	.953	23	.33
PNSXT1	.125	23	.200*	.976	23	.83
PNSYT1	.118	23	.200*	.974	23	.78
PNSZT1	.114	23	.200*	.969	23	.66
OrRtXT1	.137	23	.200*	.935	23	.14
OrRtYT1	.150	23	.194	.949	23	.27
OrRtZT1	.112	23	.200*	.963	23	.53
PgXT1	.130	23	.200*	.972	23	.73
PgYT1	.130	23	.200*	.964	23	.55
PgZT1	.074	23	.200*	.988	23	.99
MeXT1	.124	23	.200*	.978	23	.88
MeYT1	.121	23	.200*	.972	23	.73
MeZT1	.078	23	.200*	.988	23	.99
RGoXT1	.094	23	.200*	.982	23	.94
RGoYT1	.084	23	.200*	.972	23	.74
RGoZT1	.189	23	.033	.879	23	.01
LGoXT1	.066	23	.200*	.980	23	.91
LGoYT1	.195	23	.023	.910	23	.04
LGoZT1	.166	23	.098	.937	23	.16
RCoXT1	.145	23	.200*	.918	23	.06
RCoYT1	.180	23	.051	.946	23	.24
RCoZT1	.103	23	.200*	.984	23	.96
LCoXT1	.121	23	.200*	.946	23	.24
LCoYT1	.125	23	.200*	.978	23	.87
LCoZT1	.128	23	.200*	.975	23	.81
MaxcX	.115	23	.200*	.949	23	.28
MaxcY	.120	23	.200*	.974	23	.79
MaxcZ	.138	23	.200*	.959	23	.44
MandcX	.127	23	.200*	.956	23	.38
MandcY	.092	23	.200*	.974	23	.78

MandcZ	.143	23	.200*	.957	23	.41
UR3X	.123	23	.200*	.943	23	.21
UR3Y	.113	23	.200*	.976	23	.83
UR3Z	.140	23	.200*	.945	23	.23
UL3X	.106	23	.200*	.956	23	.39
UL3Y	.130	23	.200*	.976	23	.83
UL3Z	.156	23	.150	.955	23	.37
LR3X	.147	23	.200*	.932	23	.12
LR3Y	.114	23	.200*	.971	23	.71
LR3Z	.138	23	.200*	.936	23	.15
LL3X	.130	23	.200*	.947	23	.25
LL3Y	.136	23	.200*	.966	23	.60
LL3Z	.148	23	.200*	.956	23	.39
UR6X	.161	23	.128	.936	23	.15
UR6Y	.129	23	.200*	.963	23	.53
UR6Z	.125	23	.200*	.929	23	.11
UL6X	.138	23	.200*	.963	23	.54
UL6Y	.109	23	.200*	.985	23	.97
UL6Z	.140	23	.200*	.939	23	.17
LR6X	.087	23	.200*	.949	23	.27
LR6Y	.126	23	.200*	.967	23	.63
LR6Z	.149	23	.200*	.923	23	.08
LL6X	.131	23	.200*	.960	23	.46
LL6Y	.113	23	.200*	.975	23	.81
LL6Z	.157	23	.148	.919	23	.06
ANSX	.113	23	.200*	.962	23	.51
ANSY	.127	23	.200*	.971	23	.71
ANSZ	.131	23	.200*	.960	23	.47
PNSX	.179	23	.054	.896	23	.02
PNSY	.095	23	.200*	.979	23	.90
PNSZ	.121	23	.200*	.960	23	.46
OrRtX	.093	23	.200*	.986	23	.98
OrRtY	.144	23	.200*	.972	23	.74
OrRtZ	.109	23	.200*	.955	23	.36
PgX	.112	23	.200*	.954	23	.35
PgY	.126	23	.200*	.951	23	.31
PgZ	.157	23	.149	.959	23	.44
MeX	.136	23	.200*	.939	23	.18
MeY	.164	23	.110	.966	23	.59
MeZ	.113	23	.200*	.975	23	.82
RGoX	.078	23	.200*	.979	23	.89
RGoY	.147	23	.200*	.921	23	.07
RGoZ	.201	23	.017	.882	23	.01

LGoX	.112	23	.200*	.953	23	.34
LGoY	.153	23	.175	.907	23	.04
LGoZ	.179	23	.054	.932	23	.12
RCoX	.101	23	.200*	.983	23	.95
RCoY	.136	23	.200*	.928	23	.10
RCoZ	.126	23	.200*	.952	23	.32
LCoX	.116	23	.200*	.963	23	.53
LCoY	.109	23	.200*	.975	23	.80
LCoZ	.162	23	.120	.941	23	.19

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 12: Class III Normality Testing

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Max. c X	.191	23	.029	.897	23	.02
Max. c Y	.226	23	.003	.759	23	.00
Max. c Z	.136	23	.200*	.911	23	.04
Mand. c. X	.168	23	.091	.888	23	.01
Mand. c Y	.205	23	.013	.767	23	.00
Mand. c Z	.173	23	.073	.885	23	.01
UR3 X	.143	23	.200*	.927	23	.09
UR3 Y	.217	23	.006	.774	23	.00
UR3 Z	.150	23	.195	.883	23	.01
UL3 X	.148	23	.200*	.944	23	.22
UL3 Y	.227	23	.003	.788	23	.00
UL3 Z	.140	23	.200*	.892	23	.02
LR3 X	.174	23	.068	.903	23	.03
LR3 Y	.187	23	.036	.772	23	.00
LR3 Z	.129	23	.200*	.893	23	.02
LL3 X	.166	23	.102	.880	23	.01
LL3 Y	.226	23	.004	.759	23	.00
LL3 Z	.145	23	.200*	.886	23	.01
UR6 X	.151	23	.189	.933	23	.13
UR6 Y	.206	23	.013	.803	23	.00
UR6 Z	.139	23	.200*	.879	23	.01
UL6 X	.138	23	.200*	.960	23	.46
UL6 Y	.250	23	.001	.772	23	.00

