A COMPUTER AIDED CEPHALOMETRIC STUDY OF ORTHODONTICALLY TREATED PATIENTS TEN YEARS POST-RETENTION: A LONGITUDINAL IMPLANT STUDY

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"...generalization fails completely when applied to the individual. He is and will forever remain a unique biologic mechanism in which variation is the rule."

A. Goldstein, 1965[1]

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INTRODUCTION

Analysis of orthodontic results and the concomitant posttreatment changes is essential in evaluating the success of orthodontic treatment. Not until the advent of the standardized roentgenographic cephalogram pioneered by Broadbent,[2] Brodie,[3] and Hofrath,[4] was the study of changes in the relationship between the teeth and the skull possible.

The first attempt to employ this technique in an appraisal of orthodontic results was that made by Brodie, Downs, Goldstein and Myer.[5] In that study and those that followed, serial tracings were superimposed upon the various anatomical structures in order to appraise changes that had occurred due to growth and or orthodontic treatment. It was from this work, and that of Downs,[6] Litowitz,[7] Cole,[8] Reidel,[9] and others that the groundwork of our current knowledge of craniofacial growth and development and the effects of orthodontic treatment have arose.

In these early studies the anatomic landmarks and planes used to superimpose serial tracings were considered to be relatively stable reference structures. As research methodology and observation improved, it was found that the craniofacial complex was an altogether more dynamic structure with considerably more remodelling and change in areas once thought to be relatively stable.[10,11,12]

Perhaps the most significant improvement in the assessment of the craniofacial complex in vivo occurred when Bjork and co-workers

developed a systematic method for placing and monitoring metallic implants in the maxilla and mandible.[10,13] With this important contribution, this method which is perhaps the most powerful tool for the precise quantitation of osseous remodeling available to date, Bjork was able to monitor longitudinally the development of the mandible[14,15] and maxilla[16,17] in living subjects. Arising from this work, Bjork proposed certain "Natural registration points" that remain relatively stable throughout growth and thus could be used for superimposition of the images of the maxilla and mandible in serial films in the place of metallic implants.[14,17] However, the accuracy that results from superimpositions obtained with the use of these anatomic queues compared to superimpositions with implants has been questioned.

Currently, superimpositions of serial cephalograms utilizing metallic implants are considered the most nearly valid two dimensional measurements of skull changes available.[18] Thus the presence of metallic implants would be beneficial for evaluating the growth and treatment effects that occur over time. Unfortunately the vast majority of cases that orthodontists are called upon to evaluate do not and will not have such markers. Thus orthodontists and craniofacial research workers are presently forced to use anatomic structures to superimpose serial head films. Since data derived from such anatomical superimpositions play an extremely important role in the evaluation of treatment effects, knowledge in whether there is a clinically significant difference between the two methods would be valuable.

The purpose of this study was two fold. First, it was desireable to ascertain what changes occurred during and more importantly after

treatment of a selected sample of orthodontically treated cases at the University of Oregon Orthodontics department. Second, and of greater importance, whether the use of metallic implants would give a significantly better approximation of these changes.

REVIEW OF THE LITERATURE

Utilizing the standard lateral cephalometric method developed by Broadbent[2] and Hofrath,[4] early workers underwent numerous attempts to analyze posttreatment changes cephalometrically. The first examination of posttreatment changes was done by Brodie and co-workers.[5] Examining the serial cephalograms of nonextraction cases, and using point R as the origin of reference for measure, Brodie found that tooth movement was not as great as clinical observation had lead them to believe. Also, that growth and development accounted for a considerable part of the changes that occurred during orthodontic treatment. Further it was found that changes to the occlusal plane and axial inclinations of teeth showed a strong tendency to return.

Downs,[6] analyzing tooth movement in a later paper stated:

> Our first attempts to correlate the readings showed conclusively that we could not use the methods of recording that are accepted for growth studies, that is, the registration of pictures on the point R with the Bolton planes parallel and taking readings from R.

Subsequently, premised on the "stability" of various planes and the anatomic structures from which they were based, Downs and the numerous workers that followed, developed various methods of superimposition with which to measure or observe the various changes that occur between successive serial tracings of individual cases.

In 1948, Cole[8] examined twenty one four first molar extraction cases a minimum of one year postretention. Measuring differences found by superimposing the tracings of successive films on the images of the maxilla and mandible, Cole found that the mandibular incisor root apices either held their position or moved posteriorly as a result of treatment. Concurrently the crowns all showed posterior movement. Recovery after active treatment showed movement in all directions. Nevertheless there was a definite tendency for the mandibular incisors to return to their original inclinations. He noted also that treatment with extraction was successful in establishing a more vertical position of the incisors to the mandibular plane. Evaluation of the molars revealed that most moved anteriorly with treatment but only a few showed a tendency to return to the pretreatment axial inclinations. Further, he noted the maxillary molars had a tendency to continue tipping anteriorly following retention. Cole also observed that overbite increased in all cases and that 62% of these showed greater overbite following retention than before treatment began.

Litowitz,[7] in a study paralleling Cole's, evaluated twenty nonextraction cases. He found that mandibular molars, when moved posteriorly, tended to return to their original position, and those that moved anteriorly showed an even stronger tendency to continue moving anteriorly postretention. Similarly the maxillary molars, showing greater movement from treatment, exhibited an even stronger tendency to move anteriorly following treatment. Evaluation of the lower incisors revealed that disturbances of the root apex or crown during treatment was followed by a return to the original position in almost every case,

especially those in which treatment resulted in labial movement. Litowitz also noted that any depression of the lower incisor as a result of treatment returned to or exceeded its original vertical position, and thus contributed to the increase in overbite observed in all cases postretention.

Wallman[19] who examined posttreatment changes in a group of thirty six patients treated by Tweed, found that the dentition tended to return to its original inclination and position following treatment, but that their was a great deal of individual variation. Indicating that maxillary molars showed a range of movement that covered most all of the possible movements that one could expect, Wallman also noted that the maxillary molars were the least variable of all the teeth in their recovery attempts. He found that eighty-three percent of all the changes resulted in anterior movement of the crown, with the root moving back in nineteen cases and forward in eleven cases. In very few instances did the maxillary molar move bodily posteriorly during or after treatment. Regarding the mandibular molars, Wallman concluded that there was no typical recovery. Observation of the maxillary incisors revealed that eighty-nine percent of the cases showed a forward movement after treatment. Twelve showed the crown moved forward more than the root, six the root more than the crown, six moved bodily, and five the crowns moved forward alone. The mandibular incisor was less regular in its recovery pattern, sometimes tipping labially, lingually or bodily in either direction.

Van Dyke[20] examined the lateral head films of sixty-four patients treated by the Utah Study Club of Orthodontists taken before treatment,

immediately following treatment and five or more years after treatment. He compared these cases to another sample of sixty-seven cases from the postretention files of the University of Washington. Van Dyke concluded that the lower incisors have a tendency to return to their original angulation and that the lower incisors have a tendency to move posteriorly on the denture base following treatment. In both samples the mandibular incisors were about 1.5 mm lingual to their original positions. Van Dyke, like Litowitz and Cole found also that the degree of incisor change that occurs is related to the amount of facial growth that occurs after treatment.

It is evident from these studies and others, that the changes occurring in the denture and other craniofacial structures following orthodontic treatment is highly variable. This variability is further exemplified by the fact that at best only moderate trends and correlations of these changes can be established. Much of this variability has been attributed to physiologic recovery and the developmental changes that occur following treatment.[21] Albeit reduced, growth is now known to continue throughout life.[22,23,24]

The changes in tooth position and inclination, whether related to skeletal factors, functional factors, or physiologic recovery, are thought to result from a mechanism of compensation.[16]

Another factor that contributes to the inability to discern clear trends is the occurrence of local remodeling of the bony structures used for superimpositions of serial cephalograms. The incapacity to accurately superimpose the anatomic images of various structures in

serial films increases the error and thus the variability of the assessed changes.[25,26]

By far the most important advancement in our ability to assess changes between successive cephalograms was the development by Bjork and co-workers a method for placing and monitoring metallic implants in the mandible and maxilla.[10,13] Utilizing these fixed reference points for superimposition, and thus avoiding the errors that result from the osseous remodeling of conventional landmarks, Bjork was able to assess much more accurately the skeletal and dental changes that occurred from one time point to another. His initial findings demonstrated that there was considerable osseous remodeling of the maxilla and mandible which strongly tended to mask the changes in relationship which occurred between these structures and the rest of the cranium through time.

In 1972, Bjork and Skieller[16] examined a sample of 21 untreated boys and girls with various malocclusions. Bjork concluded that facial growth is characterized by rotation of both jaws and that rotation of the maxilla is influenced by the rotation of the mandible. He noted that in nineteen cases the mandible rotated forward (counterclockwise) an average of six degrees and the maxilla and average of 2.5 degrees based on implant superimposition. This was almost twice the amount of rotation that was detected using anatomic superimposition. Further, he found definite trends in the movements of the dentition when related to the direction of jaw rotation. When there was predominately forward rotation of the jaws, it was found that the lower incisors were tipped back in relation to the nasion-sella line, but tipped forward in relation to the mandibular base. The upper incisors tipped forward to

the nasion-sella line but remained unchanged in relationship to their base. Molars in both jaws followed the mandible in its rotation but since the maxilla rotates on average less than the mandible, there was much more forward tipping of the maxillary molars on their base. For backward rotation of the jaws, the lower incisors and molars tipped back, but the change was small for the mandibular molars due to their restricted eruption. It must be noted however, that Bjork could show no significant correlation between jaw rotation and incisor inclination. On the other hand he did find that the change in overbite was significantly correlated with the direction of jaw rotation.

Orthodontic journals routinely report on tooth movement resulting from various techniques and philosophies. Such movement is often measured by superimposing mandibles on the lower border registered at the symphysis, and likewise superimposing the maxilla on the palatal plane formed by the points ANS and PNS. It is clear now that these reference points are remodeling and moving different amounts as mandibular and maxillary rotation occurs. The result of these methods of superimpositioning greatly reduces the reliability of the obtained results.[25,26]

Realizing the inherent errors with the previously used conventional superimpositional methods, many orthodontists and craniofacial researchers alike have modified their superimpositional techniques in order to use the "natural registration points" suggested by Bjork.[14,17] Bjork's "structural method arose from his studies using implants. He found that there was several anatomic areas in the maxilla and mandible

which stay "relatively stable" in location throughout growth and development.

Recent workers however, have questioned the stability of these landmarks.[27,28,29,30]

Mathews,[29] examined lower incisor changes in thirty-six children who had tantalum implants placed in the mandible and maxilla. Comparing routine mandibular superimposition with that obtained with tantalum implants, Mathews concluded that natural registration points should better be regarded as areas. Additionally he concluded that dentoalveolar morphologic change cannot be demonstrated with accuracy when marked facial growth is occurring and one is forced to rely on customary anatomic superimposition methodology.

Baumrind,[28] in a study still yet unpublished, measured the differences that occurred between anatomic and implant superimpositions of the maxilla. He found that the anatomical best fit method of superimposition resulted in significantly different changes than was found with the implant method of superimposition. Not only did the anatomic method under or overstate particular remodeling changes, but also directional changes as well. In conclusion Baumrind stated:

1) The anatomical best fit superimposition as herein defined was found in this sample to mask completely the downward remodeling of the superior surface of the maxilla that had been detected previously when an implant superimposition was used.
2) The anatomical best fit superimposition appears on average to understate the true downward remodeling of the osseous palate by an average of about 0.3 to 0.4 mm per year, although this value differs at different ages and timepoints.
3) Individual variation in the perceived displacement of ANS, PNS, and Point A is in general smaller when the anatomical best fit superimposition is used than when an implant superimposition is used.

4) Landmark displacement variability is increased when the implant superimposition is used because not all patients remodel in the same fashion relative to their landmarks.

Clearly the use of metallic implant methodology has contributed greatly to our understanding of craniofacial growth. It is apparent the improved acuity this method provides could help to elucidate many of the obscure processes of craniofacial growth. There is mounting evidence to suggest that the use of implants for superimposing serial cephalograms does give a significantly better appraisal of changes when dealing with actively growing individuals, especially as the period between assessments increases.

MATERIALS AND METHODS

SAMPLE DESCRIPTION

The material used in this study was selected from the files of patients who had implants placed prior to undergoing routine orthodontic therapy at the OHSU School of Dentistry. Since recent postretention records were not available for these cases, an initial sample who were females that exhibited Angle Class II malocclusion and were treated by extraction were sent letters asking if they would come to the school to have records taken. Of the initial eighty five cases selected, fifteen complete sets of longterm postretention records were obtained.

The final sample consisted exclusively of female caucasians of Northern European extraction. No consideration was given to the specific method or to the quality of results of orthodontic treatment in the selection of this sample. All patients had fixed appliances and most had supplemental extraoral traction.

All patients had three or four tantalum-tungsten implants placed unilaterally in the maxilla and mandible between the years of 1965 to 1970 after the method described by Bjork.[10,13] Further information on the method and location of implants in this sample can be found in Thorburn's 1965 certificate paper.[31]

There was a full range of teeth extracted in this sample. Cases 3-6, 11,13,14 had four first bicuspids removed. Case 1 had a lower right

first bicuspid and lower left second bicuspid extracted. Case 2 had upper first bicuspids removed, and case 12 had lower first bicuspids removed. Case 9 had the left lower second bicuspid removed and was congenitally missing the lower right second bicuspid. Case 7 had all second bicuspids and second molars removed. Case 10 was missing the lower left lateral incisor and had the remaining lateral incisors extracted. Case 15 had all eight bicuspids removed. Somehow case 8 had no teeth removed.

Cases 1 and 8 underwent surgery as part of their treatment. Case 1 underwent mandibular advancement and anterior maxillary setback with the removal of the remaining upper first bicuspids shortly after active treatment with appliances had finished. Genioplasty was performed on case 9 towards the end of active therapy. Variables which were affected by these surgeries were thus not included in the sample calculations.

The serial head films needed to be of reasonable quality and correspond to the following time periods:

T_1 Pretreatment film - taken prior to any orthodontic treatment but after placement of implants

T_2 Posttreatment film - taken as close as possible to correspond with the end of active treatment

T_3 Postretention film - taken as close as possible to correspond with the end of retention

T_4 Longterm Postretention film - taken as recent as possible

A complete summary of sample demographics can be found in Tables IA and IB.

METHOD

Pretreatment, posttreatment, postretention, and longterm postretention lateral cephalometric radiographs were traced at two separated times on acetate film by the same investigator. For each tracing forty six points were located. These included; Four corner fiducials (A - D), thirty-two anatomic landmarks (1 - 32), and ten superimposition registration points of which two were for each of five superimpositions (33 - 42)(Figure 1).

Landmark definitions used were those commonly used by most researchers and clinicians with the exception of ANS and Condyle. ANS is defined as the point on the image of the inferior surface of the anatomical anterior nasal spine at which the vertical thickness of the bony process is 3 mm (after Harvold[92]). In this study Condyle was defined as the most posterior superior point of the mandibular condyle head image. Those points indicating the cusp and apex of the molars were located by taking the most anterior cusp and root apex images of the maxillary and mandibular first molars.

Five separate superimpositions were made with all referenced to the pretreatment (T_1) film. Longitudinal skeletal changes were assessed by superimposing tracings upon anterior cranial base structures centering upon the best fit of the ethmoid triad structures.[15] In order to analyze horizontal and vertical dentofacial changes on the overall superimpositions, the sella nasion line of the pretreatment (T_1) tracing was selected as the X axis; the Y axis was a perpendicular to the sella nasion line through sella.

Two separate maxillary superimpositions were made to assess individual dental changes in that arch. The first superimposition was made using only the maxillary implants. The second superimposition was established using a best fit of the hard palate images and anterior maxillary images in the region between anterior nasal spine and point A.[18] The palatal plane formed by anterior nasal spine and posterior nasal spine of the pretreatment (T_1) tracing was chosen as the X axis, and a line perpendicular to the palatal plane through posterior nasal spine determined the Y axis.

As well, two mandibular superimpositions were made based on implants and anatomic structures. The anatomic superimposition was determined by registering on the inner contour of the symphysis while obtaining a best fit of the inferior alveolar canal and anterior contour of the chin.[15] Changes in tooth position were assessed using frankfort horizontal of the reference film as the X axis, and a perpendicular to frankfort passing through machine porion as the Y axis.

The tracings were digitized and then evaluated with an updated variant of the UCSF Computer-aided Head Film Analysis System.[33,34] Outlier deletion criteria for both landmarks and superimpositions were established on the basis of previous studies done by Baumrind.[25,35] Where concordance between estimates fell below previously defined standards, additional blind and independent estimates were made.

In all, one-hundred and six angular and linear variables were obtained for each tracing. From these, fifteen conventional orthodontic measures (Table II), and twenty landmark variables recorded as (X,Y) coordinates (Tables III, IV, V), were retained for use in this study.

The conventions used to designate direction of change or displacement are:

Angular changes: - Positive values indicate an increase, negative values indicate a decrease. An exception is the implant line convention. A positive value indicates a clockwise rotation and a negative value indicates a counterclockwise rotation.

Linear changes - A positive change in the x or y value indicates a change in the posterior or downward direction respectively. A negative change in the x or y value indicates a change in the anterior or upward direction respectively.

STATISTICAL ANALYSIS

Statistical analysis of the data included calculation of means, standard deviations, and ranges for each variable. Pretreatment, posttreatment, and longterm postretention changes were compared by students' t test for repeated measures. Likewise, differences between measurements of landmark displacement relative to superimposition on implants and measurements of displacement of the same landmarks relative to superimposition on anatomic structures were compared by student's t test. Statistical significance was established at * = $p < 0.05$ and ** = $p < 0.01$.

Due to the small sample sizes, correlations were not calculated for associations between variables. As well, assumptions[36,37] of normal distribution and homogeneity of variance, needed for student's t test on small sample size, were tested and found to be valid.

ANALYSIS OF ERROR

The interpretation of results for this or any other study must be considered in the light of the errors involved in collection of data. Sources of errors in cephalometric analysis can be broken down into "errors of projection" (radiographic), "errors of identification" (radiologic), and "errors of measure" (radiometric).[35,38]

Two errors of projection that deserve discussion with respect to this study involve enlargement and head positioning. The films at timepoints T_1, T_2, and T_3, were taken by residents using the Proflex machine that was in place at the Department of Orthodontics, OHSU. The final films at timepoint T_4 were taken by the same technician on a Broadbent Bolton Cephalometer. Due to differences in calibration (i.e. source-film, target-film distances), differences in focal spot size, quality of head holder and thus head orientation, there were considerable differences between the films taken on both machines. Observation of the films taken on the Proflex machine showed considerable variation in the alignment of the ear posts, thus suggesting that head positioning error was much larger for the films taken on this machine. This resulted in a greater variation in distortion of the image with the films taken at timepoints T_1, T_2, and T_3.

Usually error produced by enlargement of the target remains constant when the same apparatus is used to take successive radiographs. In a case such as this enlargement can be ignored for all intents and purposes. However since the final films used in this study were taken with a different apparatus, the enlargement of the resulting images differed. Since there was no common static reference points on the films from which to calculate the differences in enlargement, no correction was made. It was noted however that the image produced on the time point T_4 films was less. Although the largest error found in a cephalometric study of this kind is usually associated with landmark identification,[35,39] the differences between the timepoints T_1, T_2, T_3, and timepoint T_4 must be considered the largest error. However, this should not significantly affect the differences measured between the displacements of landmarks found by comparing the different superimposition methods, since the enlargement error for both is the same.

Intraoperator landmark identification error was assessed using duplicate digitizations. Two skeletal and two dental landmarks were chosen which correspond to the landmarks that show minimal and maximal envelopes of error as an indication of the range of error for estimates in landmark location. For each landmark, ten sum of the squares for x and y residuals were randomly selected from the sample. The resulting standard deviations for error is summarized in Table VI.

TABLE VI. Standard Deviation for error in mm

Landmark		SD_x	SD_y
Skeletal	ANS	0.68	0.32
	Nasion	0.21	0.35
Dental	L 1 apex	0.37	0.46
	U 1 edge	0.23	0.19

In difference to the equation $SE = \sqrt{\frac{\Sigma d^2}{2N}}$ proposed by Dahlberg[40] for estimating random error, the formula $SE = \sqrt{\frac{\Sigma d^2}{N(K-1)}}$ was used. Where N = the number of head films, K the number of tracings per head film, and each d = the deviation of the individual tracing value from the mean value for that landmark for that film. This later equation is considered preferable because it accounts for the lack of complete independence among each tracing value obtained.

In contrast to the error of landmark identification, the true "error of method" or "error of measure" was calculated using the four corner fiducials. From ten films selected at random, the sums of the squares for x and y residuals of each corner fiducial was used. The resulting error of the measure was found to be 0.12 mm in the x direction and 0.11 mm in the y direction.

The final comment on error deals with superimpositions. Aside from the usual error involved using different superimpositional techniques, the previously discussed enlargement differential idiomatic to this study increases this error both on anatomic and implant superimpositions. Of special regard is one of superimposition on implants. Implant methodology establishes "fixed" points of reference within a given bone unless they are displaced through remodeling resorption or as a result of the pin being placed improperly. Examples

of both were seen in this longitudinal study. These factors along with the enlargement differential and rotational head positioning errors made it difficult at times to have confidence in the resulting superimposition.

RESULTS

Information on the composition of the sample are summarized in Tables IA and IB. Of special note from Table IB is the mean age at debanding, which was 15.83 years. This indicates that growth for this female sample was relatively complete following active orthodontic therapy. The mean age at the time the last records were taken was 31.85 years. This resulted in an average postretention time of 13.45 years. The mean elapsed period of between film comparisons was 3.08, 15.91, and 18.87 years for treatment time, posttreatment time, and overall time respectively. The importance of these periods will become apparent later.

Tables VIII through XXI list by individual the values at each timepoint and the changes between each timepoint for some of the more common cephalometric variables. The means and standard deviations for the entire sample are summarized in Table II. Figures 2 and 3 graphically illustrate the magnitude and direction of change for each of the between timepoint intervals.

Cumulative displacements of specific landmarks in the maxilla and mandible relative to superimposition on anatomical and implant structures are reported by individual in Tables XXII through XXXV A and B respectively. Again, the means and standard deviations for the entire sample are summarized in Table III for anatomic superimposition

and Table IV for implant superimposition. Similarly the difference in the perceived displacements of each landmark, as a function of the choice between the two superimpositions are tabulated in Tables XXII C through XXXV C for the individual and summarized for the entire sample in Table V.

A graphic sense of the individual variation in the displacement of four representative landmarks in the maxilla and mandible for the period between timepoints T_2 and T_4 are presented in Figures 4 through 7. Figures 4 through 7, A, plot the displacements for each individual relative to superimposition on anatomical best fit. Similarly, analogous data for the same cases and time interval relative to superimposition on implants is shown in Figures 4 through 7, B. Figures 4 through 7, C, plot the individual case differences between the two superimpositions using the superimposition on implants as the reference.

DISCUSSION

The discussion is divided into three sections. The first will focus upon the treatment and posttreatment changes observed for the skeletal relationships, while the second will consider the changes observed in the individual arches. Lastly, the differences found in perceived landmark displacement between the two superimpositional techniques will be discussed.