UL6 Z	.158	23	.140	.908	23	.04
LR6 X	.102	23	.200*	.971	23	.72
LR6 Y	.203	23	.015	.781	23	.00
LR6 Z	.135	23	.200*	.902	23	.03
LL6 X	.147	23	.200*	.957	23	.40
LL6 Y	.221	23	.005	.772	23	.00
LL6 Z	.120	23	.200*	.904	23	.03
ANS X	.133	23	.200*	.973	23	.77
ANS Y	.233	23	.002	.718	23	.00
ANS Z	.167	23	.096	.894	23	.02
PNS X	.087	23	.200*	.978	23	.87
PNS Y	.225	23	.004	.710	23	.00
PNS Z	.098	23	.200*	.954	23	.36
Or Rt X	.097	23	.200*	.982	23	.94
Or Rt Y	.256	23	.000	.683	23	.00
Or Rt Z	.162	23	.122	.934	23	.13
Pg X	.231	23	.002	.904	23	.03
Pg Y	.189	23	.033	.812	23	.00
Pg Z	.174	23	.068	.818	23	.00
Me X	.229	23	.003	.903	23	.03
Me Y	.196	23	.022	.827	23	.00
Me Z	.199	23	.018	.812	23	.00
R Go X	.117	23	.200*	.974	23	.79
R Go Y	.168	23	.092	.910	23	.04
R Go Z	.119	23	.200*	.946	23	.25
L Go X	.130	23	.200*	.962	23	.50
L Go Y	.157	23	.147	.932	23	.12
L Go Z	.140	23	.200*	.919	23	.06
R Co X	.116	23	.200*	.955	23	.37
R Co Y	.279	23	.000	.640	23	.00
R Co Z	.171	23	.078	.916	23	.05
L Co X	.148	23	.200*	.960	23	.45
L Co Y	.207	23	.012	.740	23	.00
L Co Z	.120	23	.200*	.976	23	.83
Max. c X	.078	23	.200*	.979	23	.89
Max. c Y	.211	23	.009	.784	23	.00
Max. c Z	.137	23	.200*	.859	23	.00
Mand. c. X	.128	23	.200*	.954	23	.35
Mand. c Y	.203	23	.015	.791	23	.00
Mand. c Z	.149	23	.200*	.858	23	.00
UR3 X	.094	23	.200*	.974	23	.79

UR3 Y	.212	23	.009	.793	23	.00
UR3 Z	.171	23	.079	.835	23	.00
UL3 X	.104	23	.200*	.982	23	.93
UL3 Y	.227	23	.003	.775	23	.00
UL3 Z	.116	23	.200*	.881	23	.01
LR3 X	.146	23	.200*	.931	23	.11
LR3 Y	.205	23	.013	.787	23	.00
LR3 Z	.149	23	.200*	.856	23	.00
LL3 X	.098	23	.200*	.969	23	.67
LL3 Y	.213	23	.008	.779	23	.00
LL3 Z	.120	23	.200*	.874	23	.01
UR6 X	.121	23	.200*	.929	23	.10
UR6 Y	.200	23	.018	.804	23	.00
UR6 Z	.149	23	.200*	.877	23	.01
UL6 X	.127	23	.200*	.963	23	.52
UL6 Y	.205	23	.013	.789	23	.00
UL6 Z	.158	23	.141	.907	23	.04
LR6 X	.168	23	.093	.952	23	.32
LR6 Y	.220	23	.005	.788	23	.00
LR6 Z	.147	23	.200*	.896	23	.02
LL6 X	.122	23	.200*	.959	23	.44
LL6 Y	.206	23	.013	.787	23	.00
LL6 Z	.144	23	.200*	.905	23	.03
ANS X	.116	23	.200*	.972	23	.74
ANS Y	.251	23	.001	.730	23	.00
ANS Z	.172	23	.076	.879	23	.01
PNS X	.142	23	.200*	.932	23	.12
PNS Y	.231	23	.002	.718	23	.00
PNS Z	.096	23	.200*	.973	23	.76
Or Rt X	.134	23	.200*	.939	23	.17
Or Rt Y	.247	23	.001	.678	23	.00
Or Rt Z	.105	23	.200*	.962	23	.51
Pg X	.118	23	.200*	.945	23	.22
Pg Y	.204	23	.014	.814	23	.00
Pg Z	.198	23	.020	.808	23	.00
Me X	.117	23	.200*	.946	23	.24
Me Y	.187	23	.035	.843	23	.00
Me Z	.207	23	.011	.822	23	.00
R Go X	.127	23	.200*	.959	23	.44
R Go Y	.138	23	.200*	.885	23	.01
R Go Z	.138	23	.200*	.947	23	.25
L Go X	.101	23	.200*	.970	23	.70
L Go Y	.112	23	.200*	.943	23	.20

L Go Z	.107	23	.200*	.958	23	.42
R Co X	.128	23	.200*	.939	23	.17
R Co Y	.252	23	.001	.655	23	.00
R Co Z	.134	23	.200*	.940	23	.18
L Co X	.191	23	.029	.914	23	.05
L Co Y	.186	23	.038	.776	23	.00
L Co Z	.134	23	.200*	.941	23	.19

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 13: Treatment Changes of Cl III

Test Statistics[a]

	Max. c X - Max. c X	Max. c Y - Max. c Y	Max. c Z - Max. c Z	Mand. c. X - Mand. c. X	Mand. c Y - Mand. c Y	Mand. c Z - Mand. c Z
Z	-2.00[b]	-2.75[b]	-2.84[c]	-2.53[b]	-1.89[b]	-2.48[c]
Asymp. Sig. (2-tailed)	.05	.01	.00	.01	.06	.01

Test Statistics[a]

	UR3 X - UR3 X	UR3 Y - UR3 Y	UR3 Z - UR3 Z	UL3 X - UL3 X	UL3 Y - UL3 Y	UL3 Z - UL3 Z
Z	-2.66[b]	-3.15[b]	-3.32[c]	-1.31[b]	-3.74[b]	-2.68[c]
Asymp. Sig. (2-tailed)	.01	.00	.00	.19	.00	.01

Test Statistics[a]

	LR3 X - LR3 X	LR3 Y - LR3 Y	LR3 Z - LR3 Z	LL3 X - LL3 X	LL3 Y - LL3 Y	LL3 Z - LL3 Z
Z	-2.25[b]	-.90[b]	-1.85[c]	-3.33[b]	-2.45[b]	-1.49[c]
Asymp. Sig. (2-tailed)	.02	.37	.06	.00	.01	.14

Test Statistics[a]

	UR6 X - UR6 X	UR6 Y - UR6 Y	UR6 Z - UR6 Z	UL6 X - UL6 X	UL6 Y - UL6 Y	UL6 Z - UL6 Z
Z	-3.22[b]	-3.36[b]	-3.75[c]	-2.08[b]	-4.11[b]	-3.07[c]
Asymp. Sig. (2-tailed)	.00	.00	.00	.04	.00	.00

Test Statistics[a]

	LR6 X - LR6 X	LR6 Y - LR6 Y	LR6 Z - LR6 Z	LL6 X - LL6 X	LL6 Y - LL6 Y	LL6 Z - LL6 Z
Z	-3.06[b]	-2.89[b]	-2.68[c]	-1.70[b]	-4.04[b]	-1.42[c]
Asymp. Sig. (2-tailed)	.00	.00	.01	.09	.00	.16

Test Statistics[a]

	ANS X - ANS X	ANS Y - ANS Y	ANS Z - ANS Z	PNS X - PNS X	PNS Y - PNS Y	PNS Z - PNS Z
Z	-1.36[b]	-1.15[b]	-1.39[c]	-3.00[b]	-1.55[b]	-.47[c]
Asymp. Sig. (2-tailed)	.17	.25	.16	.00	.12	.64

Test Statistics[a]

	Or Rt X - Or Rt X	Or Rt Y - Or Rt Y	Or Rt Z - Or Rt Z	Pg X - Pg X	Pg Y - Pg Y	Pg Z - Pg Z
Z	-2.10[b]	-1.16[b]	-2.92[c]	-1.92[b]	-3.07[b]	-2.05[c]
Asymp. Sig. (2-tailed)	.04	.25	.00	.06	.00	.04

Test Statistics[a]

	Me X - Me X	Me Y - Me Y	Me Z - Me Z	R Go X - R Go X	R Go Y - R Go Y	R Go Z - R Go Z
Z	-1.93[b]	-3.74[b]	-1.83[c]	-3.82[b]	-.16[b]	-1.54[c]
Asymp. Sig. (2-tailed)	.05	.00	.07	.00	.87	.12

Test Statistics[a]

	L Go X - L Go X	L Go Y - L Go Y	L Go Z - L Go Z	R Co X - R Co X	R Co Y - R Co Y	R Co Z - R Co Z
Z	-1.05[b]	-2.34[b]	-2.63[c]	-2.62[b]	-2.48[b]	-1.80[c]
Asymp. Sig. (2-tailed)	.29	.02	.01	.01	.01	.07

Test Statistics[a]

	L Co X - L Co X	L Co Y - L Co Y	L Co Z - L Co Z
Z	-2.01[b]	-2.14[b]	-1.51[c]
Asymp. Sig. (2-tailed)	.04	.03	.13

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.
c. Based on positive ranks.

Table 14: Treatment Changes of Cl I

Test Statistics[a]

	MaxcXT1 - MaxcX	MaxcYT1 - MaxcY	MaxcZT1 - MaxcZ	MandcXT1 - MandcX	MandcYT1 - MandcY	MandcZT1 - MandcZ
Z	-1.45[b]	-2.51[b]	-1.51[c]	-1.13[b]	-3.45[b]	-3.21[c]
Asymp. Sig. (2-tailed)	.15	.01	.13	.26	.00	.00

Test Statistics[a]

	UR3XT1 - UR3X	UR3YT1 - UR3Y	UR3ZT1 - UR3Z	UL3XT1 - UL3X	UL3YT1 - UL3Y	UL3ZT1 - UL3Z
Z	-1.39[b]	-3.36[b]	-2.99[c]	-.41[b]	-3.73[b]	-2.60[c]
Asymp. Sig. (2-tailed)	.16	.00	.00	.68	.00	.01

Test Statistics[a]

	LR3XT1 - LR3X	LR3YT1 - LR3Y	LR3ZT1 - LR3Z	LL3XT1 - LL3X	LL3YT1 - LL3Y	LL3ZT1 - LL3Z
Z	-.96[b]	-3.74[b]	-3.43[c]	-.08[b]	-3.68[b]	-3.53[c]
Asymp. Sig. (2-tailed)	.34	.00	.00	.94	.00	.00

Test Statistics[a]

	UR6XT1 - UR6X	UR6YT1 - UR6Y	UR6ZT1 - UR6Z	UL6XT1 - UL6X	UL6YT1 - UL6Y	UL6ZT1 - UL6Z
Z	-1.92[b]	-3.72[b]	-2.71[c]	-.26[b]	-3.75[b]	-2.14[c]
Asymp. Sig. (2-tailed)	.06	.00	.01	.80	.00	.03

Test Statistics[a]

	LR6XT1 - LR6X	LR6YT1 - LR6Y	LR6ZT1 - LR6Z	LL6XT1 - LL6X	LL6YT1 - LL6Y	LL6ZT1 - LL6Z
Z	-1.43[b]	-3.89[b]	-3.47[c]	-.97[b]	-4.14[b]	-3.13[c]

Asymp. Sig. (2-tailed)	.15	.00	.00	.33	.00	.00

Test Statistics[a]

	ANSXT1 - ANSX	ANSYT1 - ANSY	ANSZT1 - ANSZ	PNSXT1 - PNSX	PNSYT1 - PNSY	PNSZT1 - PNSZ
Z	-.87[b]	-1.41[b]	-1.36[c]	-.23[b]	-2.50[b]	-.12[c]
Asymp. Sig. (2-tailed)	.39	.16	.17	.82	.01	.90

Test Statistics[a]

	OrRtXT1 - OrRtX	OrRtYT1 - OrRtY	OrRtZT1 - OrRtZ	PgXT1 - PgX	PgYT1 - PgY	PgZT1 - PgZ
Z	-.03[b]	-.99[b]	-2.27[c]	-2.37[b]	-3.89[b]	-1.17[c]
Asymp. Sig. (2-tailed)	.97	.32	.02	.02	.00	.24

Test Statistics[a]

	MeXT1 - MeX	MeYT1 - MeY	MeZT1 - MeZ	RGoXT1 - RGoX	RGoYT1 - RGoY	RGoZT1 - RGoZ
Z	-1.17[b]	-4.20[b]	-1.45[c]	-1.46[b]	-2.77[b]	-1.83[c]
Asymp. Sig. (2-tailed)	.24	.00	.15	.14	.01	.07

Test Statistics[a]

	LGoXT1 - LGoX	LGoYT1 - LGoY	LGoZT1 - LGoZ	RCoXT1 - RCoX	RCoYT1 - RCoY	RCoZT1 - RCoZ
Z	-1.78[b]	-2.89[b]	-1.73[c]	-.65[b]	-1.62[b]	-2.24[c]
Asymp. Sig. (2-tailed)	.08	.00	.08	.52	.10	.03

Test Statistics[a]

	LCoXT1 - LCoX	LCoYT1 - LCoY	LCoZT1 - LCoZ
Z	-1.06[b]	-.58[b]	-1.46[c]
Asymp. Sig. (2-tailed)	.29	.56	.14

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.
c. Based on positive ranks.

Table 15: Comparing treatment changes of the two groups [(T2-T1)Cl III – (T2-T1)Cl I]

Test Statistics[a]

	MAXC_X	MAXC_Y	MAXC_Z	MANDC_X	MANDC_Y	MANDC_Z	URCX	URCY
Mann-Whitney U	229.50	256.50	210.00	197.00	183.50	238.50	200.00	225.50
Wilcoxon W	505.50	532.50	486.00	473.00	459.50	514.50	476.00	501.50
Z	-.77	-.18	-1.20	-1.48	-1.78	-.57	-1.42	-.86
Asymp. Sig. (2-tailed)	.44	.86	.23	.14	.08	.57	.16	.39

Test Statistics[a]

	URCZ	ULCX	ULCY	ULCZ	LRCX	LRCY	LRCZ	LLCX	LLCY
Mann-Whitney U	246.50	227.50	223.00	251.50	210.50	117.00	211.50	138.50	142.50
Wilcoxon W	522.50	503.50	499.00	527.50	486.50	393.00	487.50	414.50	418.50
Z	-.40	-.81	-.91	-.29	-1.19	-3.24	-1.17	-2.77	-2.68
Asymp. Sig. (2-tailed)	.69	.42	.36	.78	.24	.00	.24	.01	.01

Test Statistics[a]

	LLCZ	URMX	URMY	URMZ	ULMX	ULMY	ULMZ	LRMX	LRMY
Mann-Whitney U	197.50	194.50	259.00	226.00	210.00	199.00	254.50	177.00	246.50
Wilcoxon W	473.50	470.50	535.00	502.00	486.00	475.00	530.50	453.00	522.50
Z	-1.47	-1.54	-.12	-.85	-1.20	-1.44	-.22	-1.92	-.40
Asymp. Sig. (2-tailed)	.14	.12	.90	.40	.23	.15	.83	.05	.69