SKELETAL PARAMETERS

Initially the pretreatment values for the variables listed in Table II were compared to those reported for other Class II samples.[41,42,43] This was done in order to determine if this sample was a representative Angle Class II sample, and also to determine if it would be reasonable to roughly compare the results obtained from this study with those of others. The pretreatment values for this sample were found to be very similar to those reported by Shields,[41] Blair,[42] and Moyers.[43] The changes observed for the skeletal parameters in this study in general parallel data from previous studies on treatment and posttreatment changes of angle Class II samples.[41,44,45]

Even though the sample size was relatively small, many statistically significant changes were noted. The overall correction of the anteroposterior skeletal discrepancy in this sample was primarily

due to a significant reduction of the SNA angle (Table II, and Figure 2). SNB actually showed a small decrease (-2.33°); resulting from the net retraction of the lower incisors and thus Point B during treatment. There was however a small but significant increase in the SN-POG angle during treatment. The SN-OP angle increased a significant 3.29°, indicating the occlusal plane was rotated clockwise during treatment. Both the frankfort mandibular plane angle and SN-GoGn angle demonstrated a slight mean decrease of -0.34° and -0.20° respectively. However, the rotation observed in the mandibular implant line (figure 7) revealed that there was actually a mean opening or backward rotation of the mandible of 1.23°. This tends to indicate that there was enough remodeling of the mandibular borders to mask and thus alter the observed rotation of the mandible. Whether this discrepancy is a true difference or is just a result of chance fluctuations in the measurement process is not known. The variability of all three of these values would tend to indicate the difference is negligible.

Posttreatment changes again showed some significant changes. Both SNA and SNB angles increased in the posttreatment period. Since the results of Behrents study[22] on skeletal changes of adults revealed a mean change in SNA of 0.0° and -0.1° for SNB, it can be postulated that the resultant change of SNA was due to rebound following treatment. The change in SNA was thus responsible for the significant increase in ANB posttreatment. The effects of treatment did show a significant improvement in SNA and thus ANB overall. The SN-OP angle decreased significantly -1.74° during the posttreatment period partially offsetting the backward rotation caused by treatment. This supports the

view by Reidel[46] and Schudy[47] that the occlusal plane is relatively stable and thus reverts to its pretreatment value. It must be noted however that in this sample there was an overall increase in the SN-OP angle which may have aided in correction of the Class II molar relationship. Posttreatment changes in the mandibular plane angle were significant showing a mean decrease of FMPA of -2.03° and a standard deviation of ± 1.32°. Again, this was in contrast to the value obtained for implant line rotation which was 1.18° with a standard deviation of ± 3.38°. The clockwise rotation of the mandible as found using the normal cephalometric variables FMPA and SN-GoGN is similar to the observations found in the previous studies noted; But these studies did not have the aid of metallic implants from which to measure changes. A study done by Lavergne[48] on a sample of Class II cases with implants revealed a positive rotation of the mandible of 0.63°. However, the average age of the cases as well as the length of the observation period was less.

DENTAL PARAMETERS

For the purposes of this discussion, the data collected using the superimposition of tracings on implants is going to be considered the most accurate and valid reference framework for the measurement of these changes.[10] Thus the changes reported in this section will solely be the values obtained by registering superimpositions on implants.

Generally the changes that occurred in the dentition during and following treatment showed much more variability than the skeletal parameters. This variability was demonstrated by the values obtained for the interincisal angle. At timepoint one the mean was 132.68° but

had a standard deviation of ± 18.94° and a range of 100.85° to 170.8°. Treatment resulted in a mean value of 134.89° with a much smaller standard deviation of ± 7.62°. The later would be expected since a goal of treatment would be towards an ideal relationship of these teeth. Posttreatment change demonstrated a continued increase of the interincisal angle, however this mean value of 1.46° was strongly affected by one individuals value of 19.69°. Discarding this value, the resultant change was -0.17° which is similar to the value Behrents and Sinclair found for normal dentofacial maturation.

Of more interest was that of overbite and overjet changes. The mean average at pretreatment for overbite was 3.79 mm. Treatment reduced the mean by -.66 mm. However posttreatment showed a continued increase in overbite of 1.39 mm, which was a significant change. In fact, overbite increased in essentially all cases posttreatment; the average increase being 1.39 mm. Overjet showed significant changes both during and following treatment, with an average decrease of -4.81 mm from the pretreatment mean of 7.75 mm. The posttreatment period resulted in a significant average increase of 0.55 mm that resulted in an overall significant reduction in overjet of -3.22 mm. These findings were similar to those of reported by others[41,44,45] and has been attributed to overbite relapse and the associated return of the occlusal plane angle towards pretreatment values.[49]

In considering individual tooth movement it was found that space closure during treatment in the upper arch resulted in almost equal reciprocal movement of the incisors and molars; with the incisors moving posteriorly an average of 4.23 mm and the molars moving anteriorly 3.44

mm. The maxillary incisor movement was characterized on average to result in more posterior movement of the crown than the root apex (75% of the cases). This resulted in a lingual tipping of the incisor to the palatal plane an average of -5.83°. The movement of the maxillary molar was just the opposite showing anterior tipping of 6.51°.

Posttreatment movement showed a continued almost bodily movement of the maxillary incisors posteriorly (82%). This significant change is contrary to the previous findings of Litowitz[7], Cole[8], and Van Dyke[20] who found the majority of maxillary incisors to move anteriorly posttreatment. Movement of the maxillary first molars posttreatment demonstrated a continued tipping in the anterior direction as a result of the root apices moving posteriorly (73%).

Space closure in the lower arch resulted from the anterior movement of the lower first molars four times as much as the lower incisors moved posteriorly. The resultant overall retraction of the lower incisors of -1.30 mm was similar to that reported by Van Dyke[20]. This lower incisor retraction resulted in a significant posterior movement of the crowns, but a slight forward movement of the apex. Anterior movement of the lower first molars was characterized by more anterior movement of the apex then the crown resulting in a significant posterior tipping of 3.14° on average (83% of the cases).

During the posttreatment period, the lower incisor crowns and roots continued to move posteriorly a small but insignificant amount (64%). The lower first molars however continued to move anteriorly with the root apex moving forward almost twice the amount of the crown.

Aside from the significant anterior tipping, the maxillary molars seemed to show the least posttreatment movement of all the teeth investigated. It is interesting to note that the correction of the Class II molar relationships during treatment in this sample appears not to be due to a greater anterior movement of the lower first molar crown, since it move on average only ½ mm more than the maxillary molars. It must be assumed that much of the anteroposterior correction resulted from the restraint of maxillary growth while mandibular growth was allowed to continue; as was indicated previously while discussing the changes in SNA and SNB. However, during the posttreatment period, the mandibular molar continued to move anteriorly while the maxillary molar remained relatively stationary. This tends to support Bjork's[16] contention that the intercuspation of teeth plays a significant role in the dental compensation that occurs in response to skeletal changes; in order to maintain the integrity of the occlusion.

Examination of the vertical movements of the teeth revealed that the maxillary incisors were extruded on average a significant 1.73 mm and the maxillary molars a significant 2.01 mm. Since the posttreatment change of 0.29 mm and 0.57 mm for the incisors and molars was much smaller and encompassed a much longer time period, it can be concluded that both the molars and incisors were extruded as a result of treatment. The lower incisors were actually intruded an average of 0.83 mm during treatment while the mandibular molars only moved occlusally 0.55 mm.

The discrepancy between the extrusion of the upper incisors and the intrusion of the lower incisors seems to indicate that much of the

overbite reduction during treatment was the result of "opening the bite" by rotation of the mandible clockwise. This finding further adds credibility to the implant line changes as compared to the FMPA and SN-GoGn changes. Backward rotation of the mandible on average would also explain the observed posterior tipping of the lower molars.[16] Rotation of the maxilla during treatment was a mean 0.86° forward. This is similar to the forward rotation of the maxilla of 1.1° reported by Baumrind[18]. Rotation of both the jaws in an opposite direction concurrently with the intrusion of the lower incisors could explain the resulting overbite decrease.

During the posttreatment period the lower incisors (82%) demonstrated a significant reversal and erupted an average of 1.20 mm. Conversely the mandibular molars demonstrated on average an intrusion of 0.20 mm.

The mean changes observed in the lower dentition, the continued upward and backward movement of the incisors and the intrusion and backward tipping of the molars, parallel those observations by Bjork for clockwise rotation of the mandible. Previous reports by Bjork[16], Lee[27], and Isaacson[26] have indicated that mandibular rotation occurs much more often in the forward direction. This was not the case in this sample. 66% of the cases demonstrated backward rotation during treatment and 50% following treatment. Because of the small sample size this discrepancy may be due to the chance selection of an atypical sample.

DIFFERENCES BETWEEN SUPERIMPOSITIONS

Of much greater consequence, and more appropriate for the sample size are the differences observed in perceived landmark displacement as a function of superimpositional method. The results listed in Table V were obtained by subtracting the landmark displacement values found by superimposition on implants from those obtained by superimposition on anatomic best fit. Figures 4 through 7, C graphically illustrate the individual differences found for two representative landmarks in the maxilla and mandible during the posttreatment time interval. The asterisks indicate the mean difference.

Overall, the impression gained from the data was that there was a significant difference in the perceived displacements of landmarks when comparing the two superimpositional techniques. In both the maxilla and mandible, the perceived displacements of landmarks using the anatomic best fit superimposition was often found to be the opposite of that found by implant superimposition. For example, the movement of the upper incisal edge during the posttreatment period was found to be 0.64 mm anteriorly, based on anatomical superimposition in contrast to a 1.01 mm posterior movement based on implant superimposition. This was found for all landmarks in the maxilla during the posttreatment period for anteroposterior movement. The discrepancy in landmark displacement for vertical movement was limited to an underestimation of the downward displacement of landmarks. The underestimation of downward and backward displacement of landmarks between the two superimpositional methods in the maxilla for the overall time period of 18.87 years was 1.77 mm in

the anteroposterior direction and 1.02 mm in the vertical direction. Similar discrepancies in landmark displacement between the two superimpositional methods were also found for the mandible. Here however, the anatomical best fit method was found to understate the upward and backward displacement of landmarks. The magnitude of the understatement was less in the mandible and was a mean of 0.81 mm in the anteroposterior direction and 0.60 mm in the vertical direction. This also encompassed the overall time period of 18.87 years. The perceived direction of change based on anatomic superimposition was also found to be inaccurate for many of the variables in the mandible. However they were much more unpredictable and occurred in both the anteroposterior and vertical directions. On further examination of the results, this discrepancy in direction occurs when the landmarks are displaced a greater distance than the difference between the two superimpositional techniques (i.e. 0.81 mm in the anteroposterior direction).

As Baumrind noted in his study, individual variation in the displacement of landmarks was generally smaller for the anatomic superimpositions than was found for the implant superimpositions (figures 4-7, A and B). However the relative magnitude of this difference was again smaller in this study due to the smaller amount of growth that took place during the period studied for this sample.

A significant difference between the two methods was found in only 58% of the variables, as compared to Baumrind's study[19] which found all the differences to be significantly different. Failure to show all the differences to be significant does not necessarily mean that no real

differences exist. The small sample size and superimpositional error previously discussed were both factors that contributed to this failure.

Generally the findings found for the maxilla in this study agree qualitatively with those found by Baumrind[19]. In that study he found the discrepancies to be greater in magnitude, and greater in the vertical direction (2.5 mm) than in the anteroposterior direction (1.4 mm) as compared to this study. His study however observed cases that were in an active period of growth, 8.5 to 15.5 years, where as in this study the period of observation was from and average age of 13 years to 32 years of age. The reduction in growth during this later age range would account for the discrepancies in magnitude found between the two studies. Further, the magnitude of growth in the anteroposterior and vertical directions may be different for the two age ranges. The data from this study for the period of observation tend to indicate that dentoalveolar changes occur greater in magnitude in the anteroposterior direction than in the vertical direction.

There are many possible clinical implications that arise when considering the discrepancies between the two superimpositional techniques. It is evident that conclusions based on the different superimpositional methods can be entirely different. The discrepancies that occur become progressively larger as the time period between film comparisons increase or as the amount of growth between the film comparisons increases. Such inaccuracies make it difficult if not impossible to extract detailed information on treatment and posttreatment changes as well as growth and development in general.

Clearly there is a need to improve the present methods of evaluation of cephalometric radiographs.

SUMMARY

On the basis of cephalometric records taken before treatment, after treatment, and a minimum of ten years posttreatment, on a sample of fifteen females with Angle Class II malocclusions, the following conclusions were reached:

1. Correction of the anteroposterior discrepancy during treatment was mainly due to a reduction in the protrusion of the maxilla relative to the cranial base and mandible.

2. Individual variation best described postretention changes in both skeletal and dental parameters.

3. Overbite increased in all cases posttreatment.

4. Based on superimposition on implants, there was no strong evidence to suggest that teeth tend to move towards their pretreatment angulation or crown positions. In fact, both the maxillary and mandibular incisor crowns tended to continue moving in a posterior direction posttreatment.

5. There are definite real differences in the perceived movement of cephalometric landmarks between anatomical best fit superimpositions and implant superimpositions.

6. In the maxilla, the anatomical best fit method of superimposition generally understates the downward and backward displacement of landmarks an average of 1.77 mm in the anteroposterior

direction and 1.02 mm in the vertical direction over an average of 18.87 years beginning at the average age of 12.97 years.

7. In the mandible, the anatomic best fit method of superimposition generally understates the upward and backward displacement of landmarks an average of 0.81 mm in the anteroposterior direction and 0.60 mm in the vertical direction.

8. The use of anatomical best fit superimposition can lead to false conclusions when determining the direction and magnitude of landmark displacements.

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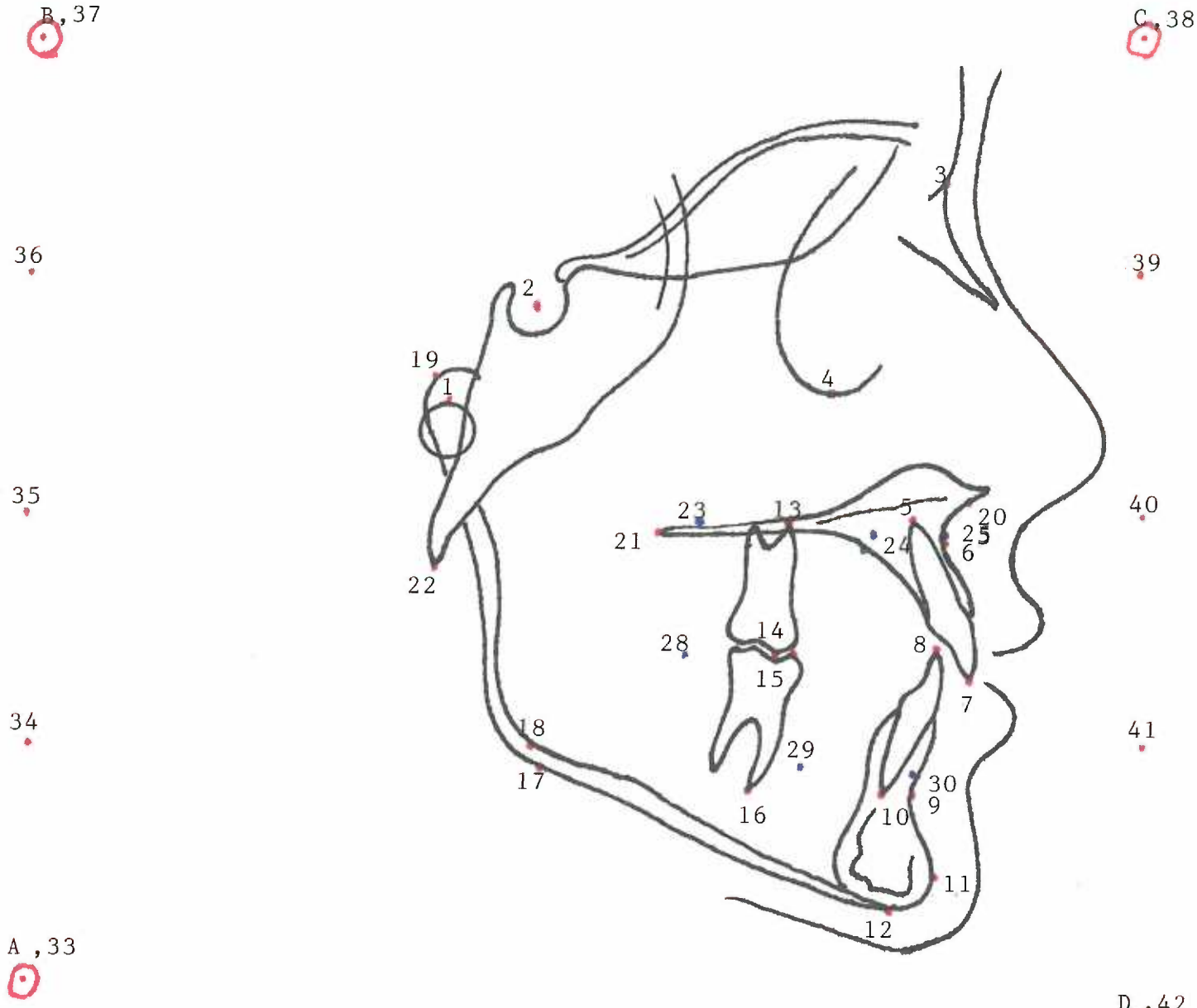
FIGURE I. Fiducial, landmark, and superimpositon points digitized



A - A FIDUCIAL
B - B FIDUCIAL
C - C FIDUCIAL
D - D FIDUCIAL
1 - PORION
2 - SELLA
3 - NASION
4 - ORBITALE
5 - UPPER INCISOR APEX
6 - POINT A
7 - UPPER INCISOR EDGE
8 - LOWER INCISOR EDGE
9 - POINT B
10 - LOWER INCISOR APEX
11 - POGONION
12 - MENTON
13 - UPPER 1ST MOLAR APEX
14 - UPPER 1ST MOLAR CUSP
15 - LOWER 1ST MOLAR CUSP
16 - LOWER 1ST MOLAR APEX
17 - LOWER GONION
18 - UPPER GONION
19 - CONDYLE
20 - ANS (HARVOLD)
21 - PNS
22 - BASION
23 - UPPER IMPLANT 1 (rearmost)
24 - UPPER IMPLANT 2
25 - UPPER IMPLANT 3
26 - UPPER IMPLANT 4
27 - UPPER IMPLANT 5
28 - LOWER IMPLANT 1 (rearmost)
28 - LOWER IMPLANT 2
30 - LOWER IMPLANT 3
31 - LOWER IMPLANT 4
32 - LOWER IMPLANT 5
33 - LEFT MANDIBULAR IMPLANT SUPERIMP
34 - LEFT MANDIBULAR ANATOMIC SUPERIMP
35 - LEFT MAXILLARY ANATOMIC SUPERIMP
36 - LEFT ACB ANATOMIC SUPERIMP
37 - LEFT MAXILLARY IMPLANT SUPERIMP
38 - RIGHT MAXILLARY IMPLANT SUPERIMP
39 - RIGHT ACB ANATOMIC SUPERIMP
40 - RIGHT MAXILLARY ANATOMIC SUPERIMP
41 - RIGHT MANDIBULAR ANATOMIC SUPERIMPOSITION
42 - RIGHT MANDIBULAR IMPLANT SUPERIMP