Test Statistics[a]

	LRMZ	LLMX	LLMY	LLMZ	ANS_X	ANS_Y	ANS_Z	PNS_X	PNS_Y

Mann-Whitney U	212.50	226.50	243.00	201.50	244.50	245.00	264.00	174.50	262.00
Wilcoxon W	488.50	502.50	519.00	477.50	520.50	521.00	540.00	450.50	538.00
Z	-1.14	-.84	-.47	-1.38	-.44	-.43	-.01	-1.98	-.06
Asymp. Sig. (2-tailed)	.25	.40	.64	.17	.66	.67	.99	.05	.96

Test Statistics[a]

	PNS_Z	OR_X	OR_Y	OR_Z	PG_X	PG_Y	PG_Z	ME_X	ME_Y
Mann-Whitney U	251.50	200.00	255.50	254.00	171.50	227.00	260.50	235.00	261.50
Wilcoxon W	527.50	476.00	531.50	530.00	447.50	503.00	536.50	511.00	537.50
Z	-.29	-1.42	-.20	-.23	-2.04	-.82	-.09	-.65	-.07
Asymp. Sig. (2-tailed)	.77	.16	.84	.82	.04	.41	.93	.52	.95

Test Statistics[a]

	ME_Z	RGO_X	RGO_Y	RGO_Z	LGO_X	LGO_Y	LGO_Z	RCO_X	RCO_Y
Mann-Whitney U	260.00	170.00	167.00	262.00	167.00	236.50	257.00	207.50	217.00
Wilcoxon W	536.00	446.00	443.00	538.00	443.00	512.50	533.00	483.50	493.00
Z	-.10	-2.08	-2.14	-.05	-2.14	-.62	-.16	-1.25	-1.04
Asymp. Sig. (2-tailed)	.92	.04	.03	.96	.03	.54	.87	.21	.30

Test Statistics[a]

	RCO_Z	LCO_X	LCO_Y	LCO_Z
Mann-Whitney U	234.00	166.50	187.00	155.00
Wilcoxon W	510.00	442.50	463.00	431.00
Z	-.67	-2.15	-1.70	-2.41
Asymp. Sig. (2-tailed)	.50	.03	.09	.02

a. Grouping Variable: CLASS

Table 16: Comparison of T1 of Cl I and Cl III

Test Statistics[a]

	Max. c X	Max. c Y	Max. c Z	Mand. c. X	Mand. c Y	Mand. c Z	UR3 X	UR3 Y
Mann-Whitney U	204.00	243.00	263.50	162.00	223.50	233.00	183.50	264.00
Wilcoxon W	480.00	519.00	539.50	438.00	499.50	509.00	459.50	540.00
Z	-1.33	-.47	-.02	-2.25	-.90	-.69	-1.78	-.01
Asymp. Sig. (2-tailed)	.18	.64	.98	.02	.37	.49	.08	.99

Test Statistics[a]

	UR3 Z	UL3 X	UL3 Y	UL3 Z	LR3 X	LR3 Y	LR3 Z	LL3 X	LL3 Y
Mann-Whitney U	241.50	203.00	255.00	239.50	176.00	209.50	217.50	140.00	218.50
Wilcoxon W	517.50	479.00	531.00	515.50	452.00	485.50	493.50	416.00	494.50
Z	-.51	-1.35	-.21	-.55	-1.94	-1.21	-1.03	-2.74	-1.01
Asymp. Sig. (2-tailed)	.61	.18	.83	.58	.05	.23	.30	.01	.31

Test Statistics[a]

	LL3 Z	UR6 X	UR6 Y	UR6 Z	UL6 X	UL6 Y	UL6 Z	LR6 X	LR6 Y
Mann-Whitney U	222.00	189.00	233.50	257.00	225.50	252.50	245.00	213.00	212.00
Wilcoxon W	498.00	465.00	509.50	533.00	501.50	528.50	521.00	489.00	488.00
Z	-.93	-1.66	-.68	-.16	-.86	-.26	-.43	-1.13	-1.15
Asymp. Sig. (2-tailed)	.35	.10	.50	.87	.39	.79	.67	.26	.25

Test Statistics[a]

	LR6 Z	LL6 X	LL6 Y	LL6 Z	ANS X	ANS Y	ANS Z	PNS X	PNS Y
Mann-Whitney U	214.00	203.00	234.50	224.00	254.00	242.00	264.00	262.00	237.00
Wilcoxon W	490.00	479.00	510.50	500.00	530.00	518.00	540.00	538.00	513.00
Z	-1.11	-1.35	-.66	-.89	-.23	-.49	-.01	-.05	-.60
Asymp. Sig. (2-tailed)	.27	.18	.51	.37	.82	.62	.99	.96	.55

Test Statistics[a]

	PNS Z	Or Rt X	Or Rt Y	Or Rt Z	Pg X	Pg Y	Pg Z	Me X	Me Y
Mann-Whitney U	223.00	260.50	230.00	253.00	168.50	206.50	217.00	166.50	207.00
Wilcoxon W	499.00	536.50	506.00	529.00	444.50	482.50	493.00	442.50	483.00
Z	-.91	-.09	-.76	-.25	-2.11	-1.27	-1.04	-2.15	-1.26
Asymp. Sig. (2-tailed)	.36	.93	.45	.80	.03	.20	.30	.03	.21

Test Statistics[a]

	Me Z	R Go X	R Go Y	R Go Z	L Go X	L Go Y	L Go Z	R Co X	R Co Y
Mann-Whitney U	223.50	227.50	200.00	222.00	233.50	220.00	251.50	228.00	246.00
Wilcoxon W	499.50	503.50	476.00	498.00	509.50	496.00	527.50	504.00	522.00
Z	-.90	-.81	-1.42	-.93	-.68	-.98	-.29	-.80	-.41
Asymp. Sig. (2-tailed)	.37	.42	.16	.35	.50	.33	.78	.42	.68

Test Statistics[a]

	R Co Z	L Co X	L Co Y	L Co Z
Mann-Whitney U	245.00	254.00	229.50	251.50
Wilcoxon W	521.00	530.00	505.50	527.50
Z	-.43	-.23	-.77	-.29
Asymp. Sig. (2-tailed)	.67	.82	.44	.78

a. Grouping Variable: CLASS

Table 17: Comparison of T2 of Cl I and Cl III

Test Statistics[a]

	Max. c X	Max. c Y	Max. c Z	Mand. c. X	Mand. c Y	Mand. c Z	UR3 X	UR3 Y
Mann-Whitney U	247.50	257.00	235.00	239.00	246.50	231.50	257.50	241.50
Wilcoxon W	523.50	533.00	511.00	515.00	522.50	507.50	533.50	517.50
Z	-.37	-.16	-.65	-.56	-.40	-.73	-.15	-.51
Asymp. Sig. (2-tailed)	.71	.87	.52	.58	.69	.47	.88	.61