FIGURE 2

SKELETAL CHANGES

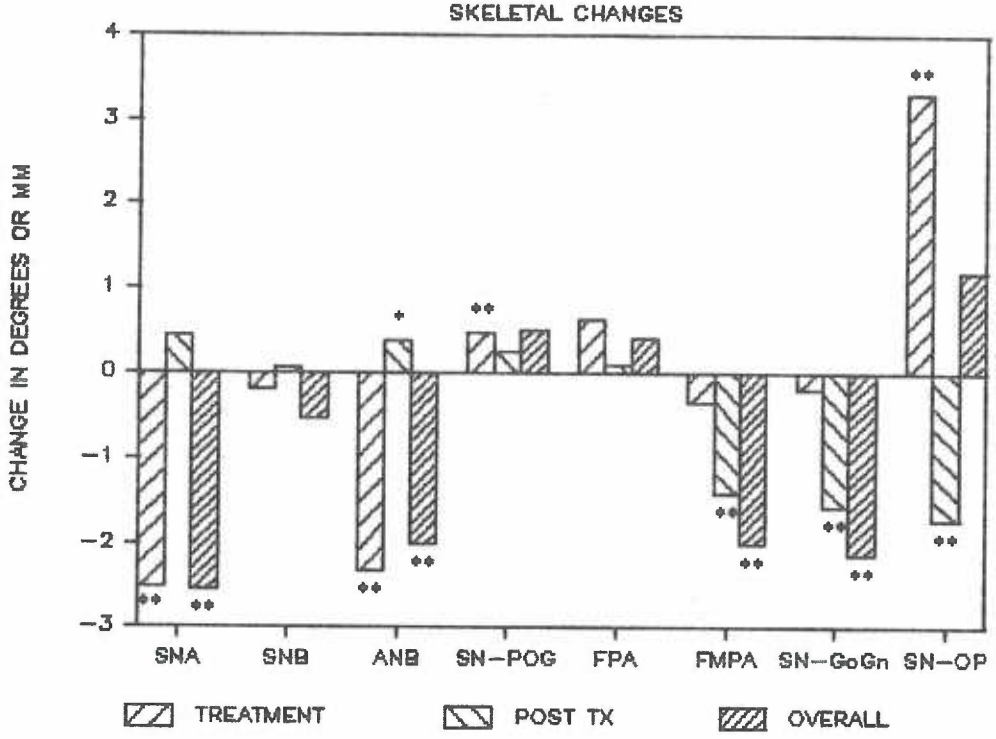


FIGURE 3

DENTAL CHANGES

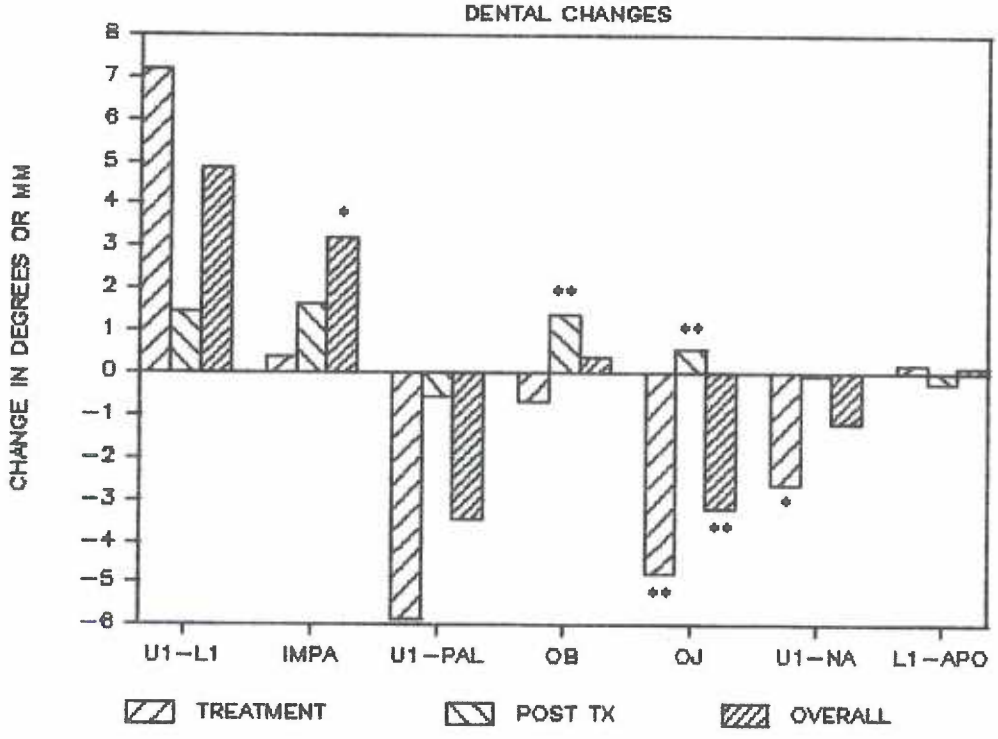


FIGURE 4A

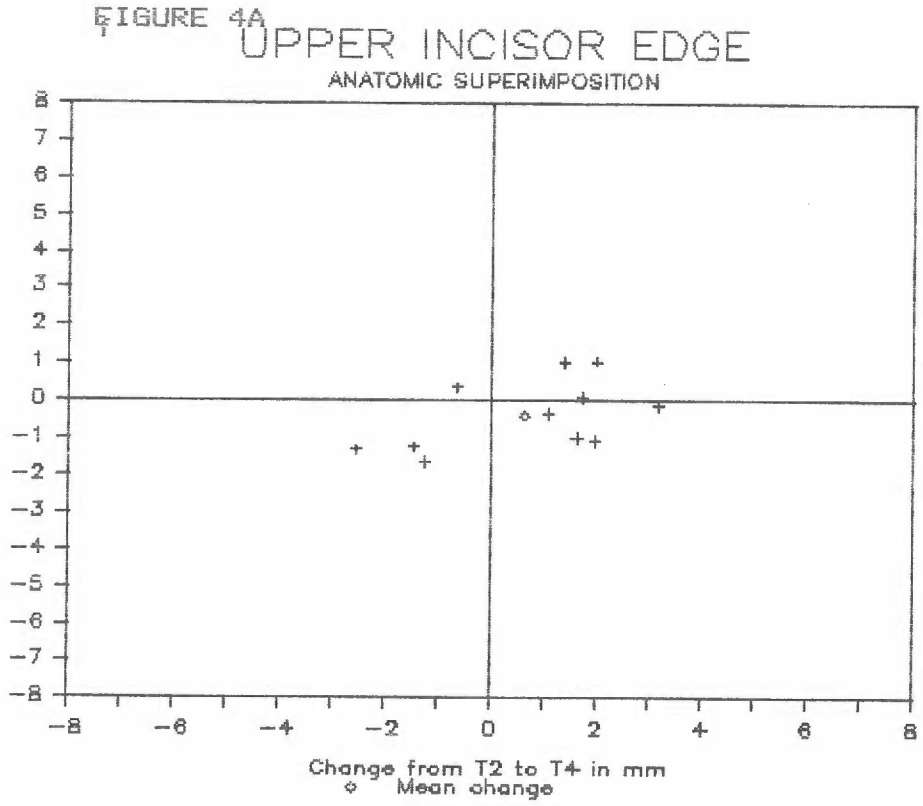


FIGURE 5A

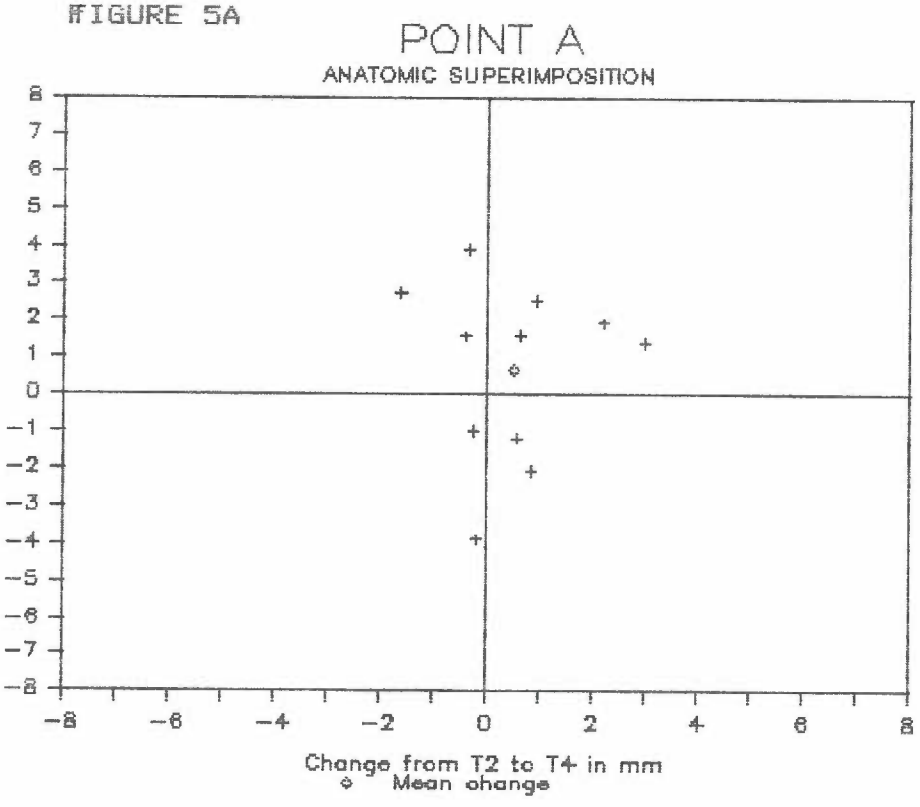


FIGURE 6A

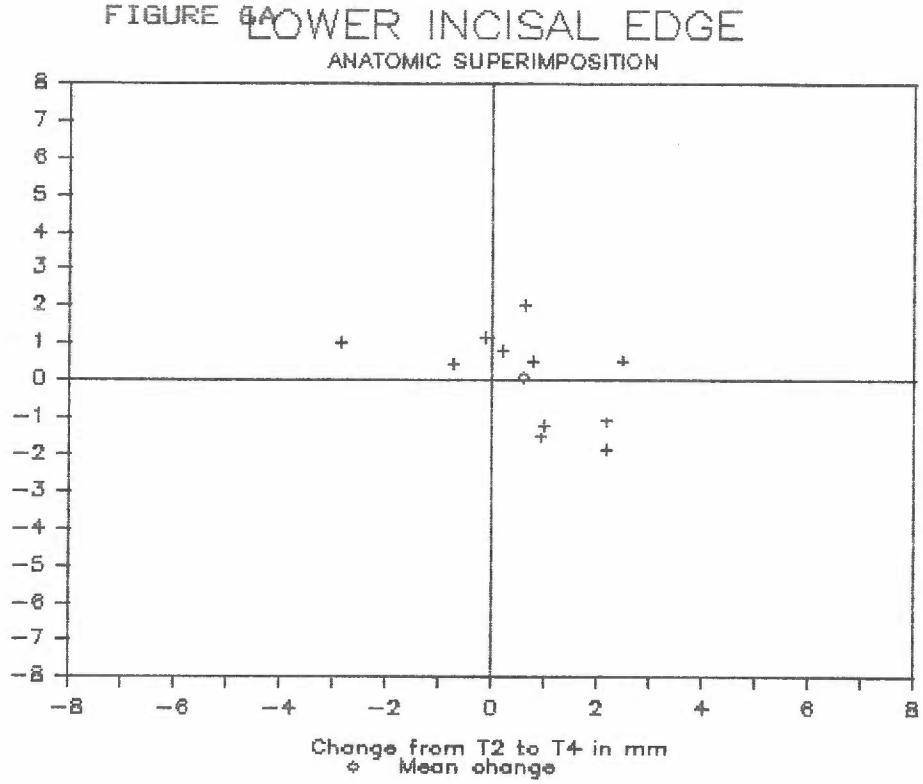


FIGURE 7A

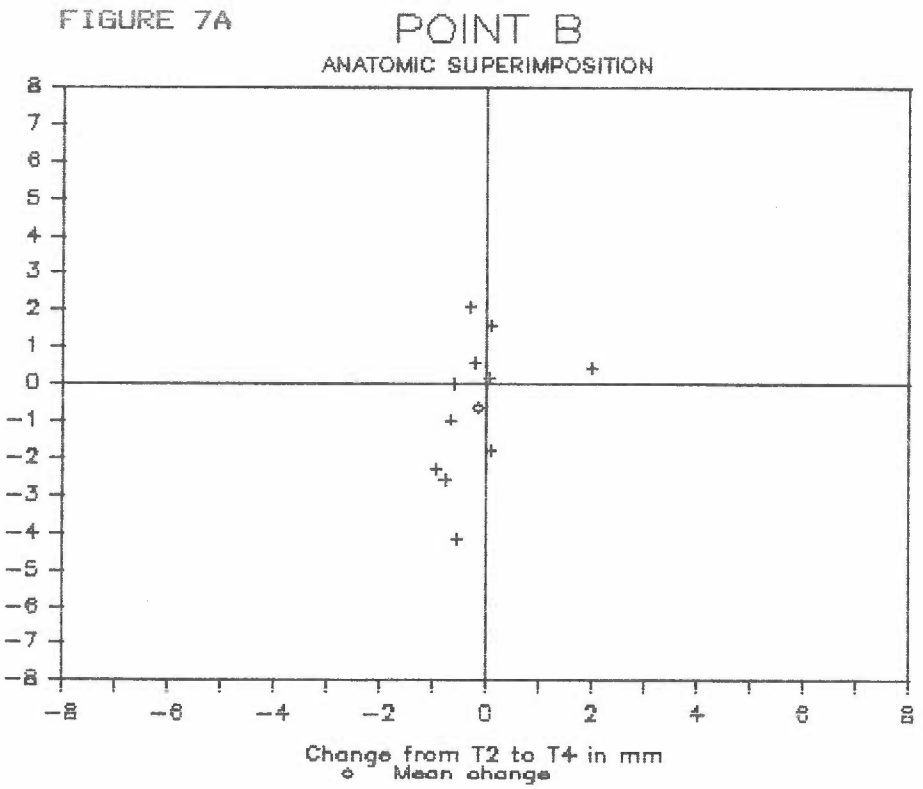


FIGURE 4B

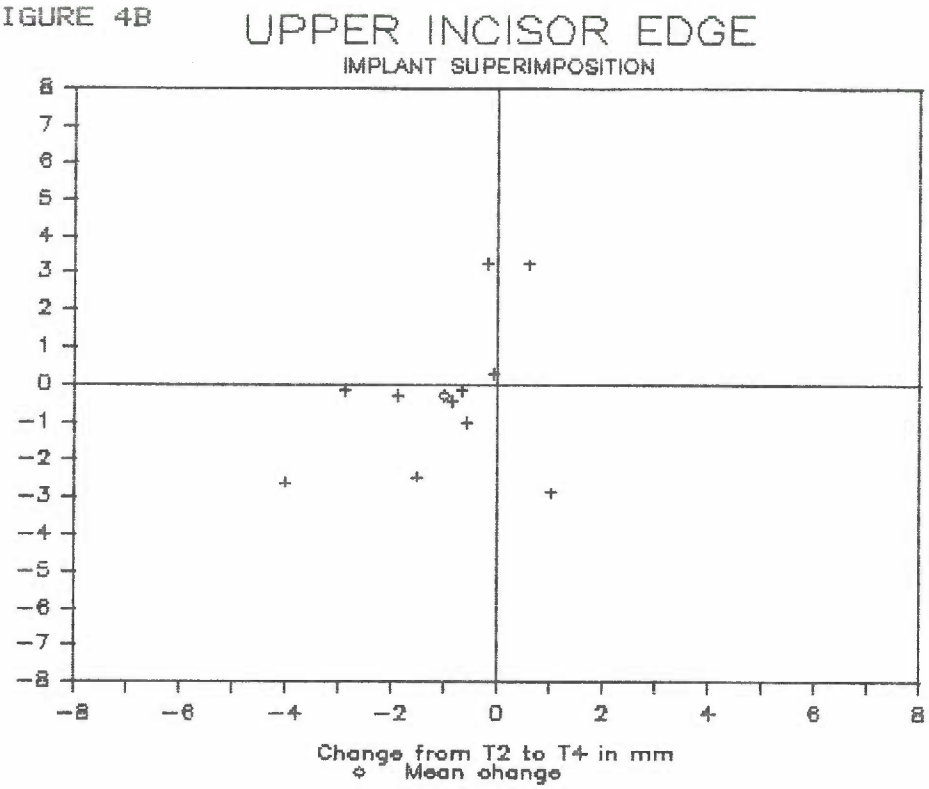


FIGURE 5B

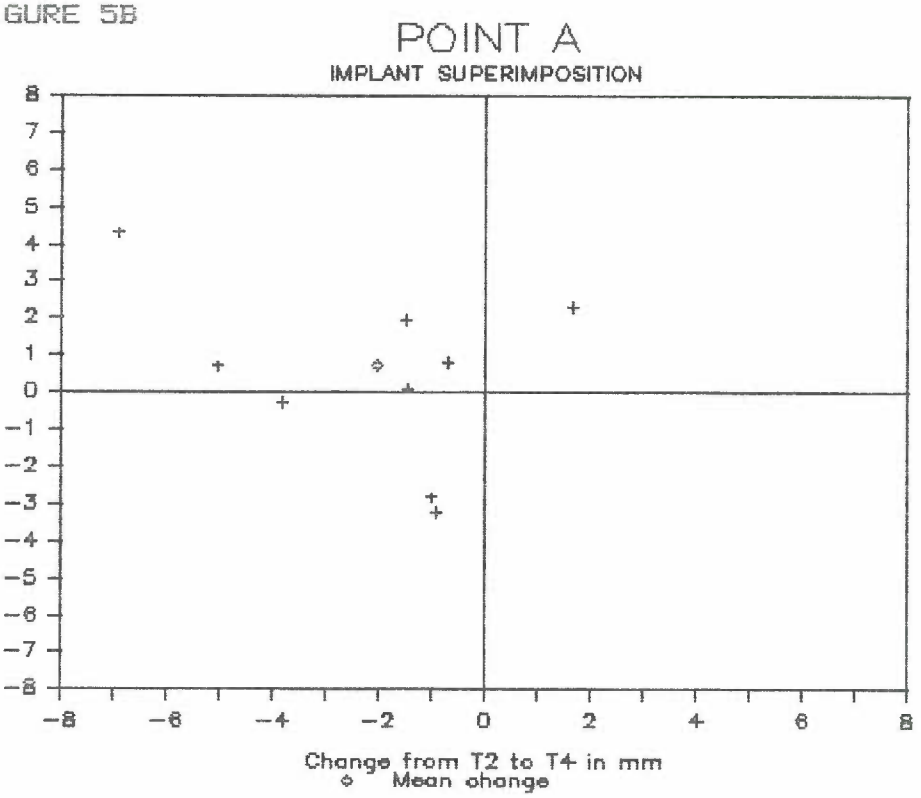


FIGURE 6B

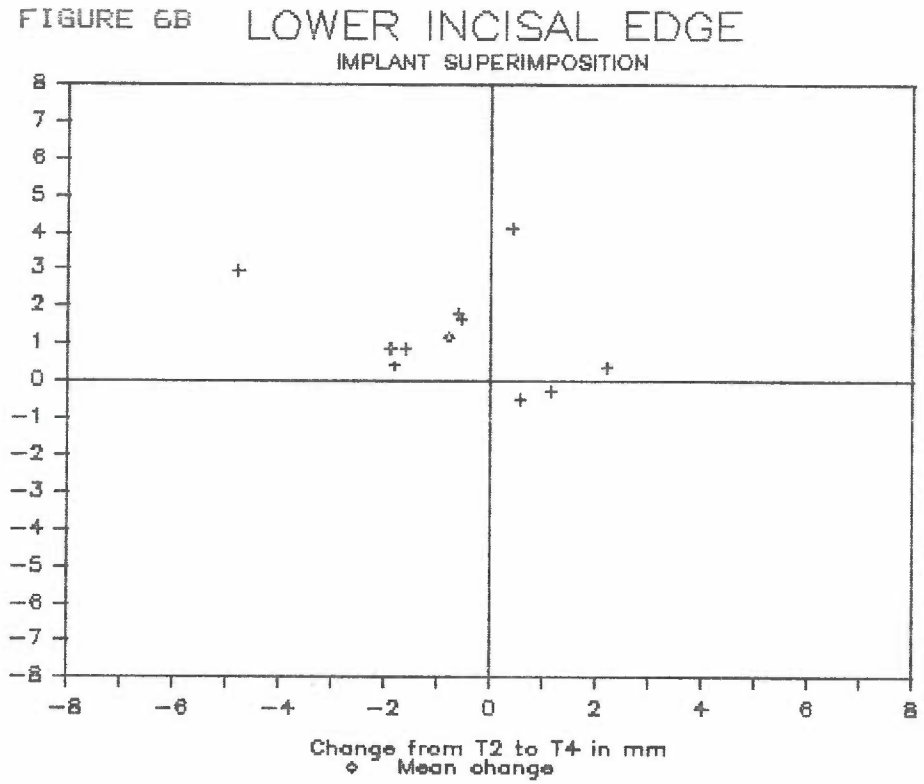


FIGURE 7B

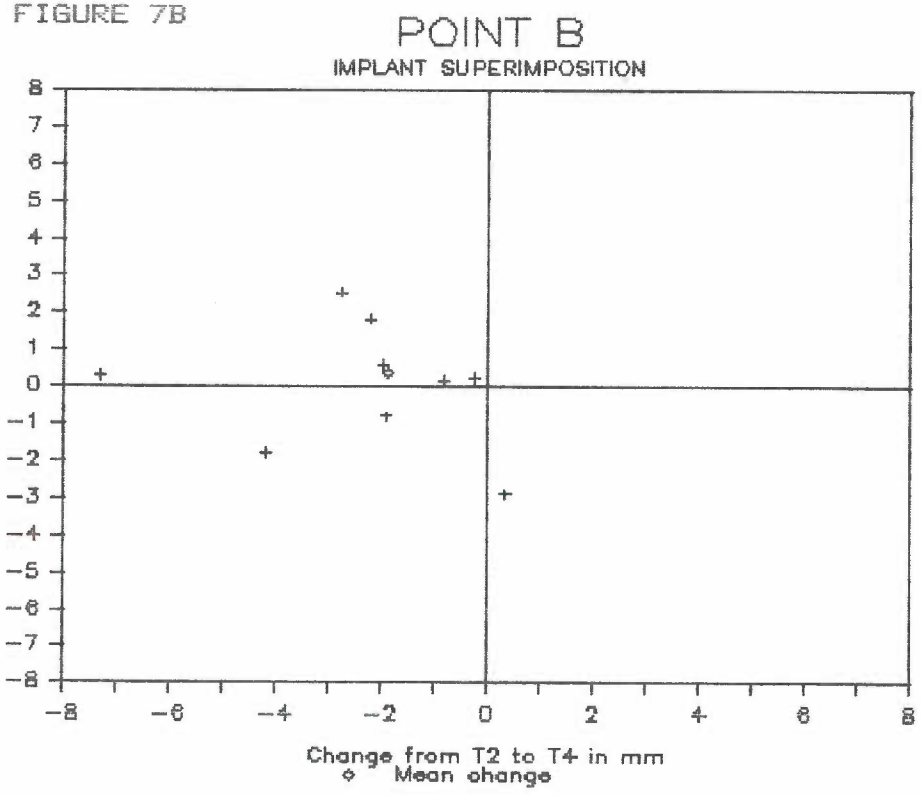


FIGURE 4C

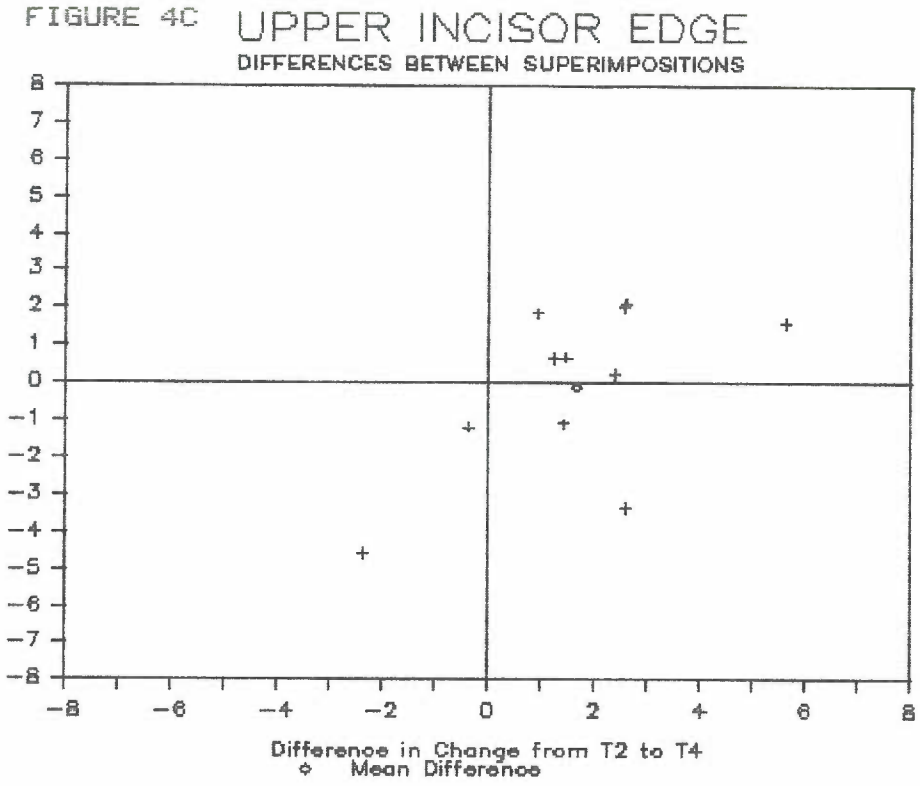


FIGURE 5C

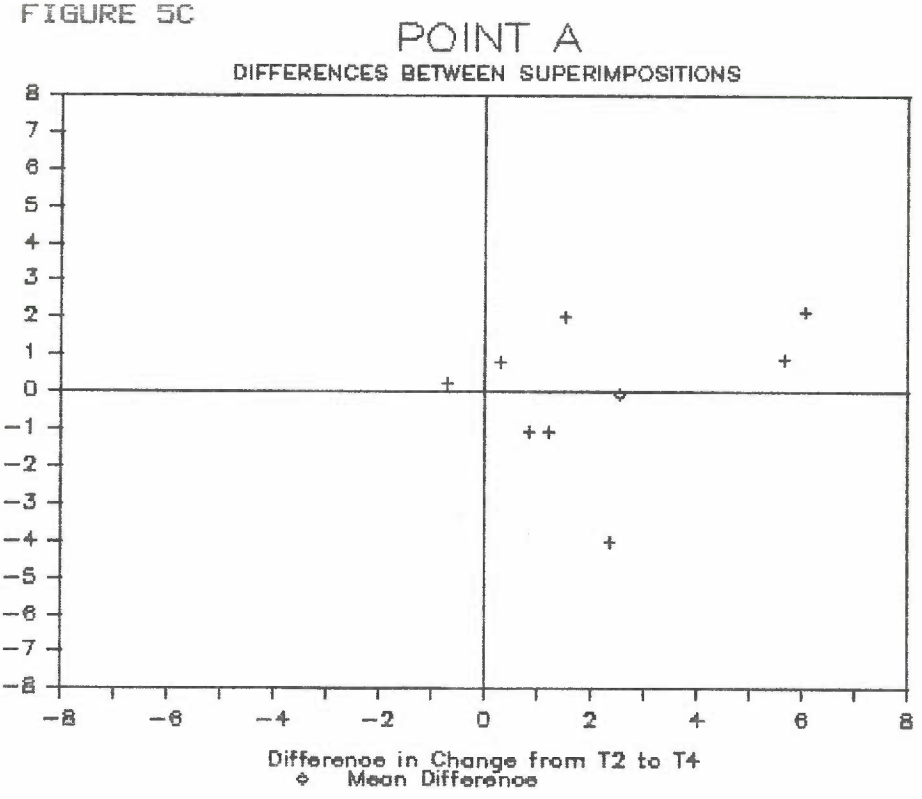


FIGURE 6C

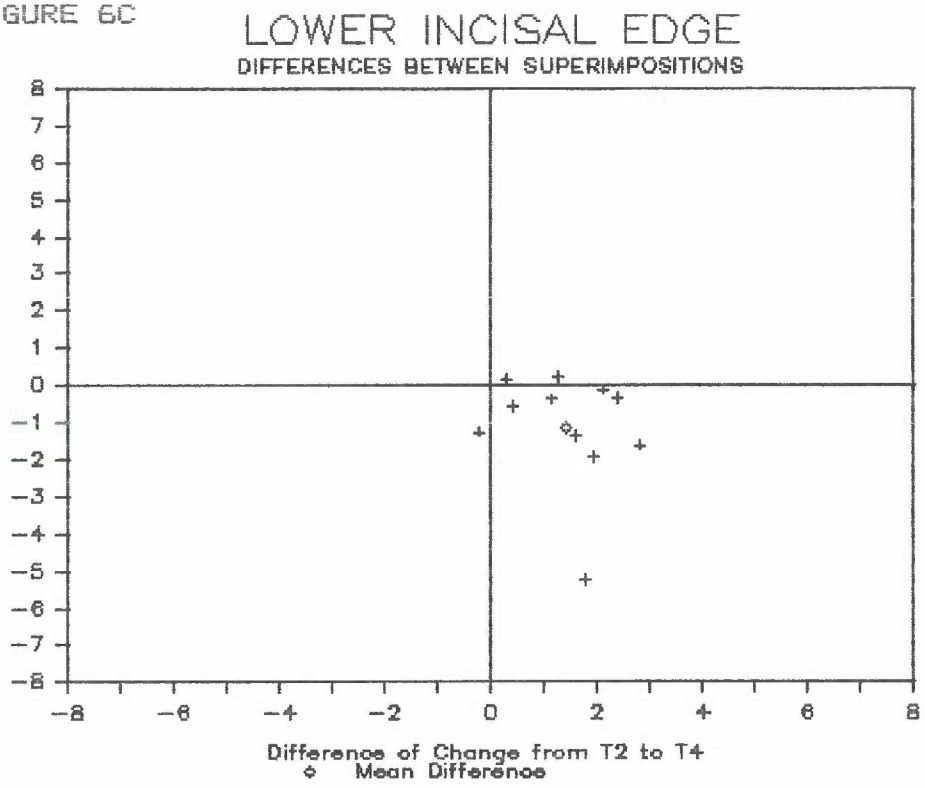


FIGURE 7C

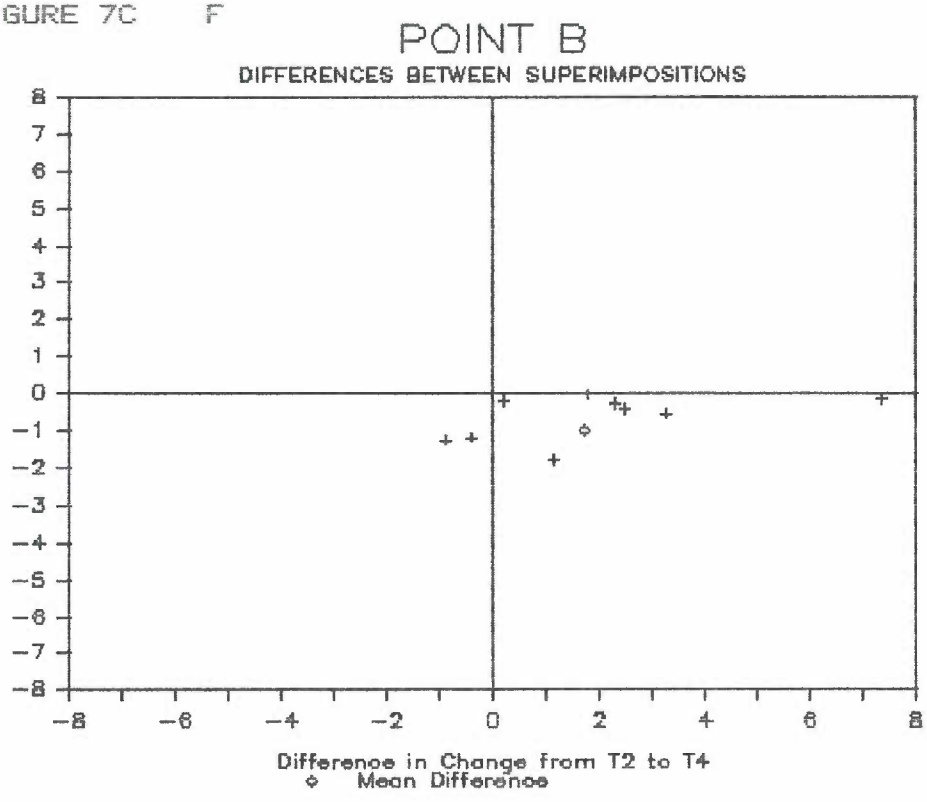


TABLE I A. SAMPLE DEMOGRAPHICS

	NAME Last	First	CASE #	BIRTH DATE	IMPLANT DATE	DEBAND DATE	RETENTION REMOVED	Begining T_1	End of Tx T_2	End of Ret. T_3	Recall D. T_4
‡	1. Baker	Mary Ann	284	25-Mar-56	24-Nov-69	07-Jun-71	---------	02-Dec-69	09-Jun-71	---------	04-Dec-86
	2. Boyd	Bernadette	292	09-Oct-58	20-Feb-70	31-May-74	25-Jul-75	20-Feb-70	---------	---------	14-Nov-86
	3. Brown	Janet	134	19-Sep-55	23-Oct-67	11-May-70	27-Feb-75	23-Oct-67	03-Aug-72	12-Mar-75	02-Apr-87
	4. Cummings	Barbara	008	31-Dec-49	10-Nov-65	07-May-68	12-May-70	24-Jan-66	14-May-68	---------	26-Feb-87
	5. Dawell	Adrienne	122	06-Mar-53	19-Oct-67	30-May-70	04-Oct-74	30-Nov-67	17-Dec-70	---------	03-Apr-87
	6. Day	Dusti	010	25-Aug-48	02-May-66	07-May-68	28-Sep-70	02-May-66	---------	28-Sep-70	27-Feb-87
	7. Hughes	Karen	111	04-Feb-56	12-Oct-67	05-Nov-69	08-Apr-76	12-Oct-67	11-Mar-71	---------	19-Mar-87
	8. Morton	Carol	231	21-Oct-59	31-Mar-69	25-Mar-74	---------	31-Mar-69	---------	---------	04-Nov-86
‡‡	9. Osterhaudt	Sharon	287	30-Nov-58	18-Feb-70	19-Mar-73	27-Apr-77	18-Feb-70	02-Jul-73	---------	24-Nov-86
	10. Pankonin	Marilyn	196	18-Mar-54	12-Nov-68	11-May-70	30-Nov-70	12-Nov-68	27-May-70	---------	23-Dec-86
	11. Riley	Jill	120	29-May-57	19-Oct-67	23-Apr-70	17-Oct-74	01-Nov-67	07-May-70	17-Oct-74	10-Dec-86
	12. Schiller	Cathy	070	10-Feb-56	10-Nov-66	28-Jun-72	19-Jul-74	10-Nov-66	03-Aug-72	05-Apr-76	08-Dec-86
	13. Scott	Elyse	286	25-Nov-58	09-Dec-69	16-Feb-72	12-Aug-75	13-Jan-70	15-Mar-72	04-Sep-75	11-Nov-86
	14. Stark	Lori	015	19-Oct-53	03-Nov-65	05-Dec-67	17-Sep-69	03-Nov-65	23-Jan-68	---------	02-Apr-87
	15. Williams	Anita	136	25-Apr-50	24-Oct-67	19-Jul-71	06-Jun-72	24-Oct-67	10-Feb-72	18-Apr-74	02-Dec-86
		N = 15		15	15	15	13	15	12	6	15

‡ Surgery Case - Patient underwent mandibular advancement and anterior maxillary setback 11-18-71
‡‡ Surgery Case - Patient underwent genioplasty

TABLE I B. SUMMARY OF SAMPLE DEMOGRAPHICS
At each time point and for each between timepoint interval

	TEETH REM.	ACT TX TIME	RET TIME	TIME NO APPL.	POST RET TIME	DEBAND AGE	AGE @ T_1	AGE @ T_2	AGE @ T_3	AGE @ T_4	PERIOD T_1-T_2	PERIOD T_1-T_4	PERIOD T_2-T_4
1.	4+5	1.51	0.00	15.50	15.50	15.21	13.70	15.22		30.72	1.52	17.02	15.50
2.	4+4	4.28	1.15	12.47	11.32	15.65	11.38			28.12		16.74	
3.	3+3	2.55	4.80	16.90	12.10	14.65	12.10	16.88	19.49	31.56	4.78	19.45	14.67
4.	3+3	2.28	2.01	18.82	16.81	18.36	16.08	18.38		37.18	2.30	21.10	18.80
5.	3+3	2.50	4.35	16.85	12.50	17.24	14.75	17.79		34.10	3.05	19.35	16.30
6.	3+3	2.02	2.39	18.82	16.43	19.71	17.70		22.11	38.53		20.84	
7.	8+8	2.07	6.43	17.38	10.95	13.76	11.69	15.11		31.14	3.41	19.45	16.03
8.	+	4.99	0.00	12.62	12.62	14.44	9.45			27.06		17.61	
9.	+5	3.08	4.11	13.69	9.58	14.31	11.23	14.60		28.00	3.37	16.78	13.41
10.	2+2	1.49	0.56	16.63	16.07	16.16	14.67	16.20		32.79	1.54	18.12	16.59
11.	4+4	2.48	4.49	16.64	12.16	12.91	10.43	12.95	17.40	29.55	2.52	19.12	16.61
12.	4+4	5.64	2.06	14.45	12.40	16.39	10.76	16.49	20.16	30.85	5.73	20.09	14.36
13.	3+3	2.09	3.49	14.75	11.26	13.24	11.14	13.31	16.79	27.98	2.17	16.84	14.67
14.	3+3	2.09	1.79	19.34	17.55	14.14	12.05	14.27		33.47	2.22	21.42	19.20
15.	5+10	3.74	0.88	15.38	14.50	21.25	17.51	21.81	24.00	36.63	4.30	19.12	14.82
	N	15	15	15	15	15	15	12	6	15	12	15	12
	MEAN	2.85	2.57	16.02	13.45	15.83	12.97	16.08	19.99	31.85	3.08	18.87	15.91
	STD DEV	1.25	1.95	2.16	2.48	2.42	2.61	2.46	2.75	3.58	1.31	1.62	1.74
	MIN	1.49	0.00	12.47	9.58	12.91	9.45	12.95	16.79	27.06	1.52	16.74	13.41
	MAX	5.64	6.43	19.34	17.55	21.25	17.70	21.81	24.00	38.53	5.73	21.42	19.20

TABLE II. Summary of means and standard deviations of angular and linear variables at pretreatment (T_1), posttreatment (T_2), and postretention (T_4).

VARIABLE	PRETREATMENT T_1	END OF TREATMENT T_2	POSTRETENTION T_4	TREATMENT $T_1 - T_2$	OVERALL $T_1 - T_4$	POSTTREATMENT $T_2 - T_4$
	N = 15	N = 12	N = 14	N = 12	N = 14	N = 11
SNA	81.34 ± 4.55	78.47 ± 4.43	78.61 ± 4.64	-2.50 ± 1.76**	-2.54 ± 2.01**	0.45 ± 1.06
SNB	75.22 ± 4.22	74.38 ± 3.93	74.73 ± 4.64	-0.18 ± 0.86	-0.53 ± 1.45	0.05 ± 0.94
ANB	6.12 ± 3.05	4.09 ± 2.76	3.87 ± 2.59	-2.33 ± 1.40**	-2.02 ± 1.84**	0.39 ± 0.67*
SN-POG	76.09 ± 4.44	75.62 ± 4.13	76.59 ± 5.10	0.48 ± 0.75**	0.51 ± 1.57	0.25 ± 1.06
FPA	84.21 ± 2.82	84.39 ± 3.23	84.54 ± 3.87	0.62 ± 1.30	0.40 ± 1.89	0.09 ± 0.99
FMPA	26.77 ± 6.36	26.85 ± 7.79	24.73 ± 8.04	-0.34 ± 2.74	-2.03 ± 3.25**	-1.43 ± 1.32**
GG-SN	34.88 ± 7.74	35.63 ± 8.53	32.68 ± 8.82	-0.20 ± 2.33	-2.14 ± 3.07**	-1.58 ± 2.08**
SN-OP	16.82 ± 5.17	20.49 ± 6.34	18.24 ± 5.59	3.29 ± 3.23**	1.18 ± 2.86	-1.74 ± 2.73**
1-1	132.68 ± 18.94	134.89 ± 7.62	138.22 ± 11.54	7.19 ± 15.53	4.87 ± 6.31	1.46 ± 6.92
OVERBITE	3.79 ± 3.07	3.06 ± 1.80	4.02 ± 1.24	-0.66 ± 3.23	0.36 ± 2.75	1.39 ± 1.20**
OVERJET	7.75 ± 3.77	3.15 ± 0.81	4.01 ± 1.82	-4.81 ± 3.59**	-3.22 ± 3.09**	0.55 ± 0.72**
1-NA mm	3.59 ± 4.34	1.77 ± 2.27	2.10 ± 2.82	-2.61 ± 4.85*	-1.21 ± 5.08	-0.04 ± 1.90
1-APO mm	-0.14 ± 3.62	1.08 ± 3.13	0.09 ± 3.83	0.18 ± 1.69	0.15 ± 2.39	-0.26 ± 1.66
IMPA	93.69 ± 8.06	97.07 ± 7.59	98.90 ± 10.88	0.40 ± 4.60	3.20 ± 6.00*	1.65 ± 5.13
1-Pal	108.98 ± 11.94	104.88 ± 5.88	105.35 ± 5.40	-5.83 ± 14.47	-3.44 ± 11.77	-0.53 ± 6.13

Asterisks = Significant differences in Student t tests
* = $p < 0.05$
** = $p < 0.01$

TABLE III. Summary of means and standard deviations of cumulative displacements in mm or axial changes in degrees.

Relative to superimposition on anatomical "best fit"

VARIABLE		TREATMENT T_1-T_2	OVERALL T_1-T_4	POSTTREATMENT T_2-T_4
		N = 12	N = 14	N = 11
$\underline{1}$ EDGE	X	-3.94 ± 3.39 **	-2.14 ± 4.04 *	0.64 ± 1.81
	Y	-1.09 ± 2.58	-1.22 ± 2.40 *	-0.38 ± 0.93
$\underline{1}$ APEX	X	-1.63 ± 3.71	-0.65 ± 3.02	1.27 ± 1.55 **
	Y	-0.09 ± 2.76	-0.68 ± 2.81	-0.38 ± 1.38
$\underline{6}$ CUSP	X	3.69 ± 2.15 **	4.83 ± 3.05 **	1.23 ± 2.23 *
	Y	-1.60 ± 1.82 **	-2.09 ± 1.95 **	-0.25 ± 1.38
$\underline{6}$ APEX	X	1.12 ± 1.99 *	0.97 ± 1.95 *	0.37 ± 1.87
	Y	-1.61 ± 2.00 **	-2.35 ± 2.59 **	-0.77 ± 1.98
POINT A	X	-1.00 ± 2.12	-0.65 ± 1.66	0.49 ± 1.29
	Y	-1.51 ± 3.79	-0.68 ± 3.09	0.68 ± 2.37
$\underline{1}$ - PAL PLANE		-5.37 ± 14.48	-3.46 ± 12.83	-1.35 ± 3.56
$\underline{6}$ - PAL PLANE		6.97 ± 6.47 **	10.57 ± 7.34 **	2.37 ± 3.69
$\overline{1}$ EDGE	X	-1.39 ± 1.46 **	-0.33 ± 2.31	0.60 ± 1.52
	Y	-0.34 ± 2.10	-0.18 ± 1.99	0.07 ± 1.28
$\overline{1}$ APEX	X	-0.22 ± 1.81	-0.01 ± 1.81	0.41 ± 1.22
	Y	1.55 ± 1.86 **	2.45 ± 2.14 **	0.81 ± 1.69
$\overline{6}$ CUSP	X	3.50 ± 2.43 **	6.07 ± 2.36 **	2.19 ± 1.39 **
	Y	0.93 ± 1.16 **	0.35 ± 1.96	-0.95 ± 1.71 *
$\overline{6}$ APEX	X	4.84 ± 2.71 **	7.28 ± 2.61 **	2.52 ± 2.34 **
	Y	0.59 ± 1.38	0.48 ± 2.29	-0.08 ± 1.70
POINT B	X	-0.61 ± 1.06 *	-0.89 ± 1.47 *	-0.17 ± 0.80
	Y	1.59 ± 1.72 **	1.17 ± 1.76 *	-0.63 ± 1.91
$\overline{1}$ - FRANKFORT		0.40 ± 4.60	3.20 ± 6.00 *	1.65 ± 5.13
$\overline{6}$ - FRANKFORT		3.47 ± 3.46 **	2.47 ± 5.06 *	-0.39 ± 5.09

Asterisks = Significant differences in Student t tests
* = $p < 0.05$
** = $p < 0.01$

TABLE IV. Summary of means and standard deviations of cumulative displacements in mm or axial changes in degrees.

Relative to superimposition on implants

VARIABLE		TREATMENT T_1-T_2	OVERALL T_1-T_4	POSTTREATMENT T_2-T_4
		N = 12	N = 14	N = 11
$\underline{1}$ EDGE	X	-4.23 ± 3.86 **	-3.88 ± 3.92 **	-1.01 ± 1.49 *
	Y	-1.73 ± 3.01 *	-2.23 ± 3.28 **	-0.29 ± 2.07
$\underline{1}$ APEX	X	-1.71 ± 2.96 *	-2.48 ± 2.65 **	-0.78 ± 1.86
	Y	-0.65 ± 3.13	-1.67 ± 3.37 *	-0.38 ± 1.91
$\underline{6}$ CUSP	X	3.44 ± 2.78 **	3.12 ± 3.62 **	-0.45 ± 1.66
	Y	-2.01 ± 2.34 **	-3.14 ± 2.86 **	-0.57 ± 2.11
$\underline{6}$ APEX	X	1.02 ± 1.30 **	-0.80 ± 2.34	-1.62 ± 2.36 *
	Y	-2.04 ± 2.48 **	-3.42 ± 3.09 **	-1.08 ± 2.30
POINT A	X	-0.59 ± 4.81	-2.44 ± 1.44 **	-2.05 ± 5.10
	Y	-2.11 ± 3.35 *	-1.67 ± 3.20 *	0.74 ± 2.24
$\underline{1}$ - PAL PLANE		-5.83 ± 14.47	-3.34 ± 11.77	-0.53 ± 6.13
$\underline{6}$ - PAL PLANE		6.51 ± 6.59 **	10.67 ± 8.55 **	3.18 ± 5.47 *
$\overline{1}$ EDGE	X	-0.96 ± 1.22 **	-1.30 ± 2.46 *	-0.81 ± 1.90
	Y	-0.83 ± 1.94	0.63 ± 1.86	1.20 ± 1.37 **
$\overline{1}$ APEX	X	0.12 ± 1.71	-0.68 ± 1.89	-0.69 ± 1.57
	Y	1.12 ± 1.76 *	3.10 ± 2.16 **	1.75 ± 1.79 **
$\overline{6}$ CUSP	X	3.94 ± 3.26 **	5.06 ± 3.41 **	0.75 ± 1.76
	Y	0.55 ± 1.18	0.83 ± 2.23	-0.20 ± 1.71
$\overline{6}$ APEX	X	5.16 ± 3.13 **	6.54 ± 3.46 **	1.37 ± 2.69
	Y	0.26 ± 1.58	0.85 ± 2.91	0.53 ± 1.85
POINT B	X	0.33 ± 6.45	-1.53 ± 1.92 **	-1.88 ± 5.57
	Y	1.12 ± 1.54 *	1.86 ± 1.96 **	0.37 ± 1.98
$\overline{1}$ - FRANKFORT		0.73 ± 4.81	2.44 ± 7.66	0.75 ± 6.14
$\overline{6}$ - FRANKFORT		3.14 ± 4.21 *	3.24 ± 7.76	0.51 ± 6.62

Asterisks = Significant differences in Student t tests
* = $p < 0.05$
** = $p < 0.01$

TABLE V. Summary of means and standard deviations of the differences between anatomical and implant superimpositions. (casewise)

VARIABLE		TREATMENT T_1-T_2	OVERALL T_1-T_4	POSTTREATMENT T_2-T_4
		N = 12	N = 14	N = 11
$\underline{1}$ EDGE	X	0.29 ± 1.72	1.74 ± 1.65 **	1.64 ± 2.00 **
	Y	0.65 ± 1.06 *	1.00 ± 2.29	-0.09 ± 2.25
$\underline{1}$ APEX	X	0.08 ± 1.66	1.82 ± 1.86 **	2.06 ± 1.74 **
	Y	0.56 ± 0.94 *	0.99 ± 1.91 *	0.01 ± 1.69
$\underline{6}$ CUSP	X	0.25 ± 1.70	1.71 ± 1.61 **	1.68 ± 1.82 **
	Y	0.41 ± 0.74 *	1.06 ± 1.46 **	0.32 ± 1.28
$\underline{6}$ APEX	X	0.10 ± 1.66	1.77 ± 1.89 **	1.99 ± 1.76 **
	Y	0.43 ± 0.73 *	1.07 ± 1.46 **	0.31 ± 1.26
POINT A	X	-0.42 ± 6.00	1.79 ± 1.80 **	2.54 ± 5.82
	Y	0.60 ± 1.02 *	0.98 ± 2.13	-0.06 ± 2.02
$\underline{1}$ - PAL PLANE		-0.46 ± 1.96	0.12 ± 4.28	0.82 ± 5.68
$\underline{6}$ - PAL PLANE		-0.45 ± 1.97	0.12 ± 4.28	0.82 ± 5.67
$\overline{1}$ EDGE	X	-0.43 ± 1.16	0.96 ± 1.58 *	1.41 ± 0.94 **
	Y	0.49 ± 0.60 **	-0.81 ± 1.43 *	-1.12 ± 1.54 *
$\overline{1}$ APEX	X	-0.34 ± 1.12	0.68 ± 1.83	1.10 ± 1.07 **
	Y	0.44 ± 0.55 **	-0.65 ± 0.92 **	-0.94 ± 0.91 **
$\overline{6}$ CUSP	X	-0.43 ± 1.17	1.01 ± 1.65 *	1.14 ± 1.01 **
	Y	0.38 ± 0.68 *	-0.47 ± 1.12	-0.75 ± 0.91 **
$\overline{6}$ APEX	X	-0.31 ± 1.12	0.75 ± 1.82	1.15 ± 1.04 **
	Y	0.33 ± 0.89	-0.37 ± 1.44	-0.61 ± 0.79 *
POINT B	X	-0.94 ± 6.46	0.65 ± 1.75	1.70 ± 5.94
	Y	0.47 ± 0.55 **	-0.69 ± 1.04 *	-1.00 ± 1.11 **
$\overline{1}$ - PAL PLANE		0.33 ± 2.03	-0.77 ± 4.07	-0.90 ± 2.74
$\overline{6}$ - PAL PLANE		0.33 ± 2.03	-0.77 ± 4.07	-0.90 ± 2.74

Asterisks = Significant differences in Student t tests
* = $p < 0.05$
** = $p < 0.01$

TABLE VII. DIFFERENCE IN IMPLANT LINE
(rotation in degrees)

	MAXILLA			MANDIBLE		
	T_1-T_2	T_1-T_4	T_2-T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	-1.84	-4.50	-2.66	-6.78	-3.80	2.98
2.		-1.05			-7.29	
3.	-0.82	0.26	1.08	4.13	7.14	3.01
4.	2.08	-9.60	-11.68	-1.08	-2.30	-1.22
5.	-1.21	1.34	2.55	2.85	2.91	0.06
6.		-2.07			2.92	
7.	0.26	1.08	0.82	-2.92	-4.43	-1.51
8.		-3.70			4.45	
9.	-0.44	-0.47	-0.03	1.47	-2.74	-4.21
10.	0.35	1.26	0.91	1.81	1.62	-0.19
11.	0.89	0.11	-0.78	4.44	9.44	5.00
12.	-0.59	-0.02	0.57	2.54	4.35	1.81
13.	-3.56	6.61	10.17	9.60	18.23	8.63
14.	0.63	-10.03	-10.66	0.34	0.26	-0.08
15.	-6.04	-6.36	-0.32	-1.63	-1.77	-0.14
N	12	15	12	12	15	12
MEAN	-0.86	-1.81	-0.84	1.23	1.93	1.18
STD DEV	2.18	4.41	5.74	4.15	6.43	3.38
MIN	-6.04	-10.03	-11.68	-6.78	-7.29	-4.21
MAX	2.08	6.61	10.17	9.60	18.23	8.63
t value	-1.36	-1.59	-0.50	1.03	1.16	1.21

Convention: Positive value indicates clockwise rotation
Negative value indicates counterclockwise rotation

TABLE VIII.