Test Statistics[a]

	UR3 Z	UL3 X	UL3 Y	UL3 Z	LR3 X	LR3 Y	LR3 Z	LL3 X	LL3 Y
Mann-Whitney U	228.50	245.50	249.50	245.00	233.50	234.50	220.00	244.50	246.00
Wilcoxon W	504.50	521.50	525.50	521.00	509.50	510.50	496.00	520.50	522.00
Z	-.79	-.42	-.33	-.43	-.68	-.66	-.98	-.44	-.41
Asymp. Sig. (2-tailed)	.43	.68	.74	.67	.50	.51	.33	.66	.68

Test Statistics[a]

	LL3 Z	UR6 X	UR6 Y	UR6 Z	UL6 X	UL6 Y	UL6 Z	LR6 X	LR6 Y
Mann-Whitney U	230.50	263.50	227.50	234.00	258.00	241.50	254.00	246.50	225.00
Wilcoxon W	506.50	539.50	503.50	510.00	534.00	517.50	530.00	522.50	501.00
Z	-.75	-.02	-.81	-.67	-.14	-.51	-.23	-.40	-.87
Asymp. Sig. (2-tailed)	.46	.98	.42	.50	.89	.61	.82	.69	.39

Test Statistics[a]

	LR6 Z	LL6 X	LL6 Y	LL6 Z	ANS X	ANS Y	ANS Z	PNS X	PNS Y
Mann-Whitney U	226.50	232.50	232.50	239.00	263.50	257.00	261.00	204.50	239.00
Wilcoxon W	502.50	508.50	508.50	515.00	539.50	533.00	537.00	480.50	515.00
Z	-.83	-.70	-.70	-.56	-.02	-.16	-.08	-1.32	-.56
Asymp. Sig. (2-tailed)	.40	.48	.48	.58	.98	.87	.94	.19	.58

Test Statistics[a]

	PNS Z	Or Rt X	Or Rt Y	Or Rt Z	Pg X	Pg Y	Pg Z	Me X	Me Y
Mann-Whitney U	227.50	216.50	244.00	256.00	244.50	227.00	215.00	201.50	217.00
Wilcoxon W	503.50	492.50	520.00	532.00	520.50	503.00	491.00	477.50	493.00
Z	-.81	-1.05	-.45	-.19	-.44	-.82	-1.09	-1.38	-1.04
Asymp. Sig. (2-tailed)	.42	.29	.65	.85	.66	.41	.28	.17	.30

Test Statistics[a]

	Me Z	R Go X	R Go Y	R Go Z	L Go X	L Go Y	L Go Z	R Co X	R Co Y
Mann-Whitney U	219.00	244.00	248.50	228.50	254.50	230.50	251.00	217.50	249.50
Wilcoxon W	495.00	520.00	524.50	504.50	530.50	506.50	527.00	493.50	525.50

Z	-1.00	-.45	-.35	-.79	-.22	-.75	-.30	-1.03	-.33
Asymp. Sig. (2-tailed)	.32	.65	.73	.43	.83	.46	.77	.30	.74

Test Statistics[a]

	R Co Z	L Co X	L Co Y	L Co Z
Mann-Whitney U	248.00	209.00	254.00	202.00
Wilcoxon W	524.00	485.00	530.00	478.00
Z	-.36	-1.22	-.23	-1.37
Asymp. Sig. (2-tailed)	.72	.22	.82	.17

a. Grouping Variable: CLASS

MAXILLARY CONTACT

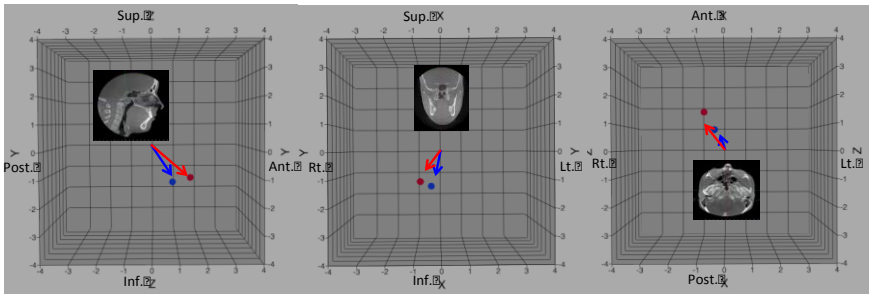


Figure 5: Maxillary Contact Point

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.38 ± 1.02	0.15	-0.8 ± 1.61	0.05	-0.43	0.44
Y	-1.38 ± 2.55	0.01*	-1.16 ± 1.87	0.01*	0.22	0.86
Z	0.84 ± 2.35	0.13	1.55 ± 2.36	0.00**	0.71	0.23

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

MANDIBULAR CONTACT

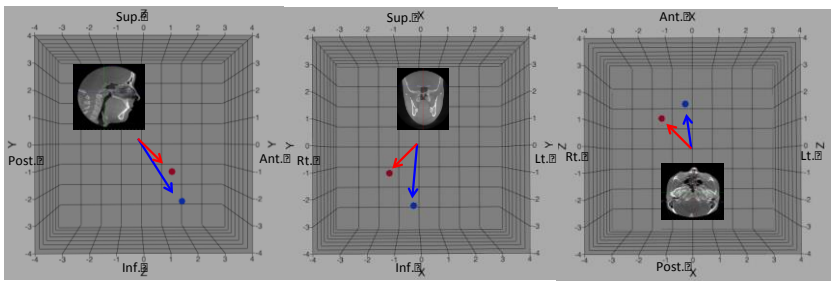


Figure 6: Mandibular Contact Point

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.28 ± 1.27	0.26	-1.28 ± 2.13	0.01*	-1.00	0.14
Y	-2.43 ± 2.58	0.00**	-1.12 ± 2.55	0.06	1.31	0.08
Z	1.69 ± 2.17	0.00**	1.2 ± 1.98	0.01*	-0.48	0.57

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

UL3

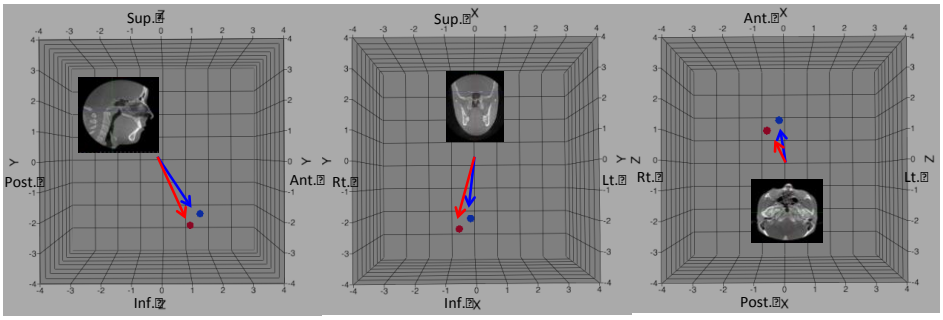


Figure 7: Maxillary Right Canine

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.18 ± 1.49	0.68	-0.6 ± 1.56	0.19	-0.42	0.42
Y	-2.03 ± 2.19	0.00**	-2.43 ± 2.21	0.00**	-0.40	0.36
Z	1.43 ± 2.37	0.01*	1.04 ± 1.67	0.01*	-0.38	0.78

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

UR3

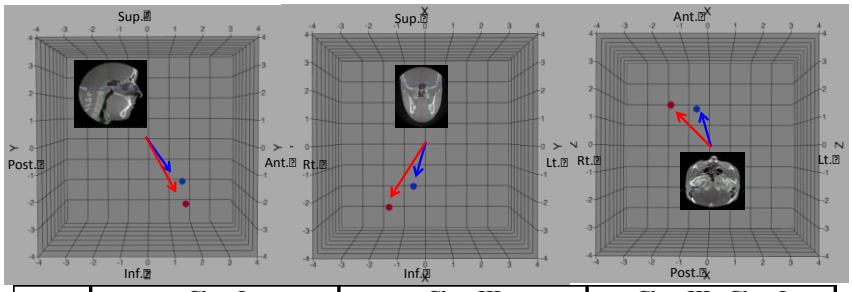


Figure 8: Maxillary Left Canine

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.46 ±1.53	0.16	-1.43 ± 2.23	0.01*	-0.97	0.16
Y	-1.61 ± 2.21	0.00**	-2.43 ± 2.92	0.00**	-0.82	0.39
Z	1.43 ± 2.19	0.00**	1.53 ± 1.88	0.00**	0.10	0.69

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

LR3

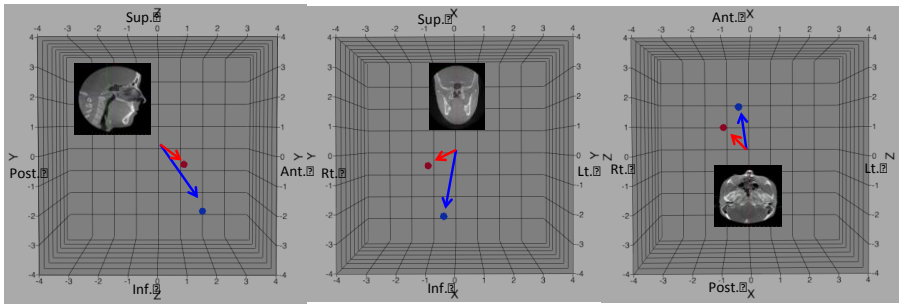


Figure 9: Mandibular right Canine

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.42 ± 1.51	0.34	-1.03 ± 2.01	0.02*	-0.61	0.24
Y	-2.29 ± 2.03	0.00**	-0.43 ± 2.10	0.37	1.86	0.00**
Z	1.73 ± 2.09	0.00**	0.99 ± 2.14	0.06	-0.74	0.24

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

LL3

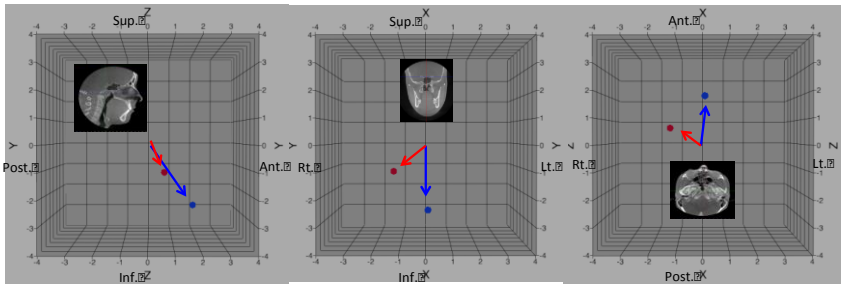


Figure 10: Mandibular Left Canine

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	0.09 ± 1.47	0.94	-1.33 ± 1.54	0.00**	-1.42	0.01*
Y	-2.59 ± 2.37	0.00**	-1.12 ± 2.09	0.01*	1.47	0.01*
Z	1.89 ± 2.36	0.00**	0.66 ± 1.86	0.14	-1.23	0.14

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

UR6

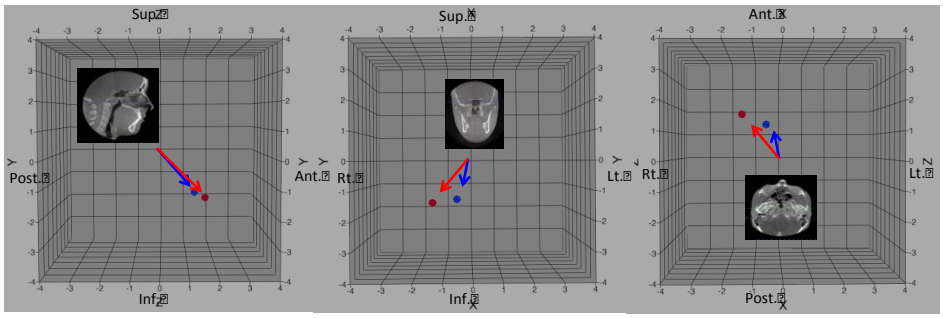


Figure 11: Maxillary Right First Molar

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.55 ± 1.43	0.06	-1.42 ± 1.76	0.00**	-0.87	0.12
Y	-1.4 ± 1.55	0.00**	-1.5 ± 1.88	0.00**	-0.09	0.90
Z	1.29 ± 2.04	0.01*	1.65 ± 1.64	0.00**	0.37	0.40

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

UL6

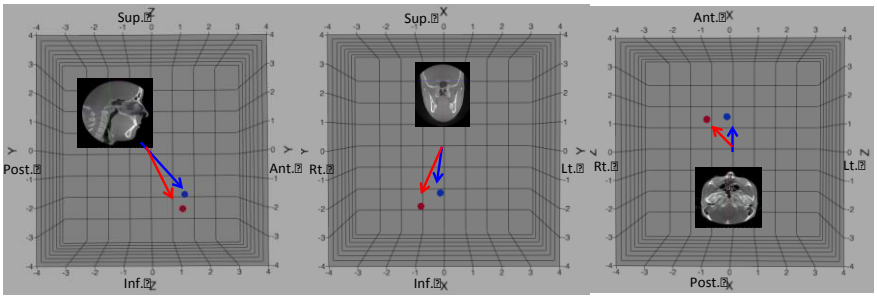


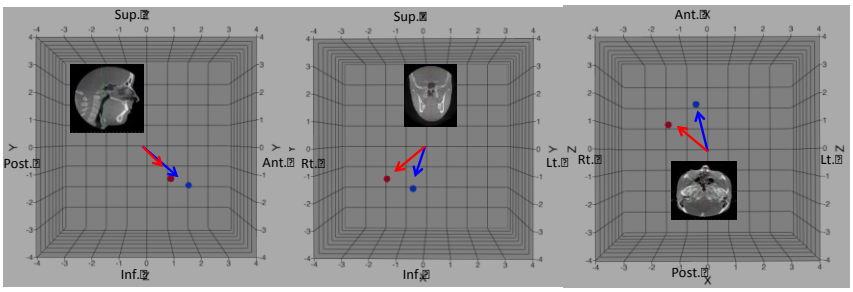
Figure 12: Maxillary Left First Molar

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.15 ± 1.56	0.80	-0.9 ± 1.72	0.04*	-0.74	0.23
Y	-1.7 ± 1.78	0.00**	-2.23 ± 1.49	0.00**	-0.53	0.15
Z	1.33 ± 2.50	0.03*	1.21 ± 1.53	0.00**	-0.12	0.83