SNA

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	83.96	82.67		-1.29		
2.	76.32		73.10		-3.22	
3.	80.48	80.32	82.01	-0.16	1.53	1.69
4.	78.48	75.73	77.58	-2.75	-0.90	1.85
5.	75.39	73.69	73.45	-1.70	-1.94	-0.24
6.	87.25		85.63		-1.62	
7.	78.68	76.66	75.45	-2.02	-3.23	-1.21
8.	84.82		77.87		-6.95	
9.	83.20	78.44	80.18	-4.76	-3.02	1.74
10.	80.04	78.83	78.06	-1.21	-1.98	-0.77
11.	84.02	78.97	79.54	-5.05	-4.48	0.57
12.	91.57	89.74	89.42	-1.83	-2.15	-0.32
13.	81.66	77.65	78.73	-4.01	-2.93	1.08
14.	75.36	74.98	74.85	-0.38	-0.51	-0.13
15.	78.81	73.94	74.60	-4.87	-4.21	0.66
N	15	12	14	12	14	11
MEAN	81.34	78.47	78.61	-2.50	-2.54	0.45
STD DEV	4.55	4.43	4.64	1.76	2.01	1.06
MIN	75.36	73.69	73.10	-5.05	-6.95	-1.21
MAX	91.57	89.74	89.42	-0.16	1.53	1.85
t value				-4.93	-4.74	1.40

TABLE IX.

SNB

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	74.61	74.75		0.14		
2.	71.68		68.99		-2.69	
3.	77.08	77.76	78.59	0.68	1.51	0.83
4.	73.44	72.08	72.51	-1.36	-0.93	0.43
5.	69.53	69.72	69.24	0.19	-0.29	-0.48
6.	83.77		82.42		-1.35	
7.	77.30	76.40	75.39	-0.90	-1.91	-1.01
8.	78.19		76.50		-1.69	
9.	69.58	69.42	70.76	-0.16	1.18	1.34
10.	74.87	75.24	74.47	0.37	-0.40	-0.77
11.	76.59	75.05	75.67	-1.54	-0.92	0.62
12.	81.88	82.52	82.10	0.64	0.22	-0.42
13.	77.04	77.63	79.19	0.59	2.15	1.56
14.	71.30	71.80	71.30	0.50	0.00	-0.50
15.	71.46	70.15	69.13	-1.31	-2.33	-1.02
N	15	12	14	12	14	11
MEAN	75.22	74.38	74.73	-0.18	-0.53	0.05
STD DEV	4.22	3.93	4.64	0.86	1.45	0.94
MIN	69.53	69.42	68.99	-1.54	-2.69	-1.02
MAX	83.77	82.52	82.42	0.68	2.15	1.56
t value				-0.73	-1.37	0.19

TABLE X.

ANB

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	9.34	7.92		-1.42		
2.	4.64		4.11		-0.53	
3.	3.40	2.56	3.42	-0.84	0.02	0.86
4.	5.04	3.66	5.06	-1.38	0.02	1.40
5.	5.86	3.97	4.21	-1.89	-1.65	0.24
6.	3.48		3.20		-0.28	
7.	1.38	0.26	0.06	-1.12	-1.32	-0.20
8.	6.63		1.37		-5.26	
9.	13.62	9.02	9.42	-4.60	-4.20	0.40
10.	5.18	3.59	3.58	-1.59	-1.60	-0.01
11.	7.44	3.92	3.87	-3.52	-3.57	-0.05
12.	9.69	7.21	7.32	-2.48	-2.37	0.11
13.	4.62	0.02	-0.47	-4.60	-5.09	-0.49
14.	4.06	3.17	3.55	-0.89	-0.51	0.38
15.	7.36	3.79	5.47	-3.57	-1.89	1.68
N	15	12	14	12	14	11
MEAN	6.12	4.09	3.87	-2.33	-2.02	0.39
TD DEV	3.05	2.76	2.59	1.40	1.84	0.67
MIN	1.38	0.02	-0.47	-4.60	-5.26	-0.49
MAX	13.62	9.02	9.42	-0.84	0.02	1.68
t value				-5.76	-4.11	1.95

TABLE XI.

SN - POG

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	76.33	75.86		-0.47		
2.	75.19		73.33		-1.86	
3.	78.06	79.63	81.09	1.57	3.03	1.46
4.	74.57	74.29	74.69	-0.28	0.12	0.40
5.	70.23	71.30	70.95	1.07	0.72	-0.35
6.	86.01		85.47		-0.54	
7.	78.27	78.35	77.86	0.08	-0.41	-0.49
8.	78.58		79.16		0.58	
9.	67.74	67.51	67.76	-0.23	0.02	0.25
10.	75.14	75.74	75.24	0.60	0.10	-0.50
11.	77.30	77.36	78.20	0.06	0.90	0.84
12.	80.79	81.87	81.55	1.08	0.76	-0.32
13.	78.25	79.87	82.57	1.62	4.32	2.70
14.	72.78	73.66	73.32	0.88	0.54	-0.34
15.	72.16	71.94	71.03	-0.22	-1.13	-0.91
N	15	12	14	12	14	11
MEAN	76.09	75.62	76.59	0.48	0.51	0.25
STD DEV	4.44	4.13	5.10	0.75	1.57	1.06
MIN	67.74	67.51	67.76	-0.47	-1.86	-0.91
MAX	86.01	81.87	85.47	1.62	4.32	2.70
t value				2.22	1.22	0.78

TABLE XII.

FACIAL PLANE ANGLE

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	85.15	84.67		-0.48		
2.	82.01		78.59		-3.42	
3.	83.18	84.29	84.82	1.11	1.64	0.53
4.	78.40	78.57	78.45	0.17	0.05	-0.12
5.	84.75	85.71	85.64	0.96	0.89	-0.07
6.	88.39		87.87		-0.52	
7.	83.81	82.79	83.27	-1.02	-0.54	0.48
8.	87.48		88.00		0.52	
9.	83.88	85.29	83.97	1.41	0.09	-1.32
10.	87.07	88.14	87.32	1.07	0.25	-0.82
11.	86.18	87.70	87.12	1.52	0.94	-0.58
12.	86.56	87.91	89.69	1.35	3.13	1.78
13.	84.12	86.88	88.47	2.76	4.35	1.59
14.	79.59	80.30	79.46	0.71	-0.13	-0.84
15.	82.51	80.43	80.82	-2.08	-1.69	0.39
N	15	12	14	12	14	11
MEAN	84.21	84.39	84.54	0.62	0.40	0.09
STD DEV	2.82	3.23	3.87	1.30	1.89	0.99
MIN	78.40	78.57	78.45	-2.08	-3.42	-1.32
MAX	88.39	88.14	89.69	2.76	4.35	1.78
t value				1.66	0.79	0.31

TABLE XIII.

FRANKFORT MANDIBULAR PLANE ANGLE

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	26.97	33.48		6.51		
2.	25.34		30.55		5.21	
3.	24.66	22.61	20.62	-2.05	-4.04	-1.99
4.	41.06	40.69	41.65	-0.37	0.59	0.96
5.	23.10	21.36	20.71	-1.74	-2.39	-0.65
6.	23.38		21.43		-1.95	
7.	26.53	28.38	27.04	1.85	0.51	-1.34
8.	26.42		21.12		-5.30	
9.	38.88	35.32	33.25	-3.56	-5.63	-2.07
10.	19.71	18.31	17.03	-1.40	-2.68	-1.28
11.	21.36	19.23	16.66	-2.13	-4.70	-2.57
12.	26.81	25.83	24.60	-0.98	-2.21	-1.23
13.	17.55	14.96	10.75	-2.59	-6.80	-4.21
14.	29.94	30.25	29.83	0.31	-0.11	-0.42
15.	29.79	31.83	30.93	2.04	1.14	-0.90
N	15	12	14	12	14	11
MEAN	26.77	26.85	24.73	-0.34	-2.03	-1.43
STD DEV	6.36	7.79	8.04	2.74	3.25	1.32
MIN	17.55	14.96	10.75	-3.56	-6.80	-4.21
MAX	41.06	40.69	41.65	6.51	5.21	0.96
t value				-0.43	-2.33	-3.58

TABLE XIV.

SN - GoGn

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	35.80	42.29		6.49		
2.	32.15		35.81		3.66	
3.	29.78	27.27	24.35	-2.51	-5.43	-2.92
4.	44.88	44.97	45.41	0.09	0.53	0.44
5.	37.62	35.77	35.40	-1.85	-2.22	-0.37
6.	25.76		23.83		-1.93	
7.	32.06	32.81	32.45	0.75	0.39	-0.36
8.	35.33		29.97		-5.36	
9.	55.02	53.10	49.46	-1.92	-5.56	-3.64
10.	31.64	30.71	29.11	-0.93	-2.53	-1.60
11.	30.24	29.58	25.59	-0.66	-4.65	-3.99
12.	32.58	31.87	32.74	-0.71	0.16	0.87
13.	23.43	21.97	16.66	-1.46	-6.77	-5.31
14.	36.75	36.89	35.97	0.14	-0.78	-0.92
15.	40.13	40.33	40.73	0.20	0.60	0.40
N	15	12	14	12	14	11
MEAN	34.88	35.63	32.68	-0.20	-2.14	-1.58
STD DEV	7.74	8.53	8.82	2.33	3.07	2.08
MIN	23.43	21.97	16.66	-2.51	-6.77	-5.31
MAX	55.02	53.10	49.46	6.49	3.66	0.87
t value				-0.29	-2.60	-2.53

TABLE XV.

SN TO OCCLUSAL PLANE

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	13.51	19.57		6.06		
2.	17.37		21.08		3.71	
3.	8.47	12.48	12.71	4.01	4.24	0.23
4.	16.85	23.52	19.61	6.67	2.76	-3.91
5.	25.50	28.41	23.41	2.91	-2.09	-5.00
6.	9.67		12.61		2.94	
7.	20.42	19.85	20.02	-0.57	-0.40	0.17
8.	18.88		14.45		-4.43	
9.	27.33	32.46	32.63	5.13	5.30	0.17
10.	16.82	15.08	18.79	-1.74	1.97	3.71
11.	17.25	22.57	18.49	5.32	1.24	-4.08
12.	13.18	15.95	14.18	2.77	1.00	-1.77
13.	12.25	10.83	10.35	-1.42	-1.90	-0.48
14.	16.03	24.20	19.71	8.17	3.68	-4.49
15.	18.73	20.94	17.27	2.21	-1.46	-3.67
N	15	12	14	12	14	11
MEAN	16.82	20.49	18.24	3.29	1.18	-1.74
STD DEV	5.17	6.34	5.59	3.23	2.86	2.73
MIN	8.47	10.83	10.35	-1.74	-4.43	-5.00
MAX	27.33	32.46	32.63	8.17	5.30	3.71
t value				3.53	1.55	-2.11

TABLE XVI.

INTERINCISAL ANGLE

	T_1	T_2	T_4	T_1-T_1	T_1-T_4	T_2-T_4
1.	123.16	134.16		11.00		
2.	148.43		130.89		-17.54	
3.	100.85	135.10	141.40	34.25	40.55	6.30
4.	137.44	130.16	149.85	-7.28	12.41	19.69
5.	140.52	148.31	150.90	7.79	10.38	2.59
6.	170.18		160.79		-9.39	
7.	140.68	139.49	140.68	-1.19	0.00	1.19
8.	139.16		142.88		3.72	
9.	112.13	120.28	116.12	8.15	3.99	-4.16
10.	133.83	131.26	126.50	-2.57	-7.33	-4.76
11.	144.56	133.45	134.06	-11.11	-10.50	0.61
12.	101.36	128.68	125.84	27.32	24.48	-2.84
13.	150.82	134.55	136.69	-16.27	-14.13	2.14
14.	119.53	136.23	135.26	16.70	15.73	-0.97
15.	127.51	146.96	143.27	19.45	15.76	-3.69
N	15	12	14	12	14	11
MEAN	132.68	134.89	138.22	7.19	4.87	1.46
STD DEV	18.94	7.62	11.54	15.53	16.31	6.92
MIN	100.85	120.28	116.12	-16.27	-17.54	-4.76
MAX	170.18	148.31	160.79	34.25	40.55	19.69
t value				1.60	1.12	0.70

TABLE XVII.

OVERBITE

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	5.51	6.59		1.08		
2.	4.45		3.55		-0.90	
3.	5.37	4.14	4.60	-1.23	-0.77	0.46
4.	1.69	-0.06	3.46	-1.75	1.77	3.52
5.	6.25	3.11	5.14	-3.14	-1.11	2.03
6.	4.04		3.97		-0.07	
7.	2.35	1.59	2.84	-0.76	0.49	1.25
8.	3.62		3.30		-0.32	
9.	1.87	2.38	5.37	0.51	3.50	2.99
10.	4.53	1.84	1.76	-2.69	-2.77	-0.08
11.	7.50	2.87	4.40	-4.63	-3.10	1.53
12.	-4.92	2.09	2.38	7.01	7.30	0.29
13.	8.12	3.93	6.03	-4.19	-2.09	2.10
14.	3.52	2.64	3.94	-0.88	0.42	1.30
15.	2.90	5.60	5.53	2.70	2.63	-0.07
N	15	12	14	12	14	11
MEAN	3.79	3.06	4.02	-0.66	0.36	1.39
STD DEV	3.07	1.80	1.24	3.23	2.75	1.20
MIN	-4.92	-0.06	1.76	-4.63	-3.10	-0.08
MAX	8.12	6.59	6.03	7.01	7.30	3.52
t value				-0.71	0.48	3.85

TABLE XVIII.

OVERJET

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	15.13	4.04				
2.	13.10		9.59		-3.51	
3.	10.42	2.46	2.27	-7.96	-8.15	-0.19
4.	6.78	4.50	5.80	-2.28	-0.98	1.30
5.	5.56	2.99	3.17	-2.57	-2.39	0.18
6.	3.92		3.29		-0.63	
7.	2.84	2.91	3.63	0.07	0.79	0.72
8.	3.71		3.32		-0.39	
9.	8.25	4.46	4.29	-3.79	-3.96	-0.17
10.	8.51	2.94	2.35	-5.57	-6.16	-0.59
11.	4.65	2.81	3.50	-1.84	-1.15	0.69
12.	9.94	1.73	3.61	-8.21	-6.33	1.88
13.	3.18	3.19	4.13	0.01	0.95	0.94
14.	10.34	2.67	3.53	-7.67	-6.81	0.86
15.	9.92	3.13	3.61	-6.79	-6.31	0.48
N	15	12	14	12	14	11
MEAN	7.75	3.15	4.01	-4.81	-3.22	0.55
STD DEV	3.77	0.81	1.82	3.59	3.09	0.72
MIN	2.84	1.73	2.27	-11.09	-8.15	-0.59
MAX	15.13	4.50	9.59	0.07	0.95	1.88
t value				-4.64	-3.90	2.57

TABLE XIX.

UPPER INCISOR TO NA mm

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	7.60	-0.34		-7.94		
2.	5.26		6.40		1.14	
3.	11.57	2.01	0.67	-9.56	-10.90	-1.34
4.	3.60	4.22	0.04	0.62	-3.56	-4.18
5.	0.79	-2.05	-2.33	-2.84	-3.12	-0.28
6.	-2.52		-1.97		0.55	
7.	3.63	5.22	5.47	1.59	1.84	0.25
8.	-1.35		3.91		5.26	
9.	3.59	2.21	0.54	-1.38	-3.05	-1.67
10.	4.04	1.73	3.29	-2.31	-0.75	1.56
11.	-3.16	0.24	2.15	3.40	5.31	1.91
12.	8.03	-0.34	1.95	-8.37	-6.08	2.29
13.	-0.63	5.01	6.42	5.64	7.05	1.41
14.	8.88	2.70	2.89	-6.18	-5.99	0.19
15.	4.53	0.57	-0.06	-3.96	-4.59	-0.63
N	15	12	14	12	14	11
MEAN	3.59	1.77	2.10	-2.61	-1.21	-0.04
STD DEV	4.34	2.27	2.82	4.85	5.08	1.90
MIN	-3.16	-2.05	-2.33	-9.56	-10.90	-4.18
MAX	11.57	5.22	6.42	5.64	7.05	2.29
t value				-1.86	-0.89	-0.08

TABLE XX.

LOWER INCISOR TO APO mm

	T_1	T_2	T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	-1.16	0.48		1.64		
2.	-7.23		-3.84		3.39	
3.	1.97	-0.18	-1.14	-2.15	-3.11	-0.96
4.	0.01	0.86	-3.52	0.85	-3.53	-4.38
5.	-0.08	-2.93	-3.15	-2.85	-3.07	-0.22
6.	-5.06		-4.77		0.29	
7.	1.47	0.92	0.15	-0.55	-1.32	-0.77
8.	-0.54		0.13		0.67	
9.	7.53	9.32	9.52	1.79	1.99	0.20
10.	-0.55	1.07	3.23	1.62	3.78	2.16
11.	-2.68	-1.24	0.08	1.44	2.76	1.32
12.	5.66	4.44	5.20	-1.22	-0.46	0.76
13.	-1.47	0.37	-0.12	1.84	1.35	-0.49
14.	-0.10	0.96	0.41	1.06	0.51	-0.55
15.	0.17	-1.10	-0.99	-1.27	-1.16	0.11
N	15	12	14	12	14	11
MEAN	-0.14	1.08	0.09	0.18	0.15	-0.26
STD DEV	3.62	3.13	3.83	1.69	2.39	1.66
MIN	-7.23	-2.93	-4.77	-2.85	-3.53	-4.38
MAX	7.53	9.32	9.52	1.84	3.78	2.16
t value				0.37	0.23	-0.51

TABLE XXI.

IMPA

	@ T_1	@ T_2	@ T_4	T_1-T_2	T_1-T_4	T_2-T_4
1.	94.01	85.33		-2.17		
2.	82.30		89.31		12.21	
3.	100.58	103.94	106.17	1.31	1.55	0.24
4.	81.95	90.63	79.26	8.30	-2.10	-10.40
5.	99.76	94.24	94.77	-7.26	-7.38	-0.13
6.	77.75		86.36		6.66	
7.	90.87	89.45	89.57	0.43	-0.79	-1.22
8.	89.40		95.47		0.77	
9.	94.75	98.88	107.52	0.57	7.14	6.57
10.	97.69	105.62	112.85	6.52	12.47	5.95
11.	98.71	104.09	113.82	3.25	10.41	7.16
12.	107.67	105.31	106.50	-3.34	-3.38	-0.04
13.	99.54	102.58	111.24	0.45	4.90	4.45
14.	96.10	98.47	98.66	2.68	2.45	-0.23
15.	94.26	86.31	93.05	-5.91	-0.07	5.84
N	15	12	14	12	14	11
MEAN	93.69	97.07	98.90	0.40	3.20	1.65
STD DEV	8.06	7.59	10.88	4.60	6.00	5.13
MIN	77.75	85.33	79.26	-7.26	-7.38	-10.40
MAX	107.67	105.62	113.82	8.30	12.47	7.16
t value				0.30	2.00	1.07

TABLE XXII A.

PALATAL FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON PALATE

UPPER INCISAL EDGE

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	58.54	51.54		33.49	35.74		-7.00			-2.25		
2.	52.35		50.49	26.24		29.37		-1.86			-3.13	
3.	59.66	52.07	50.62	21.12	24.88	26.12	-7.59	-9.04	-1.45	-3.76	-5.00	-1.24
4.	51.55	48.30	45.75	29.01	28.29	29.60	-3.25	-5.80	-2.55	0.72	-0.59	-1.31
5.	50.13	45.71	45.05	28.18	27.74	27.40	-4.42	-5.08	-0.66	0.44	0.78	0.34
6.	44.75		44.23	30.20		29.73		-0.52			0.47	
7.	51.41	52.14	50.89	31.31	32.46	34.08	0.73	-0.52	-1.25	-1.15	-2.77	-1.62
8.	47.39		53.03	27.75		27.17		5.64			0.58	
9.	55.94	50.55	51.62	27.09	27.47	27.81	-5.39	-4.32	1.07	-0.38	-0.72	-0.34
10.	53.49	49.49	51.21	27.43	24.25	24.17	-4.00	-2.28	1.72	3.18	3.26	0.08
11.	47.46	47.36	49.31	25.22	24.28	25.32	-0.10	1.85	1.95	0.94	-0.10	-1.04
12.	66.71	60.81	62.19	23.38	30.01	29.00	-5.90	-4.52	1.38	-6.63	-5.62	1.01
13.	45.33	48.17	49.78	26.66	26.29	27.29	2.84	4.45	1.61	0.37	-0.63	-1.00
14.	54.62	47.69	50.87	27.48	30.24	30.38	-6.93	-3.75	3.18	-2.76	-2.90	-0.14
15.	55.41	49.17	51.16	30.32	32.09	31.04	-6.24	-4.25	1.99	-1.77	-0.72	1.05
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	52.98	50.25	50.44	27.66	28.65	28.46	-3.94	-2.14	0.64	-1.09	-1.22	-0.38
STD DEV	5.87	3.88	4.29	3.09	3.59	2.55	3.39	4.04	1.81	2.58	2.40	0.93
MIN	44.75	45.71	44.23	21.12	24.25	24.17	-7.59	-9.04	-2.55	-6.63	-5.62	-1.62
MAX	66.71	60.81	62.19	33.49	35.74	34.08	2.84	5.64	3.18	3.18	3.26	1.05
t value							-4.03	-1.98	1.17	-1.46	-1.90	-1.36

TABLE XXII B.

PALATAL FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON PALATE

UPPER INCISOR EDGE

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	58.54	49.63		33.49	34.61		-8.91			-1.12		
2.	52.35		50.79	26.24		32.37		-1.56			-6.13	
3.	59.66	51.03	48.15	21.12	25.92	26.06	-8.63	-11.51	-2.88	-4.80	-4.94	-0.14
4.	51.55	47.61	47.43	29.01	29.86	26.59	-3.94	-4.12	-0.18	-0.85	2.42	3.27
5.	50.13	46.60	44.71	28.18	27.81	28.11	-3.53	-5.42	-1.89	0.37	0.07	-0.30
6.	44.75		40.91	30.20		28.87		-3.84			1.33	
7.	51.41	49.43	48.56	31.31	33.65	34.09	-1.98	-2.85	-0.87	-2.34	-2.78	-0.44
8.	47.39		51.30	27.75		31.25		3.91			-3.50	
9.	55.94	51.10	49.57	27.09	29.20	31.67	-4.84	-6.37	-1.53	-2.11	-4.58	-2.47
10.	53.49	50.33	49.66	27.43	25.13	25.27	-3.16	-3.83	-0.67	2.30	2.16	-0.14
11.	47.46	46.39	47.42	25.22	24.42	27.31	-1.07	-0.04	1.03	0.80	-2.09	-2.89
12.	66.71	57.72	57.64	23.38	32.61	32.29	-8.99	-9.07	-0.08	-9.23	-8.91	0.32
13.	45.33	49.97	45.96	26.66	26.54	29.16	4.64	0.63	-4.01	0.12	-2.50	-2.62
14.	54.62	48.32	48.91	27.48	30.39	27.17	-6.30	-5.71	0.59	-2.91	0.31	3.22
15.	55.41	51.40	50.81	30.32	31.35	32.33	-4.01	-4.60	-0.59	-1.03	-2.01	-0.98
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	52.98	49.96	48.70	27.66	29.29	29.47	-4.23	-3.88	-1.01	-1.73	-2.23	-0.29
STD DEV	5.87	2.98	3.77	3.09	3.39	2.82	3.86	3.92	1.49	3.01	3.28	2.07
MIN	44.75	46.39	40.91	21.12	24.42	25.27	-8.99	-11.51	-4.01	-9.23	-8.91	-2.89
MAX	66.71	57.72	57.64	33.49	34.61	34.09	4.64	3.91	1.03	2.30	2.42	3.27
t value							-3.79	-3.71	-2.25	-1.99	-2.54	-0.46

TABLE XXIII A.

PALATAL FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON PALATE

UPPER INCISOR APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	47.85	47.94		8.32	8.58		0.09			-0.26		
2.	42.65		40.24	0.89		7.12		-2.41			-6.23	
3.	39.24	44.38	44.89	2.91	1.58	4.31	5.14	5.65	0.51	1.33	-1.40	-2.73
4.	41.46	38.70	40.25	0.43	0.62	0.82	-2.76	-1.21	1.55	-0.19	-0.39	-0.20
5.	47.35	42.24	41.91	4.62	5.04	4.20	-5.11	-5.44	-0.33	-0.42	0.42	0.84
6.	44.55		42.07	4.09		5.98		-2.48			-1.89	
7.	46.33	45.98	45.53	9.71	8.93	9.90	-0.35	-0.80	-0.45	0.78	-0.19	-0.97
8.	41.35		42.75	4.87		1.28		1.40			3.59	
9.	44.76	39.68	40.78	3.57	-1.28	-0.61	-5.08	-3.98	1.10	4.85	4.18	-0.67
10.	45.43	42.56	45.38	2.40	1.20	2.77	-2.87	-0.05	2.82	1.20	-0.37	-1.57
11.	43.44	37.88	41.71	-0.01	1.04	2.57	-5.56	-1.73	3.83	-1.05	-2.58	-1.53
12.	50.72	55.31	54.05	-1.50	5.39	3.53	4.59	3.33	-1.26	-6.89	-5.03	1.86
13.	42.72	36.76	39.12	2.29	3.73	2.83	-5.96	-3.60	2.36	-1.44	-0.54	0.90
14.	44.14	43.76	46.17	7.55	5.42	6.42	-0.38	2.03	2.41	2.13	1.13	-1.00
15.	47.15	45.84	47.30	6.18	7.29	6.36	-1.31	0.15	1.46	-1.11	-0.18	0.93
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	44.61	43.42	43.73	3.75	3.96	4.11	-1.63	-0.65	1.27	-0.09	-0.68	-0.38
STD DEV	2.97	5.12	3.90	3.21	3.34	2.83	3.71	3.02	1.55	2.76	2.81	1.38
MIN	39.24	36.76	39.12	-1.50	-1.28	-0.61	-5.96	-5.44	-1.26	-6.89	-6.23	-2.73
MAX	50.72	55.31	54.05	9.71	8.93	9.90	5.14	5.65	3.83	4.85	4.18	1.86
t value							-1.52	-0.81	2.72	-0.11	-0.90	-0.91

TABLE XXIII B.

PALATAL FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON PALATE

UPPER INCISOR APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	47.85	44.70		8.32	7.66		-3.15			0.66		
2.	42.65		41.09	0.89		9.87		-1.56			-8.98	
3.	39.24	43.54	42.86	2.91	2.56	4.14	4.30	3.62	-0.68	0.35	-1.23	-1.58
4.	41.46	39.20	37.51	0.43	1.79	-0.99	-2.26	-3.95	-1.69	-1.36	1.42	2.78
5.	47.35	42.78	42.28	4.62	5.16	4.83	-4.57	-5.07	-0.50	-0.54	-0.21	0.33
6.	44.55		37.97	4.09		5.21		-6.58			-1.12	
7.	46.33	44.05	42.78	9.71	9.94	10.01	-2.28	-3.55	-1.27	-0.23	-0.30	-0.07
8.	41.35		40.80	4.87		5.45		-0.55			-0.58	
9.	44.76	41.34	39.85	3.57	0.06	2.85	-3.42	-4.91	-1.49	3.51	0.72	-2.79
10.	45.43	44.02	44.36	2.40	1.90	3.73	-1.41	-1.07	0.34	0.50	-1.33	-1.83
11.	43.44	38.07	41.00	-0.01	0.74	4.20	-5.37	-2.44	2.93	-0.75	-4.21	-3.46
12.	50.72	52.78	50.08	-1.50	7.87	6.64	2.06	-0.64	-2.70	-9.37	-8.14	1.23
13.	42.72	37.72	38.34	2.29	4.42	3.59	-5.00	-4.38	0.62	-2.13	-1.30	0.83
14.	44.14	44.70	40.52	7.55	5.53	4.24	0.56	-3.62	-4.18	2.02	3.31	1.29
15.	47.15	47.18	47.17	6.18	6.68	7.62	0.03	0.02	-0.01	-0.50	-1.44	-0.94
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	44.61	43.34	41.90	3.75	4.53	5.10	-1.71	-2.48	-0.78	-0.65	-1.67	-0.38
STD DEV	2.97	4.15	3.49	3.21	3.15	2.84	2.96	2.65	1.86	3.13	3.37	1.91
MIN	39.24	37.72	37.51	-1.50	0.06	-0.99	-5.37	-6.58	-4.18	-9.37	-8.98	-3.46
MAX	50.72	52.78	50.08	9.71	9.94	10.01	4.30	3.62	2.93	3.51	3.31	2.78
t value							-2.00	-3.50	-1.40	-0.72	-1.85	-0.66

TABLE XXIV A.

PALATAL FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON PALATE

UPPER FIRST MOLAR MESIAL CUSP

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	20.33	23.36		24.66	24.72		3.03			-0.06		
2.	16.03		22.36	22.12		25.03		6.33			-2.91	
3.	21.85	27.01	26.51	18.93	21.74	20.82	5.16	4.66	-0.50	-2.81	-1.89	0.92
4.	20.25	24.49	22.35	25.78	24.34	25.86	4.24	2.10	-2.14	1.44	-0.08	-1.52
5.	18.49	20.61	19.87	19.09	20.20	21.10	2.12	1.38	-0.74	-1.11	-2.01	-0.90
6.	20.69		21.56	24.81		25.24		0.87			-0.43	
7.	20.16	25.79	25.47	22.74	25.76	25.59	5.63	5.31	-0.32	-3.02	-2.85	0.17
8.	15.70		21.27	20.16		24.18		5.57			-4.02	
9.	16.28	19.46	22.64	18.49	20.39	18.90	3.18	6.36	3.18	-1.90	-0.41	1.49
10.	20.91	20.97	24.71	22.04	21.98	19.90	0.06	3.80	3.74	0.06	2.14	2.08
11.	18.71	20.69	21.56	19.37	19.68	21.71	1.98	2.85	0.87	-0.31	-2.34	-2.03
12.	27.51	30.65	31.61	19.24	24.12	24.75	3.14	4.10	0.96	-4.88	-5.51	-0.63
13.	21.12	23.57	26.58	22.13	25.15	24.60	2.45	5.46	3.01	-3.02	-2.47	0.55
14.	18.55	23.53	23.92	21.90	22.26	23.97	4.98	5.37	0.39	-0.36	-2.07	-1.71
15.	18.80	27.14	32.25	23.41	26.58	27.77	8.34	13.45	5.11	-3.17	-4.36	-1.19
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	19.69	23.94	24.48	21.66	23.08	23.53	3.69	4.83	1.23	-1.60	-2.09	-0.25
STD DEV	2.89	3.30	3.74	2.36	2.33	2.59	2.15	3.05	2.23	1.82	1.95	1.38
MIN	15.70	19.46	19.87	18.49	19.68	18.90	0.06	0.87	-2.14	-4.88	-5.51	-2.03
MAX	27.51	30.65	32.25	25.78	26.58	27.77	8.34	13.45	5.11	1.44	2.14	2.08
t value							5.96	5.92	1.83	-3.03	-4.00	-0.61

TABLE XXIV B.

PALATAL FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON PALATE

UPPER FIRST MOLAR MESIAL CUSP

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	20.33	20.95		24.66	25.00		0.62			-0.34		
2.	16.03		22.77	22.12		27.34		6.74			-5.22	
3.	21.85	25.99	24.15	18.93	22.56	20.29	4.14	2.30	-1.84	-3.63	-1.36	2.27
4.	20.25	23.99	23.73	25.78	24.88	26.54	3.74	3.48	-0.26	0.90	-0.76	-1.66
5.	18.49	21.39	19.74	19.09	20.66	21.06	2.90	1.25	-1.65	-1.57	-1.97	-0.40
6.	20.69		18.11	24.81		25.14		-2.58			-0.33	
7.	20.16	23.32	22.99	22.74	26.08	26.05	3.16	2.83	-0.33	-3.34	-3.31	0.03
8.	15.70		19.51	20.16		28.53		3.81			-8.37	
9.	16.28	20.30	20.96	18.49	20.94	21.64	4.02	4.68	0.66	-2.45	-3.15	-0.70
10.	20.91	21.88	23.26	22.04	22.10	20.34	0.97	2.35	1.38	-0.06	1.70	1.76
11.	18.71	19.97	19.90	19.37	18.52	22.29	1.26	1.19	-0.07	0.85	-2.92	-3.77
12.	27.51	27.70	27.17	19.24	26.04	27.35	0.19	-0.34	-0.53	-6.80	-8.11	-1.31
13.	21.12	25.35	23.25	22.13	26.32	23.67	4.23	2.13	-2.10	-4.19	-1.54	2.65
14.	18.55	24.27	21.30	21.90	22.12	25.05	5.72	2.75	-2.97	-0.22	-3.15	-2.93
15.	18.80	29.19	31.94	23.41	26.64	28.90	10.39	13.14	2.75	-3.23	-5.49	-2.26
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	19.69	23.69	22.77	21.66	23.49	24.59	3.44	3.12	-0.45	-2.01	-3.14	-0.57
STD DEV	2.89	2.96	3.53	2.36	2.68	3.03	2.78	3.62	1.66	2.34	2.86	2.11
MIN	15.70	19.97	18.11	18.49	18.52	20.29	0.19	-2.58	-2.97	-6.80	-8.37	-3.77
MAX	27.51	29.19	31.94	25.78	26.64	28.90	10.39	13.14	2.75	0.90	1.70	2.65
t value							4.30	3.23	-0.90	-2.97	-4.12	-0.90

TABLE XXV A.

PALATAL FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON PALATE

UPPER FIRST MOLAR MESIAL APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	23.91	28.91		3.59	3.32		5.00			0.27		
2.	23.80		23.79	2.97		5.04		-0.01			-2.07	
3.	27.14	26.71	25.47	-0.88	-0.06	-0.50	-0.43	-1.67	-1.24	-0.82	-0.38	0.44
4.	25.91	25.42	24.79	7.04	6.09	5.32	-0.49	-1.12	-0.63	0.95	1.72	0.77
5.	22.34	23.61	20.34	0.22	1.65	5.30	1.27	-2.00	-3.27	-1.43	-5.08	-3.65
6.	22.48		23.66	4.83		4.61		1.18			0.22	
7.	24.52	27.86	26.60	0.72	5.51	4.63	3.34	2.08	-1.26	-4.79	-3.91	0.88
8.	21.46		21.37	0.63		3.49		-0.09			-2.86	
9.	20.81	21.05	22.44	-2.94	-1.78	-4.19	0.24	1.63	1.39	-1.16	1.25	2.41
10.	24.52	22.64	24.88	2.28	2.54	3.48	-1.88	0.36	2.24	-0.26	-1.20	-0.94
11.	23.17	24.06	24.66	-1.92	-1.18	2.71	0.89	1.49	0.60	-0.74	-4.63	-3.89
12.	29.13	32.15	34.00	-5.11	0.80	2.22	3.02	4.87	1.85	-5.91	-7.33	-1.42
13.	24.58	23.62	26.38	0.49	3.31	4.46	-0.96	1.80	2.76	-2.82	-3.97	-1.15
14.	23.95	25.37	25.03	2.10	3.56	3.16	1.42	1.08	-0.34	-1.46	-1.06	0.40
15.	26.70	28.70	30.66	2.08	3.26	5.61	2.00	3.96	1.96	-1.18	-3.53	-2.35
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	24.29	25.84	25.29	1.07	2.25	3.24	1.12	0.97	0.37	-1.61	-2.35	-0.77
STD DEV	2.22	3.15	3.52	3.07	2.45	2.68	1.99	1.95	1.87	2.00	2.59	1.98
MIN	20.81	21.05	20.34	-5.11	-1.78	-4.19	-1.88	-2.00	-3.27	-5.91	-7.33	-3.89
MAX	29.13	32.15	34.00	7.04	6.09	5.61	5.00	4.87	2.76	0.95	1.72	2.41
t value							1.95	1.86	0.65	-2.80	-3.39	-1.30

TABLE XXV B.

PALATAL FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON PALATE

UPPER FIRST MOLAR MESIAL APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	23.91	25.44		3.59	3.35		1.53			0.24		
2.	23.80		24.70	2.97		7.39		0.90			-4.42	
3.	27.14	25.88	23.54	-0.88	0.76	-1.05	-1.26	-3.60	-2.34	-1.64	0.17	1.81
4.	25.91	25.70	22.95	7.04	6.69	5.87	-0.21	-2.96	-2.75	0.35	1.17	0.82
5.	22.34	24.10	20.68	0.22	2.07	5.27	1.76	-1.66	-3.42	-1.85	-5.05	-3.20
6.	22.48		19.51	4.83		4.44		-2.97			0.39	
7.	24.52	26.06	23.77	0.72	5.92	5.07	1.54	-0.75	-2.29	-5.20	-4.35	0.85
8.	21.46		19.44	0.63		7.84		-2.02			-7.21	
9.	20.81	22.74	21.65	-2.94	-1.16	-1.44	1.93	0.84	-1.09	-1.78	-1.50	0.28
10.	24.52	24.07	23.85	2.28	2.72	3.93	-0.45	-0.67	-0.22	-0.44	-1.65	-1.21
11.	23.17	24.37	23.96	-1.92	-2.15	3.47	1.20	0.79	-0.41	0.23	-5.39	-5.62
12.	29.13	29.72	30.06	-5.11	2.76	4.88	0.59	0.93	0.34	-7.87	-9.99	-2.12
13.	24.58	24.58	25.50	0.49	4.49	3.66	0.00	0.92	0.92	-4.00	-3.17	0.83
14.	23.95	26.34	19.14	2.10	3.43	4.33	2.39	-4.81	-7.20	-1.33	-2.23	-0.90
15.	26.70	29.90	30.54	2.08	3.28	6.72	3.20	3.84	0.64	-1.20	-4.64	-3.44
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	24.29	25.74	23.52	1.07	2.68	4.31	1.02	-0.80	-1.62	-2.04	-3.42	-1.08
STD DEV	2.22	2.16	3.52	3.07	2.58	2.70	1.30	2.34	2.36	2.48	3.09	2.30
MIN	20.81	22.74	19.14	-5.11	-2.15	-1.44	-1.26	-4.81	-7.20	-7.87	-9.99	-5.62
MAX	29.13	29.90	30.54	7.04	6.69	7.84	3.20	3.84	0.92	0.35	1.17	1.81
t value							2.71	-1.28	-2.28	-2.85	-4.14	-1.56

TABLE XXVI A.

PALATAL FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON PALATE

	POINT A											
	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	51.02	52.74		5.82	14.45		1.72			-8.63		
2.	47.19		45.15	4.13	4.93	8.44		-2.04			-4.31	
3.	48.26	49.87	49.62	5.80	6.26	7.23	1.61	1.36	-0.25	-0.46	-1.43	-0.97
4.	47.07	44.08	44.93	4.54	3.84	5.90	-2.99	-2.14	0.85	0.70	-1.36	-2.06
5.	49.36	48.18	47.77	4.21	8.38	6.82	-1.18	-1.59	-0.41	-4.17	-2.61	1.56
6.	46.67		46.20	5.64		8.14		-0.47			-2.50	
7.	49.57	49.61	49.43	9.22	7.70	11.60	0.04	-0.14	-0.18	1.52	-2.38	-3.90
8.	47.52		49.32	7.70		8.38		1.80			-0.68	
9.	48.60	43.49	45.70	7.07	0.03	-1.89	-5.11	-2.90	2.21	7.04	8.96	1.92
10.	49.05	47.29	48.22	2.41	4.93	2.39	-1.76	-0.83	0.93	-2.52	0.02	2.54
11.	48.18	45.73	45.38	4.05	8.23	4.34	-2.45	-2.80	-0.35	-4.18	-0.29	3.89
12.	56.61	58.64	57.01	3.74	7.12	4.40	2.03	0.40	-1.63	-3.38	-0.66	2.72
13.	45.36	43.24	43.88	5.17	6.11	4.54	-2.12	-1.48	0.64	-0.94	0.63	1.57
14.	47.62	46.97	49.97	7.03	8.46	7.10	-0.65	2.35	3.00	-1.43	-0.07	1.36
15.	51.12	49.96	50.54	5.95	7.62	8.80	-1.16	-0.58	0.58	-1.67	-2.85	-1.18
N	15	12	14	15	13	14	12	14	11	12	14	11
MEAN	48.88	48.32	48.08	5.50	6.77	6.16	-1.00	-0.65	0.49	-1.51	-0.68	0.68
STD DEV	2.64	4.36	3.37	1.76	3.29	3.30	2.12	1.66	1.29	3.79	3.09	2.37
MIN	45.36	43.24	43.88	2.41	0.03	-1.89	-5.11	-2.90	-1.63	-8.63	-4.31	-3.90
MAX	56.61	58.64	57.01	9.22	14.45	11.60	2.03	2.35	3.00	7.04	8.96	3.89
t value							-1.64	-1.46	1.26	-1.38	-0.82	0.95

TABLE XXVI B.