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

LR6

Figure 13: Mandibular Right First Molar

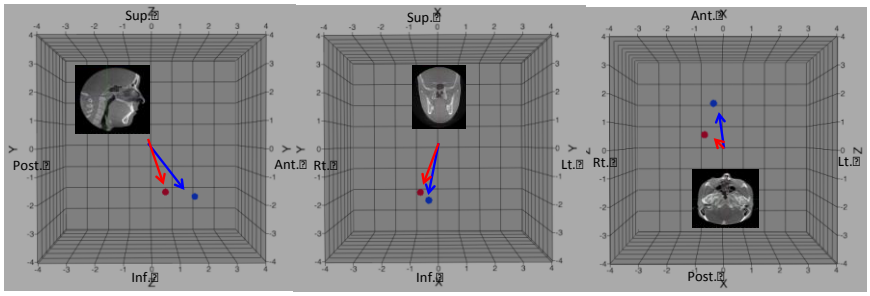


	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.45 ± 1.31	0.15	-1.56 ± 1.89	0.00**	-1.11	0.05
Y	-1.62 ± 1.54	0.00**	-1.28 ± 1.79	0.00**	0.34	0.69
Z	1.76 ± 2.17	0.00**	0.97 ± 1.67	0.01*	-0.79	0.25

Mean change in class I
Mean change in Class III
P*= 0.05 * , *P*= 0.01 *

LL6

Figure 14: Mandibular Left First Molar

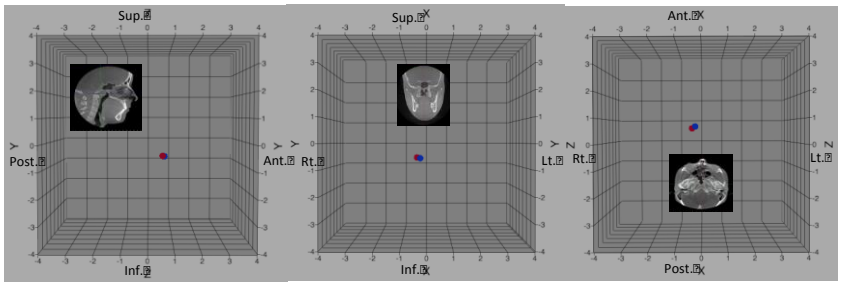


	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.36 ± 1.65	0.33	-0.71 ± 1.57	0.09	-0.35	0.40
Y	-2.03 ± 1.65	0.00**	-1.81 ± 1.54	0.00**	0.22	0.64
Z	1.77 ± 2.44	0.00**	0.57 ± 1.79	0.16	-1.20	0.17

Mean change in class I
Mean change in Class III
P*= 0.05 * , *P*= 0.01 *

Figure 15: Anterior Nasal Spine

ANS



	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.26 ± 1.09	0.39	-0.4 ± 1.32	0.17	-0.14	0.66
Y	-0.63 ± 2.18	0.16	-0.6 ± 2.23	0.25	0.03	0.67
Z	0.7 ± 2.10	0.17	0.62 ± 1.67	0.16	-0.08	0.99

Mean change in class I
Mean change in Class III
P*= 0.05 * , *P*= 0.01 *

PNS

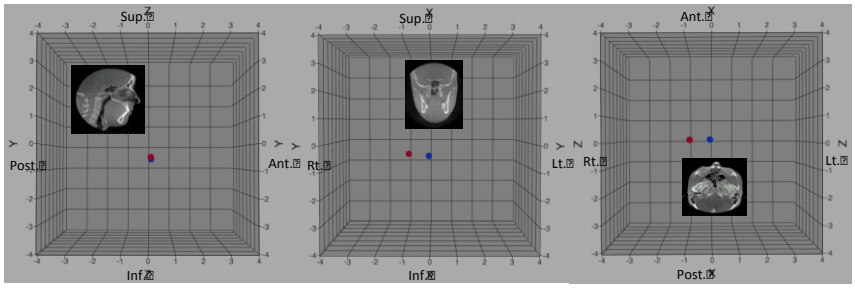


Figure 16: Posterior Nasal Spine

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.07 ± 1.35	0.82	-0.92 ± 1.23	0.00**	-0.86	0.05
Y	-0.57 ± 1.17	0.01*	-0.48 ± 1.63	0.12	0.08	0.96
Z	0.11 ± 1.45	0.90	0.1 ± 1.23	0.64	-0.01	0.77

Mean change in class I
Mean change in Class III

Rt Or

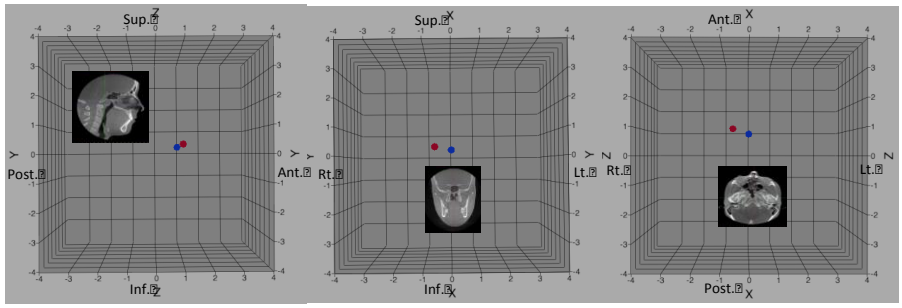


Figure 17: Right Orbitale

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	0.01 ± 1.18	0.97	-0.63 ± 1.20	0.04*	-0.64	0.16
Y	0.26 ± 1.88	0.32	0.38 ± 2.20	0.25	0.12	0.84
Z	0.87 ± 1.70	0.02*	1.09 ± 1.50	0.00**	0.23	0.82

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

Pg

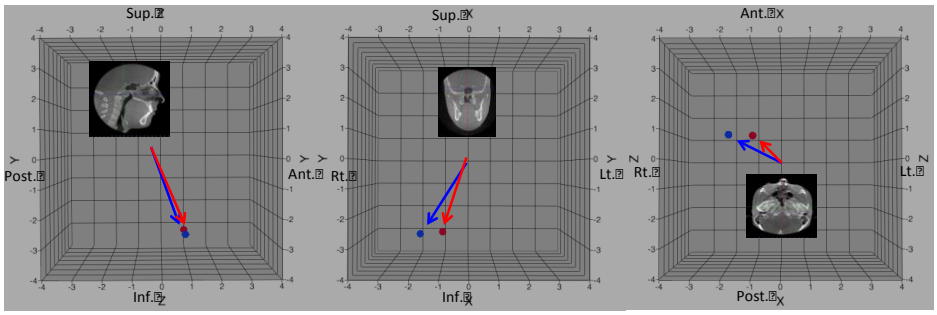


Figure 18: Pogonion

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-1.81 ± 3.09	0.02*	-0.97 ± 2.28	0.06	-2.20	0.04*
Y	-2.77 ± 2.28	0.00**	-2.7 ± 3.04	0.00**	0.06	0.41
Z	0.87 ± 3.00	0.24	0.84 ± 1.68	0.04*	-0.03	0.93