PALATAL FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON PALATE

	POINT A											
	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	51.02	49.79		5.82	13.29		-1.23			-7.47		
2.	47.19		45.97	4.13		11.32		-1.22			-7.19	
3.	48.26	48.99	47.53	5.80	7.28	7.16	0.73	-0.73	-1.46	-1.48	-1.36	0.12
4.	47.07	44.44	42.93	4.54	5.24	3.30	-2.63	-4.14	-1.51	-0.70	1.24	1.94
5.	49.36	48.77	48.06	4.21	8.41	7.63	-0.59	-1.30	-0.71	-4.20	-3.42	0.78
6.	46.67		42.16	5.64		7.23		-4.51			-1.59	
7.	49.57	47.72	46.71	9.22	8.82	11.64	-1.85	-2.86	-1.01	0.40	-2.42	-2.82
8.	47.52		47.42	7.70		12.50		-0.10			-4.80	
9.	48.60	45.10	44.81	7.07	1.51	1.76	0.05	-3.79	-3.84	5.56	5.31	-0.25
10.	49.05	48.65	47.21	2.41	5.76	3.43	-3.49	-1.84	1.65	-3.35	-1.02	2.33
11.	48.18	45.56	44.56	4.05	8.32	6.16	7.89	-3.62	-11.51	-4.27	-2.11	2.16
12.	56.61	56.07	53.02	3.74	9.68	7.58	-12.32	-3.59	8.73	-5.94	-3.84	2.10
13.	45.36	44.29	42.85	5.17	6.56	5.86	2.52	-2.51	-5.03	-1.39	-0.69	0.70
14.	47.62	47.88	44.38	7.03	8.61	4.31	3.69	-3.24	-6.93	-1.58	2.72	4.30
15.	51.12	51.31	50.39	5.95	6.87	10.09	0.19	-0.73	-0.92	-0.92	-4.14	-3.22
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	48.88	48.21	46.29	5.50	7.53	7.14	-0.59	-2.44	-2.05	-2.11	-1.67	0.74
STD DEV	2.64	3.33	3.02	1.76	2.83	3.32	4.81	1.44	5.10	3.35	3.20	2.24
MIN	45.36	44.29	42.16	2.41	1.51	1.76	-12.32	-4.51	-11.51	-7.47	-7.19	-3.22
MAX	56.61	56.07	53.02	9.22	13.29	12.50	7.89	-0.10	8.73	5.56	5.31	4.30
t value							-0.42	-6.34	-1.33	-2.18	-1.95	1.10

TABLE XXVII A. UPPER FIRST MOLAR ANGLE TO PALATAL PLANE
ANATOMICAL SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	80.36	75.46		-4.90		
2.	67.92		85.91		17.99	
3.	75.05	90.79	92.79	15.74	17.74	2.00
4.	73.19	87.08	83.23	13.89	10.03	-3.86
5.	78.47	80.81	88.30	2.35	9.83	7.48
6.	84.88		84.19		-0.69	
7.	78.80	84.16	86.91	5.36	8.11	2.75
8.	73.57		89.72		16.16	
9.	78.06	85.90	90.50	7.83	12.43	4.60
10.	79.65	85.09	89.41	5.44	9.76	4.32
11.	78.17	80.82	80.73	2.65	2.57	-0.09
12.	86.19	86.32	83.94	0.13	-2.25	-2.37
13.	80.92	89.87	90.57	8.95	9.65	0.70
14.	74.74	84.38	86.95	9.64	12.20	2.57
15.	69.68	86.17	94.10	16.50	24.43	7.93
N	15	12	14	12	14	11
MEAN	77.31	84.74	87.66	6.97	10.57	2.37
STD DEV	5.06	4.17	3.82	6.47	7.34	3.69
MIN	67.92	75.46	80.73	-4.90	-2.25	-3.86
MAX	86.19	90.79	94.10	16.50	24.43	7.93
t value	59.21	70.31	85.86	3.73	5.39	2.13

TABLE XXVII B. UPPER FIRST MOLAR ANGLE TO PALATAL PLANE
IMPLANT SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	80.36	78.28		-2.07		
2.	67.92		84.47		16.56	
3.	75.05	90.29	91.64	15.24	16.59	1.35
4.	73.19	84.63	92.16	11.44	18.97	7.53
5.	78.47	81.71	86.59	3.24	8.12	4.89
6.	84.88		86.13		1.25	
7.	78.80	82.26	87.87	3.46	9.07	5.61
8.	73.57		90.19		16.63	
9.	78.06	83.70	88.29	5.64	10.22	4.59
10.	79.65	83.55	87.94	3.91	8.29	4.39
11.	78.17	77.98	77.83	-0.19	-0.34	-0.16
12.	86.19	85.04	82.67	-1.15	-3.52	-2.37
13.	80.92	92.02	83.58	11.10	2.67	-8.44
14.	74.74	83.68	95.95	8.94	21.21	12.27
15.	69.68	88.26	93.61	18.58	23.93	5.35
N	15	12	14	12	14	11
MEAN	77.31	84.28	87.78	6.51	10.69	3.18
STD DEV	5.06	4.27	4.79	6.59	8.55	5.47
MIN	67.92	77.98	77.83	-2.07	-3.52	-8.44
MAX	86.19	92.02	95.95	18.58	23.93	12.27
t value	59.21	68.46	68.51	3.42	4.68	1.93

TABLE XXVIII A. UPPER INCISOR ANGLE TO PALATAL PLANE
ANATOMICAL SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	113.01	97.55		-15.46		
2.	110.94		114.73		3.80	
3.	138.27	108.27	104.72	-30.01	-33.55	-3.54
4.	109.45	109.13	100.82	-0.31	-8.63	-8.31
5.	96.73	98.69	97.71	1.96	0.98	-0.98
6.	90.44		95.20		4.76	
7.	103.23	104.67	102.50	1.44	-0.74	-2.17
8.	104.79		111.66		6.87	
9.	115.42	110.71	110.88	-4.71	-4.55	0.17
10.	107.85	106.73	105.24	-1.12	-2.61	-1.49
11.	99.05	112.19	108.47	13.14	9.42	-3.72
12.	122.73	102.59	107.72	-20.14	-15.00	5.13
13.	96.11	116.83	113.55	20.72	17.44	-3.28
14.	117.74	99.00	101.10	-18.74	-16.64	2.10
15.	108.89	97.65	98.89	-11.24	-10.00	1.24
N	15	12	14	12	14	11
MEAN	108.98	105.33	105.23	-5.37	-3.46	-1.35
STD DEV	11.94	6.36	6.15	14.48	12.83	3.56
MIN	90.44	97.55	95.20	-30.01	-33.55	-8.31
MAX	138.27	116.83	114.73	20.72	17.44	5.13
t value	35.35	57.37	64.06	-1.29	-1.01	-1.26

TABLE XXVIII B. UPPER INCISOR ANGLE TO PALATAL PLANE
IMPLANT SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	113.01	100.37		-12.64		
2.	110.94		113.32		2.38	
3.	138.27	107.78	103.57	-30.50	-34.71	-4.21
4.	109.45	106.68	109.78	-2.77	0.34	3.10
5.	96.73	99.57	95.96	2.84	-0.77	-3.61
6.	90.44		97.08		6.64	
7.	103.23	102.78	103.50	-0.45	0.26	0.71
8.	104.79		112.15		7.36	
9.	115.42	108.52	108.64	-6.91	-6.79	0.12
10.	107.85	105.20	103.82	-2.65	-4.03	-1.37
11.	99.05	109.36	105.53	10.31	6.47	-3.83
12.	122.73	101.29	106.42	-21.44	-16.31	5.13
13.	96.11	118.98	106.59	22.86	10.48	-12.38
14.	117.74	98.28	110.10	-19.45	-7.64	11.81
15.	108.89	99.71	98.38	-9.18	-10.51	-1.33
N	15	12	14	12	14	11
MEAN	108.98	104.88	105.35	-5.83	-3.34	-0.53
STD DEV	11.94	5.88	5.40	14.47	11.77	6.13
MIN	90.44	98.28	95.96	-30.50	-34.71	-12.38
MAX	138.27	118.98	113.32	22.86	10.48	11.81
t value	35.35	61.83	72.95	-1.40	-1.06	-0.29

TABLE XXIX A.

FRANKFORT FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON MANDIBLE

LOWER INCISAL EDGE

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	100.24	99.83		49.74	49.13		-0.41			0.61		
2.	76.63		79.27	46.00		43.62		2.64			2.38	
3.	86.95	84.53	85.30	37.38	38.31	37.78	-2.42	-1.65	0.77	-0.93	-0.40	0.53
4.	78.41	77.12	74.27	53.54	54.99	53.99	-1.29	-4.14	-2.85	-1.45	-0.45	1.00
5.	83.72	79.62	79.83	46.00	49.58	48.80	-4.10	-3.89	0.21	-3.58	-2.80	0.78
6.	84.17		85.40	54.47		56.95		1.23			-2.48	
7.	90.29	88.49	87.75	50.06	47.70	47.23	-1.80	-2.54	-0.74	2.36	2.83	0.47
8.	83.66		84.77	42.90		41.37		1.11			1.53	
9.	90.08	87.73	89.90	42.43	43.59	44.69	-2.35	-0.18	2.17	-1.16	-2.26	-1.10
10.	93.13	94.36	96.52	46.84	47.53	49.41	1.23	3.39	2.16	-0.69	-2.57	-1.88
11.	91.87	91.09	93.57	40.67	43.30	42.75	-0.78	1.70	2.48	-2.63	-2.08	0.55
12.	103.17	102.60	103.59	46.67	44.62	45.82	-0.57	0.42	0.99	2.05	0.85	-1.20
13.	84.15	83.16	83.80	40.01	41.26	39.21	-0.99	-0.35	0.64	-1.25	0.80	2.05
14.	87.52	87.46	87.34	46.68	47.67	46.53	-0.06	-0.18	-0.12	-0.99	0.15	1.14
15.	88.75	85.58	86.52	47.39	43.85	45.38	-3.17	-2.23	0.94	3.54	2.01	-1.53
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	88.18	88.46	86.99	46.05	45.96	45.97	-1.39	-0.33	0.60	-0.34	-0.18	0.07
STD DEV	7.17	7.57	7.40	4.81	4.40	5.25	1.46	2.31	1.52	2.10	1.99	1.28
MIN	76.63	77.12	74.27	37.38	38.31	37.78	-4.10	-4.14	-2.85	-3.58	-2.80	-1.88
MAX	103.17	102.60	103.59	54.47	54.99	56.95	1.23	3.39	2.48	3.54	2.83	2.05
t value							-3.30	-0.54	1.32	-0.57	-0.33	0.19

TABLE XXIX B.

FRANKFORT FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON MANDIBLE

LOWER INCISOR EDGE

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	100.24	98.58		49.74	49.72		-1.66			0.02		
2.	76.63		78.59	46.00		43.10		1.96			2.90	
3.	86.95	83.78	82.17	37.38	38.39	37.54	-3.17	-4.78	-1.61	-1.01	-0.16	0.85
4.	78.41	77.77	72.99	53.54	55.53	52.58	-0.64	-5.42	-4.78	-1.99	0.96	2.95
5.	83.72	80.97	79.06	46.00	49.60	48.72	-2.75	-4.66	-1.91	-3.60	-2.72	0.88
6.	84.17		83.24	54.47		54.50		-0.93			-0.03	
7.	90.29	89.41	87.53	50.06	48.04	47.19	-0.88	-2.76	-1.88	2.02	2.87	0.85
8.	83.66		83.25	42.90		40.14		-0.41			2.76	
9.	90.08	88.02	88.42	42.43	44.50	40.39	-2.06	-1.66	0.40	-2.07	2.04	4.11
10.	93.13	93.75	94.31	46.84	47.33	47.84	0.62	1.18	0.56	-0.49	-1.00	-0.51
11.	91.87	91.58	93.77	40.67	42.99	42.59	-0.29	1.90	2.19	-2.32	-1.92	0.40
12.	103.17	102.42	100.60	46.67	45.07	44.66	-0.75	-2.57	-1.82	1.60	2.01	0.41
13.	84.15	84.81	84.18	40.01	42.96	41.12	0.66	0.03	-0.63	-2.95	-1.11	1.84
14.	87.52	87.18	86.64	46.68	48.05	46.37	-0.34	-0.88	-0.54	-1.37	0.31	1.68
15.	88.75	88.44	89.59	47.39	45.20	45.48	-0.31	0.84	1.15	2.19	1.91	-0.28
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	88.18	88.89	86.02	46.05	46.45	45.16	-0.96	-1.30	-0.81	-0.83	0.63	1.20
STD DEV	7.17	7.01	7.18	4.81	4.32	4.81	1.22	2.46	1.90	1.94	1.86	1.37
MIN	76.63	77.77	72.99	37.38	38.39	37.54	-3.17	-5.42	-4.78	-3.60	-2.72	-0.51
MAX	103.17	102.42	100.60	54.47	55.53	54.50	0.66	1.96	2.19	2.19	2.90	4.11
t value							-2.74	-1.97	-1.41	-1.48	1.27	2.89

TABLE XXX A.

FRANKFORT FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON MANDIBLE

LOWER INCISOR APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	86.40	86.92		72.79	72.60		0.52			0.19		
2.	69.84		68.14	67.35		63.01		-1.70			4.34	
3.	70.60	70.49	73.26	60.52	57.25	53.88	-0.11	2.66	2.77	3.27	6.64	3.37
4.	63.96	59.82	61.00	75.78	74.67	76.15	-4.14	-2.96	1.18	1.11	-0.37	-1.48
5.	70.86	70.99	70.91	65.91	67.59	67.52	0.13	0.05	-0.08	-1.68	-1.61	0.07
6.	79.58		78.96	77.80		77.02		-0.62			0.78	
7.	80.01	77.89	78.31	69.89	67.78	66.07	-2.12	-1.70	0.42	2.11	3.82	1.71
8.	73.66		74.61	63.57		61.67		0.95			1.90	
9.	69.46	69.36	70.61	64.06	62.48	60.44	-0.10	1.15	1.25	1.58	3.62	2.04
10.	81.75	81.99	83.52	68.79	65.92	64.97	0.24	1.77	1.53	2.87	3.82	0.95
11.	81.47	80.21	80.69	58.63	59.85	57.84	-1.26	-0.78	0.48	-1.22	0.79	2.01
12.	83.98	87.46	87.31	66.21	61.95	64.48	3.48	3.33	-0.15	4.26	1.73	-2.53
13.	73.49	73.23	71.80	60.85	60.30	58.42	-0.26	-1.69	-1.43	0.55	2.43	1.88
14.	73.04	73.87	73.28	66.58	64.62	64.21	0.83	0.24	-0.59	1.96	2.37	0.41
15.	73.20	73.32	72.42	70.40	66.77	66.30	0.12	-0.78	-0.90	3.63	4.10	0.47
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	75.42	75.46	74.63	67.28	65.15	64.43	-0.22	-0.01	0.41	1.55	2.45	0.81
STD DEV	6.37	7.89	6.70	5.49	5.17	6.38	1.81	1.81	1.22	1.86	2.14	1.69
MIN	63.96	59.82	61.00	58.63	57.25	53.88	-4.14	-2.96	-1.43	-1.68	-1.61	-2.53
MAX	86.40	87.46	87.31	77.80	74.67	77.02	3.48	3.33	2.77	4.26	6.64	3.37
t value							-0.43	-0.01	1.11	2.89	4.28	1.58

TABLE XXX B.

FRANKFORT FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON MANDIBLE

LOWER INCISOR APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	86.40	86.13		72.79	73.44		-0.27			-0.65		
2.	69.84		68.59	67.35		63.10		-1.25			4.25	
3.	70.60	69.77	70.27	60.52	57.36	53.74	-0.83	-0.33	0.50	3.16	6.78	3.62
4.	63.96	60.95	61.03	75.78	75.63	75.48	-3.01	-2.93	0.08	0.15	0.30	0.15
5.	70.86	72.13	70.36	65.91	67.51	67.55	1.27	-0.50	-1.77	-1.60	-1.64	-0.04
6.	79.58		76.42	77.80		74.44		-3.16			3.36	
7.	80.01	79.51	79.76	69.89	68.47	66.77	-0.50	-0.25	0.25	1.42	3.12	1.70
8.	73.66		74.42	63.57		61.05		0.76			2.52	
9.	69.46	69.62	71.09	64.06	63.36	58.26	0.16	1.63	1.47	0.70	5.80	5.10
10.	81.75	81.33	81.52	68.79	65.68	63.56	-0.42	-0.23	0.19	3.11	5.23	2.12
11.	81.47	80.38	80.14	58.63	59.33	57.00	-1.09	-1.33	-0.24	-0.70	1.63	2.33
12.	83.98	87.10	84.46	66.21	62.24	63.44	3.12	0.48	-2.64	3.97	2.77	-1.20
13.	73.49	72.91	68.92	60.85	60.83	57.85	-0.58	-4.57	-3.99	0.02	3.00	2.98
14.	73.04	73.66	72.67	66.58	65.05	64.11	0.62	-0.37	-0.99	1.53	2.47	0.94
15.	73.20	76.17	75.70	70.40	68.11	66.54	2.97	2.50	-0.47	2.29	3.86	1.57
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	75.42	75.81	73.95	67.28	65.58	63.78	0.12	-0.68	-0.69	1.12	3.10	1.75
STD DEV	6.37	7.52	6.24	5.49	5.45	6.21	1.71	1.89	1.57	1.76	2.16	1.79
MIN	63.96	60.95	61.03	58.63	57.36	53.74	-3.01	-4.57	-3.99	-1.60	-1.64	-1.20
MAX	86.40	87.10	84.46	77.80	75.63	75.48	3.12	2.50	1.47	3.97	6.78	5.10
t value							0.24	-1.35	-1.46	2.20	5.38	3.25

TABLE XXXI A.

FRANKFORT FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON MANDIBLE

LOWER FIRST MOLAR MESIAL CUSP

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	74.23	75.98		51.37	50.59		1.75			0.78		
2.	51.72		63.16	43.24		41.48		11.44			1.76	
3.	59.32	63.10	65.76	38.63	35.99	35.83	3.78	6.44	2.66	2.64	2.80	0.16
4.	54.16	56.42	58.40	49.50	47.85	50.79	2.26	4.24	1.98	1.65	-1.29	-2.94
5.	54.54	58.57	60.04	43.36	44.97	47.18	4.03	5.50	1.47	-1.61	-3.82	-2.21
6.	65.37		69.37	55.14		54.74		4.00			0.40	
7.	62.79	67.96	67.29	43.80	43.31	43.20	5.17	4.50	-0.67	0.49	0.60	0.11
8.	54.86		59.99	39.71		36.88		5.13			2.83	
9.	62.34	63.96	68.12	38.53	37.88	39.19	1.62	5.78	4.16	0.65	-0.66	-1.31
10.	70.13	69.47	73.15	46.96	46.71	46.49	-0.66	3.02	3.68	0.25	0.47	0.22
11.	68.18	69.63	73.07	40.70	38.88	39.04	1.45	4.89	3.44	1.82	1.66	-0.16
12.	70.90	77.43	78.33	40.53	40.21	41.97	6.53	7.43	0.90	0.32	-1.44	-1.76
13.	60.25	64.51	67.45	40.90	40.73	38.38	4.26	7.20	2.94	0.17	2.52	2.35
14.	61.06	64.71	66.26	44.23	42.13	43.29	3.65	5.20	1.55	2.10	0.94	-1.16
15.	61.45	69.66	71.67	45.19	43.25	46.99	8.21	10.22	2.01	1.94	-1.80	-3.74
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	62.09	66.78	67.29	44.12	42.71	43.25	3.50	6.07	2.19	0.93	0.35	-0.95
STD DEV	6.71	6.24	5.68	4.85	4.31	5.46	2.43	2.36	1.39	1.16	1.96	1.71
MIN	51.72	56.42	58.40	38.53	35.99	35.83	-0.66	3.02	-0.67	-1.61	-3.82	-3.74
MAX	74.23	77.43	78.33	55.14	50.59	54.74	8.21	11.44	4.16	2.64	2.83	2.35
t value							5.00	9.64	5.24	2.79	0.68	-1.84

TABLE XXXI B.

FRANKFORT FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON MANDIBLE

LOWER FIRST MOLAR MESIAL CUSP

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	74.23	74.77		51.37	51.64		0.54			-0.27		
2.	51.72		62.38	43.24		41.90		10.66			1.34	
3.	59.32	62.34	62.61	38.63	36.11	35.77	3.02	3.29	0.27	2.52	2.86	0.34
4.	54.16	56.90	56.96	49.50	48.90	50.32	2.74	2.80	0.06	0.60	-0.82	-1.42
5.	54.54	59.98	59.24	43.36	44.74	47.33	5.44	4.70	-0.74	-1.38	-3.97	-2.59
6.	65.37		67.25	55.14		51.99		1.88			3.15	
7.	62.79	68.75	66.80	43.80	44.35	44.95	5.96	4.01	-1.95	-0.55	-1.15	-0.60
8.	54.86		58.24	39.71		37.25		3.38			2.46	
9.	62.34	64.26	66.16	38.53	38.75	37.45	1.92	3.82	1.90	-0.22	1.08	1.30
10.	70.13	68.86	70.91	46.96	46.43	45.21	-1.27	0.78	2.05	0.53	1.75	1.22
11.	68.18	70.21	73.49	40.70	38.15	37.83	2.03	5.31	3.28	2.55	2.87	0.32
12.	70.90	77.29	75.31	40.53	40.41	40.99	6.39	4.41	-1.98	0.12	-0.46	-0.58
13.	60.25	66.32	68.25	40.90	40.44	37.35	6.07	8.00	1.93	0.46	3.55	3.09
14.	61.06	64.40	65.54	44.23	42.60	43.23	3.34	4.48	1.14	1.63	1.00	-0.63
15.	61.45	72.52	74.76	45.19	44.59	47.24	11.07	13.31	2.24	0.60	-2.05	-2.65
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	62.09	67.22	66.28	44.12	43.09	42.77	3.94	5.06	0.75	0.55	0.83	-0.20
STD DEV	6.71	6.04	5.96	4.85	4.58	5.26	3.26	3.41	1.76	1.18	2.23	1.71
MIN	51.72	56.90	56.96	38.53	36.11	35.77	-1.27	0.78	-1.98	-1.38	-3.97	-2.65
MAX	74.23	77.29	75.31	55.14	51.64	51.99	11.07	13.31	3.28	2.55	3.55	3.09
t value							4.19	5.55	1.41	1.61	1.39	-0.39

TABLE XXXII A.

FRANKFORT FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON MANDIBLE

LOWER FIRST MOLAR MESIAL APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	64.13	70.89		74.95	72.12		6.76			2.83		
2.	43.69		55.14	62.26		63.36		11.45			-1.10	
3.	48.54	53.37	57.68	56.49	55.15	52.36	4.83	9.14	4.31	1.34	4.13	2.79
4.	42.38	45.53	48.34	68.32	67.68	69.68	3.15	5.96	2.81	0.64	-1.36	-2.00
5.	45.80	51.33	51.23	63.87	64.18	64.60	5.53	5.43	-0.10	-0.31	-0.73	-0.42
6.	55.65		61.20	75.62		73.84		5.55			1.78	
7.	53.78	58.75	60.58	66.04	64.31	64.68	4.97	6.80	1.83	1.73	1.36	-0.37
8.	47.63		53.56	60.27		57.53		5.93			2.74	
9.	42.52	47.17	52.99	53.27	55.46	57.25	4.65	10.47	5.82	-2.19	-3.98	-1.79
10.	61.14	60.23	66.03	68.02	68.25	68.00	-0.91	4.89	5.80	-0.23	0.02	0.25
11.	57.67	60.22	64.28	58.67	57.90	59.27	2.55	6.61	4.06	0.77	-0.60	-1.37
12.	55.75	65.86	66.58	63.63	61.30	61.68	10.11	10.83	0.72	2.33	1.95	-0.38
13.	52.31	57.19	58.61	62.83	62.53	60.24	4.88	6.30	1.42	0.30	2.59	2.29
14.	51.57	55.71	54.28	62.85	62.28	60.45	4.14	2.71	-1.43	0.57	2.40	1.83
15.	51.14	58.60	61.03	65.65	66.32	68.08	7.46	9.89	2.43	-0.67	-2.43	-1.76
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	51.58	57.07	57.97	64.18	63.12	62.93	4.84	7.28	2.52	0.59	0.48	-0.08
STD DEV	6.62	7.22	5.62	6.07	5.18	5.71	2.71	2.61	2.34	1.38	2.29	1.70
MIN	42.38	45.53	48.34	53.27	55.15	52.36	-0.91	2.71	-1.43	-2.19	-3.98	-2.00
MAX	64.13	70.89	66.58	75.62	72.12	73.84	10.11	11.45	5.82	2.83	4.13	2.79
t value							6.20	10.43	3.57	1.49	0.79	-0.16

TABLE XXXII B.

FRANKFORT FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON MANDIBLE

LOWER FIRST MOLAR MESIAL APEX

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	64.13	70.09		74.95	73.27		5.96			1.68		
2.	43.69		55.63	62.26		64.20		11.94			-1.94	
3.	48.54	52.65	54.68	56.49	55.29	52.36	4.11	6.14	2.03	1.20	4.13	2.93
4.	42.38	46.50	48.03	68.32	68.99	69.76	4.12	5.65	1.53	-0.67	-1.44	-0.77
5.	45.80	52.51	50.64	63.87	63.87	64.86	6.71	4.84	-1.87	0.00	-0.99	-0.99
6.	55.65		58.72	75.62		70.94		3.07			4.68	
7.	53.78	60.26	61.97	66.04	65.65	66.93	6.48	8.19	1.71	0.39	-0.89	-1.28
8.	47.63		53.15	60.27		58.28		5.52			1.99	
9.	42.52	47.44	53.22	53.27	56.30	57.14	4.92	10.70	5.78	-3.03	-3.87	-0.84
10.	61.14	59.56	64.06	68.02	67.95	66.82	-1.58	2.92	4.50	0.07	1.20	1.13
11.	57.67	60.44	63.68	58.67	56.99	57.60	2.77	6.01	3.24	1.68	1.07	-0.61
12.	55.75	65.50	63.71	63.63	61.37	60.80	9.75	7.96	-1.79	2.26	2.83	0.57
13.	52.31	56.72	55.62	62.83	61.34	57.26	4.41	3.31	-1.10	1.49	5.57	4.08
14.	51.57	55.49	53.65	62.85	62.79	60.45	3.92	2.08	-1.84	0.06	2.40	2.34
15.	51.14	61.45	64.32	65.65	67.65	68.43	10.31	13.18	2.87	-2.00	-2.78	-0.78
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	51.58	57.38	57.22	64.18	63.46	62.56	5.16	6.54	1.37	0.26	0.85	0.53
STD DEV	6.62	6.97	5.48	6.07	5.55	5.64	3.13	3.46	2.69	1.58	2.91	1.85
MIN	42.38	46.50	48.03	53.27	55.29	52.36	-1.58	2.08	-1.87	-3.03	-3.87	-1.28
MAX	64.13	70.09	64.32	75.62	73.27	70.94	10.31	13.18	5.78	2.26	5.57	4.08
t value							5.70	7.06	1.69	0.57	1.10	0.94

TABLE XXXIII A.