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

Me

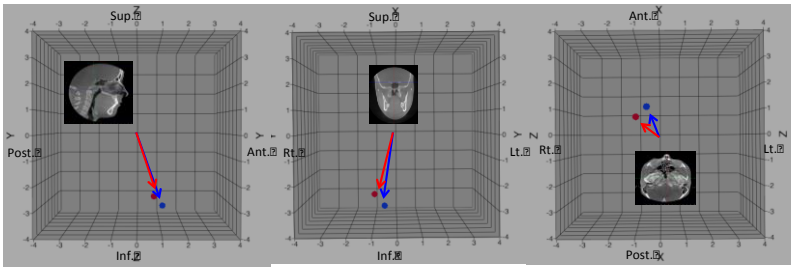


Figure 19: Menton

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.53 ± 1.93	0.24	-0.98 ± 2.26	0.05*	-0.45	0.52
Y	-3.16 ± 1.88	0.00**	-2.7 ± 2.25	0.00**	0.46	0.95
Z	1.12 ± 3.08	0.15	0.73 ± 1.63	0.07	-0.39	0.92

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

RGo

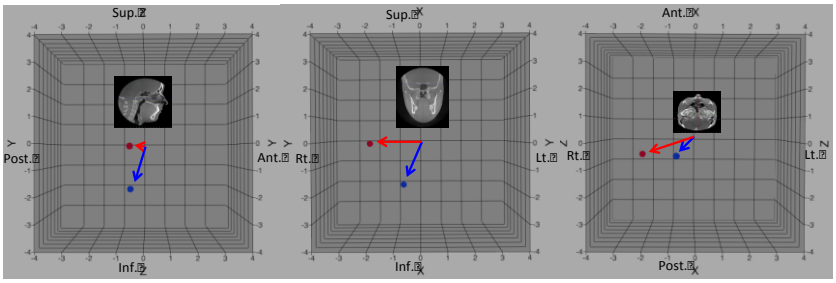


Figure 20: Right Gonion

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.74 ± 2.17	0.14	-2.22 ± 2.14	0.00**	-1.48	0.04*
Y	-1.89 ± 2.72	0.01*	-0.09 ± 2.50	0.87	1.80	0.03*
Z	-0.57 ± 1.72	0.07	-0.56 ± 1.53	0.12	0.01	0.96

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

LGo

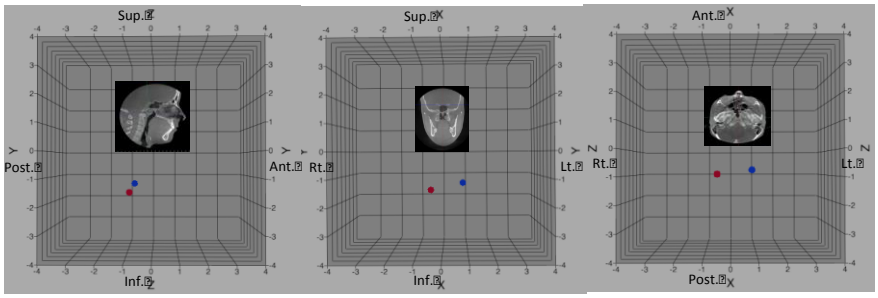


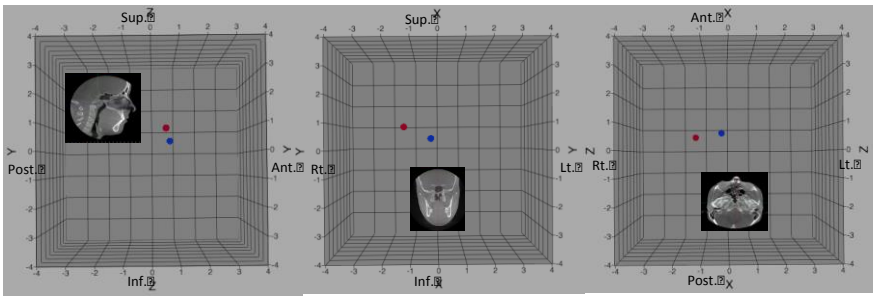
Figure 21: Left Gonion

	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	0.84 ± 2.10	0.08	-0.52 ± 2.19	0.29	-1.36	0.03*
Y	-1.32 ± 1.71	0.00**	-1.63 ± 2.89	0.02*	-0.30	0.54
Z	-0.77 ± 2.16	0.08	-0.93 ± 1.48	0.01*	-0.16	0.87

Mean change in class I
Mean change in Class III
P= 0.05 * , *P*= 0.01 **

RCo

Figure 22: Right Condylion

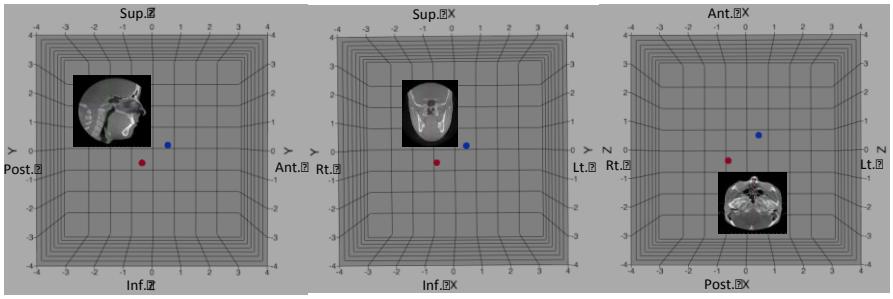


	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	-0.27 ± 2.90	0.52	-1.37 ± 2.17	0.01*	-1.10	0.21
Y	0.45 ± 1.14	0.10	0.92 ± 1.67	0.01*	0.47	0.30
Z	0.74 ± 1.42	0.03*	0.57 ± 1.68	0.07	-0.17	0.50

Mean change in class I
Mean change in Class III
P*= 0.05 * , *P*= 0.01 *

LCo

Figure 23: Left Condylion



	Class I		Class III		Class III - Class I	
	Δ mean T2 - T1	*p*	Δ mean T2 - T1	*p*	Δ mean	*p*
X	0.5 ± 2.17	0.29	-0.73 ± 2.13	0.04*	-1.23	0.03*
Y	0.18 ± 1.33	0.56	-0.52 ± 1.15	0.03*	-0.70	0.09
Z	0.63 ± 1.59	0.14	-0.41 ± 1.98	0.13	-1.04	0.02*

Mean change in class I
Mean change in Class III
P*= 0.05 * , *P*= 0.01 *