FRANKFORT FRAME OF REFERENCE
ANATOMICAL SUPERIMPOSITION ON MANDIBLE

POINT B

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	91.56	91.97		72.11	72.03		0.41			0.08		
2.	74.65		73.13	63.04		61.25		-1.52			1.79	
3.	79.82	78.61	78.68	54.16	53.04	51.47	-1.21	-1.14	0.07	1.12	2.69	1.57
4.	69.31	67.77	66.99	74.53	71.81	74.40	-1.54	-2.32	-0.78	2.72	0.13	-2.59
5.	77.42	76.30	76.09	63.73	63.99	63.40	-1.12	-1.33	-0.21	-0.26	0.33	0.59
6.	83.88		83.74	72.97		73.11		-0.14			-0.14	
7.	85.14	83.37	82.76	66.23	64.07	64.08	-1.77	-2.38	-0.61	2.16	2.15	-0.01
8.	78.50		77.34	63.91		61.27		-1.16			2.64	
9.	73.80	75.05	77.05	65.74	62.05	61.62	1.25	3.25	2.00	3.69	4.12	0.43
10.	89.05	89.36	88.80	66.93	63.84	67.98	0.31	-0.25	-0.56	3.09	-1.05	-4.14
11.	87.97	86.25	86.30	53.92	56.21	56.06	-1.72	-1.67	0.05	-2.29	-2.14	0.15
12.	92.93	93.48	93.55	61.92	59.96	61.75	0.55	0.62	0.07	1.96	0.17	-1.79
13.	79.70	79.01	78.70	57.46	56.16	54.04	-0.69	-1.00	-0.31	1.30	3.42	2.12
14.	79.53	79.48	78.53	66.28	63.27	65.57	-0.05	-1.00	-0.95	3.01	0.71	-2.30
15.	80.99	79.27	78.60	65.98	63.44	64.40	-1.72	-2.39	-0.67	2.54	1.58	-0.96
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	81.62	81.66	80.02	64.59	62.49	62.89	-0.61	-0.89	-0.17	1.59	1.17	-0.63
STD DEV	6.76	7.52	6.66	6.12	5.73	6.43	1.06	1.47	0.80	1.72	1.76	1.91
MIN	69.31	67.77	66.99	53.92	53.04	51.47	-1.77	-2.39	-0.95	-2.29	-2.14	-4.14
MAX	92.93	93.48	93.55	74.53	72.03	74.40	1.25	3.25	2.00	3.69	4.12	2.12
t value							-1.99	-2.25	-0.71	3.22	2.49	-1.09

TABLE XXXIII B.

FRANKFORT FRAME OF REFERENCE
IMPLANT SUPERIMPOSITION ON MANDIBLE

POINT B

	X1	X2	X4	Y1	Y2	Y4	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	91.56	91.16		72.11	72.77		-0.40			-0.66		
2.	74.65		73.47	63.04		61.05		-1.18			1.99	
3.	79.82	77.88	75.67	54.16	53.13	51.29	-1.94	-4.15	-2.21	1.03	2.87	1.84
4.	69.31	68.83	66.91	74.53	72.58	73.39	-0.48	-2.40	-1.92	1.95	1.14	-0.81
5.	77.42	77.48	75.49	63.73	63.97	63.36	0.06	-1.93	-1.99	-0.24	0.37	0.61
6.	83.88		81.28	72.97		70.63		-2.60			2.34	
7.	85.14	84.85	84.03	66.23	64.57	64.40	-0.29	-1.11	-0.82	1.66	1.83	0.17
8.	78.50		77.12	63.91		60.48		-1.38			3.43	
9.	73.80	75.31	77.62	65.74	62.94	58.69	14.91	3.82	-11.09	2.80	7.05	4.25
10.	89.05	88.71	86.83	66.93	63.62	66.51	-2.56	-2.22	0.34	3.31	0.42	-2.89
11.	87.97	86.49	85.83	53.92	55.80	55.51	5.17	-2.14	-7.31	-1.88	-1.59	0.29
12.	92.93	93.14	90.68	61.92	60.32	60.67	-13.83	-2.25	11.58	1.60	1.25	-0.35
13.	79.70	79.10	76.50	57.46	57.34	54.78	-0.43	-3.20	-2.77	0.12	2.68	2.56
14.	79.53	79.27	77.92	66.28	63.68	65.45	2.59	-1.61	-4.20	2.60	0.83	-1.77
15.	80.99	82.12	81.86	65.98	64.79	64.57	1.13	0.87	-0.26	1.19	1.41	0.22
N	15	12	14	15	12	14	12	14	11	12	14	11
MEAN	81.62	82.03	79.37	64.59	62.96	62.20	0.33	-1.53	-1.88	1.12	1.86	0.37
STD DEV	6.76	7.09	6.17	6.12	5.90	6.04	6.45	1.92	5.57	1.54	1.96	1.98
MIN	69.31	68.83	66.91	53.92	53.13	51.29	-13.83	-4.15	-11.09	-1.88	-1.59	-2.89
MAX	92.93	93.14	90.68	74.53	72.77	73.39	14.91	3.82	11.58	3.31	7.05	4.25
t value							0.18	-2.99	-1.12	2.53	3.56	0.63

TABLE XXXIV A. LOWER FIRST MOLAR ANGLE TO FRANKFORT ANATOMICAL SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	66.81	76.70		9.89		
2.	67.11		69.87		2.76	
3.	58.89	63.08	63.95	4.19	5.06	0.87
4.	57.96	61.23	61.96	3.27	4.01	0.74
5.	66.92	69.35	63.17	2.43	-3.75	-6.18
6.	64.61		66.84		2.23	
7.	67.95	66.32	72.65	-1.63	4.71	6.33
8.	70.63		72.70		2.08	
9.	36.64	46.32	50.04	9.68	13.41	3.73
10.	66.88	66.78	71.69	-0.10	4.80	4.90
11.	59.68	63.68	66.51	4.00	6.84	2.84
12.	56.74	61.25	59.20	4.51	2.46	-2.05
13.	70.10	71.44	67.98	1.34	-2.11	-3.46
14.	62.99	65.93	55.08	2.94	-7.91	-10.85
15.	63.26	64.39	63.23	1.13	-0.03	-1.16
N	15	12	14	12	14	11
MEAN	62.48	64.70	64.63	3.47	2.47	-0.39
STD DEV	8.37	7.29	6.63	3.46	5.06	5.09
MIN	36.64	46.32	50.04	-1.63	-7.91	-10.85
MAX	70.63	76.70	72.70	9.89	13.41	6.33
t value				3.47	1.83	-0.25

TABLE XXXIV B. LOWER FIRST MOLAR ANGLE TO FRANKFORT IMPLANT SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	66.81	77.79		10.98		
2.	67.11		73.16		6.05	
3.	58.89	63.20	64.45	4.31	5.57	1.26
4.	57.96	62.63	65.33	4.67	7.37	2.70
5.	66.92	68.67	63.87	1.75	-3.05	-4.80
6.	64.61		65.77		1.16	
7.	67.95	68.27	77.61	0.32	9.66	9.34
8.	70.63		76.39		5.77	
9.	36.64	46.22	56.69	9.58	20.05	10.47
10.	66.88	66.63	72.41	-0.26	5.53	5.78
11.	59.68	62.59	63.61	2.91	3.93	1.02
12.	56.74	60.64	59.65	3.90	2.91	-0.99
13.	70.10	65.33	57.61	-4.77	-12.49	-7.72
14.	62.99	66.19	55.38	3.19	-7.62	-10.81
15.	63.26	64.36	63.77	1.10	0.52	-0.59
N	15	12	14	12	14	11
MEAN	62.48	64.38	65.41	3.14	3.24	0.51
STD DEV	8.37	7.22	7.12	4.21	7.76	6.62
MIN	36.64	46.22	55.38	-4.77	-12.49	-10.81
MAX	70.63	77.79	77.61	10.98	20.05	10.47
t value				2.58	1.56	0.26

TABLE XXXV A. LOWER INCISOR ANGLE TO MANDIBULAR PLANE
ANATOMIC SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	94.01	85.33		-2.17		
2.	82.30		89.31		12.21	
3.	100.58	103.94	106.17	1.31	1.55	0.24
4.	81.95	90.63	79.26	8.30	-2.10	-10.40
5.	99.76	94.24	94.77	-7.26	-7.38	-0.13
6.	77.75		86.36		6.66	
7.	90.87	89.45	89.57	0.43	-0.79	-1.22
8.	89.40		95.47		0.77	
9.	94.75	98.88	107.52	0.57	7.14	6.57
10.	97.69	105.62	112.85	6.52	12.47	5.95
11.	98.71	104.09	113.82	3.25	10.41	7.16
12.	107.67	105.31	106.50	-3.34	-3.38	-0.04
13.	99.54	102.58	111.24	0.45	4.90	4.45
14.	96.10	98.47	98.66	2.68	2.45	-0.23
15.	94.26	86.31	93.05	-5.91	-0.07	5.84
N	15	12	14	12	14	11
MEAN	93.69	97.07	98.90	0.40	3.20	1.65
STD DEV	8.06	7.59	10.88	4.60	6.00	5.13
MIN	77.75	85.33	79.26	-7.26	-7.38	-10.40
MAX	107.67	105.62	113.82	8.30	12.47	7.16
t value				0.30	2.00	1.07

TABLE XXXV B. LOWER INCISOR ANGLE TO MANDIBULAR PLANE
IMPLANT SUPERIMPOSITION

	ANGLE @ T1	ANGLE @ T2	ANGLE @ T4	ANGLE T1-T2	ANGLE T1-T4	ANGLE T2-T4
1.	94.01	84.21		-3.29		
2.	82.30		86.02		8.92	
3.	100.58	103.84	105.68	1.20	1.06	-0.15
4.	81.95	89.23	75.93	6.91	-5.44	-12.35
5.	99.76	94.91	94.09	-6.59	-8.06	-1.47
6.	77.75		87.45		7.75	
7.	90.87	87.47	84.60	-1.55	-5.76	-4.21
8.	89.40		91.77		-2.92	
9.	94.75	98.97	100.87	0.66	0.49	-0.17
10.	97.69	105.78	112.10	6.69	11.73	5.04
11.	98.71	105.20	116.75	4.35	13.33	8.98
12.	107.67	105.91	106.08	-2.74	-3.81	-1.06
13.	99.54	108.70	121.62	6.57	15.28	8.71
14.	96.10	98.25	98.39	2.45	2.18	-0.28
15.	94.26	86.34	92.48	-5.88	-0.64	5.23
N	15	12	14	12	14	11
MEAN	93.69	97.40	98.13	0.73	2.44	0.75
STD DEV	8.06	8.76	13.15	4.81	7.66	6.14
MIN	77.75	84.21	75.93	-6.59	-8.06	-12.35
MAX	107.67	108.70	121.62	6.91	15.28	8.98
t value				0.53	1.19	0.41

TABLE XXII C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

UPPER INCISAL EDGE

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	1.91			-1.13		
2.		-0.30			3.00	
3.	1.04	2.47	1.43	1.04	-0.06	-1.10
4.	0.69	-1.68	-2.37	1.57	-3.01	-4.58
5.	-0.89	0.34	1.23	0.07	0.71	0.64
6.		3.32			-0.86	
7.	2.71	2.33	-0.38	1.19	0.01	-1.18
8.		1.73			4.08	
9.	-0.55	2.05	2.60	1.73	3.86	2.13
10.	-0.84	1.55	2.39	0.88	1.10	0.22
11.	0.97	1.89	0.92	0.14	1.99	1.85
12.	3.09	4.55	1.46	2.60	3.29	0.69
13.	-1.80	3.82	5.62	0.25	1.87	1.62
14.	-0.63	1.96	2.59	0.15	-3.21	-3.36
15.	-2.23	0.35	2.58	-0.74	1.29	2.03
N	12	14	11	12	14	11
MEAN	0.29	1.74	1.64	0.65	1.00	-0.09
STD DEV	1.72	1.65	2.00	1.06	2.29	2.25
MIN	-2.23	-1.68	-2.37	-1.13	-3.21	-4.58
MAX	3.09	4.55	5.62	2.60	4.08	2.13
t value	0.58	3.94	2.72	2.11	1.64	-0.14

TABLE XXIII C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

UPPER INCISOR APEX

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	3.24			-0.92		
2.		-0.85			2.75	
3.	0.84	2.03	1.19	0.98	-0.17	-1.15
4.	-0.50	2.74	3.24	1.17	-1.81	-2.98
5.	-0.54	-0.37	0.17	0.12	0.63	0.51
6.		4.10			-0.77	
7.	1.93	2.75	0.82	1.01	0.11	-0.90
8.		1.95			4.17	
9.	-1.66	0.93	2.59	1.34	3.46	2.12
10.	-1.46	1.02	2.48	0.70	0.96	0.26
11.	-0.19	0.71	0.90	-0.30	1.63	1.93
12.	2.53	3.97	1.44	2.48	3.11	0.63
13.	-0.96	0.78	1.74	0.69	0.76	0.07
14.	-0.94	5.65	6.59	0.11	-2.18	-2.29
15.	-1.34	0.13	1.47	-0.61	1.26	1.87
N	12	14	11	12	14	11
MEAN	0.08	1.82	2.06	0.56	0.99	0.01
STD DEV	1.66	1.86	1.74	0.94	1.91	1.69
MIN	-1.66	-0.85	0.17	-0.92	-2.18	-2.98
MAX	3.24	5.65	6.59	2.48	4.17	2.12
t value	0.17	3.68	3.91	2.07	1.94	0.01

TABLE XXIV C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

UPPER FIRST MOLAR MESIAL CUSP

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	2.41			0.28		
2.		-0.41			2.31	
3.	1.02	2.36	1.34	0.82	-0.53	-1.35
4.	0.50	-1.38	-1.88	0.54	0.68	0.14
5.	-0.78	0.13	0.91	0.46	-0.04	-0.50
6.		3.45			-0.10	
7.	2.47	2.48	0.01	0.32	0.46	0.14
8.		1.76			4.35	
9.	-0.84	1.68	2.52	0.55	2.74	2.19
10.	-0.91	1.45	2.36	0.12	0.44	0.32
11.	0.72	1.66	0.94	-1.16	0.58	1.74
12.	2.95	4.44	1.49	1.92	2.60	0.68
13.	-1.78	3.33	5.11	1.17	-0.93	-2.10
14.	-0.74	2.62	3.36	-0.14	1.08	1.22
15.	-2.05	0.31	2.36	0.06	1.13	1.07
N	12	14	11	12	14	11
MEAN	0.25	1.71	1.68	0.41	1.06	0.32
STD DEV	1.70	1.61	1.82	0.74	1.46	1.28
MIN	-2.05	-1.38	-1.88	-1.16	-0.93	-2.10
MAX	2.95	4.44	5.11	1.92	4.35	2.19
t value	0.50	3.97	3.08	1.92	2.70	0.84

TABLE XXV C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

UPPER FIRST MOLAR MESIAL APEX

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	3.47			0.03		
2.		-0.91			2.35	
3.	0.83	1.93	1.10	0.82	-0.55	-1.37
4.	-0.28	1.84	2.12	0.60	0.55	-0.05
5.	-0.49	-0.34	0.15	0.42	-0.03	-0.45
6.		4.15			-0.17	
7.	1.80	2.83	1.03	0.41	0.44	0.03
8.		1.93			4.35	
9.	-1.69	0.79	2.48	0.62	2.75	2.13
10.	-1.43	1.03	2.46	0.18	0.45	0.27
11.	-0.31	0.70	1.01	-0.97	0.76	1.73
12.	2.43	3.94	1.51	1.96	2.66	0.70
13.	-0.96	0.88	1.84	1.18	-0.80	-1.98
14.	-0.97	5.89	6.86	-0.13	1.17	1.30
15.	-1.20	0.12	1.32	0.02	1.11	1.09
N	12	14	11	12	14	11
MEAN	0.10	1.77	1.99	0.43	1.07	0.31
STD DEV	1.66	1.89	1.76	0.73	1.46	1.26
MIN	-1.69	-0.91	0.15	-0.97	-0.80	-1.98
MAX	3.47	5.89	6.86	1.96	4.35	2.13
t value	0.21	3.51	3.75	2.05	2.75	0.81

TABLE XXVI C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

POINT A

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	2.95			-1.16		
2.		-0.82			2.88	
3.	0.88	2.09	1.21	1.02	-0.07	-1.09
4.	-0.36	2.00	2.36	1.40	-2.60	-4.00
5.	-0.59	-0.29	0.30	0.03	0.81	0.78
6.		4.04			-0.91	
7.	1.89	2.72	0.83	1.12	0.04	-1.08
8.		1.90			4.12	
9.	-5.16	0.89	6.05	1.48	3.65	2.17
10.	1.73	1.01	-0.72	0.83	1.04	0.21
11.	-10.34	0.82	11.16	0.09	1.82	1.73
12.	14.35	3.99	-10.36	2.56	3.18	0.62
13.	-4.64	1.03	5.67	0.45	1.32	0.87
14.	-4.34	5.59	9.93	0.15	-2.79	-2.94
15.	-1.35	0.15	1.50	-0.75	1.29	2.04
N	12	14	11	12	14	11
MEAN	-0.42	1.79	2.54	0.60	0.98	-0.06
STD DEV	6.00	1.80	5.82	1.02	2.13	2.02
MIN	-10.34	-0.82	-10.36	-1.16	-2.79	-4.00
MAX	14.35	5.59	11.16	2.56	4.12	2.17
t value	-0.24	3.73	1.45	2.04	1.73	-0.10

TABLE XXVII C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

UPPER FIRST MOLAR TO PLATAL PLANE

	@ T1	@ T2	@ T4	T1-T2	T1-T4	T2-T4
1.	0.00	2.82		2.82		
2.	0.00		-1.43		-1.43	
3.	0.00	-0.50	-1.16	-0.50	-1.16	-0.66
4.	0.00	-2.45	8.94	-2.45	8.94	11.39
5.	0.00	0.89	-1.70	0.89	-1.70	-2.60
6.	0.00		1.94		1.94	
7.	0.00	-1.90	0.96	-1.90	0.96	2.86
8.	0.00		0.47		0.47	
9.	0.00	-2.20	-2.21	-2.20	-2.21	-0.01
10.	0.00	-1.54	-1.47	-1.54	-1.47	0.07
11.	0.00	-2.84	-2.91	-2.84	-2.91	-0.07
12.	0.00	-1.28	-1.27	-1.28	-1.27	0.01
13.	0.00	2.15	-6.98	2.15	-6.98	-9.14
14.	0.00	-0.70	9.00	-0.70	9.00	9.71
15.	0.00	2.09	-0.49	2.09	-0.49	-2.58
N	15	12	14	12	14	11
MEAN	0.00	-0.45	0.12	-0.45	0.12	0.82
STD DEV	0.00	1.97	4.28	1.97	4.28	5.67
MIN	0.00	-2.84	-6.98	-2.84	-6.98	-9.14
MAX	0.00	2.82	9.00	2.82	9.00	11.39
t value		-0.80	0.11	-0.80	0.11	0.48

TABLE XXVIII C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

UPPER INCISOR TO PLATAL PLANE

	@ T1	@ T2	@ T4	T1-T2	T1-T4	T2-T4
1.	0.00	2.82		2.82		
2.	0.00		-1.41		-1.41	
3.	0.00	-0.49	-1.15	-0.49	-1.15	-0.66
4.	0.00	-2.46	8.96	-2.46	8.96	11.42
5.	0.00	0.88	-1.75	0.88	-1.75	-2.63
6.	0.00		1.89		1.89	
7.	0.00	-1.89	1.00	-1.89	1.00	2.88
8.	0.00		0.49		0.49	
9.	0.00	-2.19	-2.24	-2.19	-2.24	-0.05
10.	0.00	-1.54	-1.42	-1.54	-1.42	0.12
11.	0.00	-2.83	-2.95	-2.83	-2.95	-0.11
12.	0.00	-1.30	-1.30	-1.30	-1.30	.00
13.	0.00	2.15	-6.95	2.15	-6.95	-9.10
14.	0.00	-0.71	9.00	-0.71	9.00	9.71
15.	0.00	2.06	-0.51	2.06	-0.51	-2.57
N	15	12	14	12	14	11
MEAN	0.00	-0.46	0.12	-0.46	0.12	0.82
STD DEV	0.00	1.96	4.28	1.96	4.28	5.68
MIN	0.00	-2.83	-6.95	-2.83	-6.95	-9.10
MAX	0.00	2.82	9.00	2.82	9.00	11.42
t value		-0.81	0.10	-0.81	0.10	0.48

TABLE XXIX C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

LOWER INCISAL EDGE

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	1.25			0.59		
2.		0.68			-0.52	
3.	0.75	3.13	2.38	0.08	-0.24	-0.32
4.	-0.65	1.28	1.93	0.54	-1.41	-1.95
5.	-1.35	0.77	2.12	0.02	-0.08	-0.10
6.		2.16			-2.45	
7.	-0.92	0.22	1.14	0.34	-0.04	-0.38
8.		1.52			-1.23	
9.	-0.29	1.48	1.77	0.91	-4.30	-5.21
10.	0.61	2.21	1.60	-0.20	-1.57	-1.37
11.	-0.49	-0.20	0.29	-0.31	-0.16	0.15
12.	0.18	2.99	2.81	0.45	-1.16	-1.61
13.	-1.65	-0.38	1.27	1.70	1.91	0.21
14.	0.28	0.70	0.42	0.38	-0.16	-0.54
15.	-2.86	-3.07	-0.21	1.35	0.10	-1.25
N	12	14	11	12	14	11
MEAN	-0.43	0.96	1.41	0.49	-0.81	-1.12
STD DEV	1.16	1.58	0.94	0.60	1.43	1.54
MIN	-2.86	-3.07	-0.21	-0.31	-4.30	-5.21
MAX	1.25	3.13	2.81	1.70	1.91	0.21
t value	-1.28	2.28	4.99	2.82	-2.11	-2.42

TABLE XXX C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

LOWER INCSOR APEX

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	0.79			0.84		
2.		-0.45			0.09	
3.	0.72	2.99	2.27	0.11	-0.14	-0.25
4.	-1.13	-0.03	1.10	0.96	-0.67	-1.63
5.	-1.14	0.55	1.69	-0.08	0.03	0.11
6.		2.54			-2.58	
7.	-1.62	-1.45	0.17	0.69	0.70	0.01
8.		0.19			-0.62	
9.	-0.26	-0.48	-0.22	0.88	-2.18	-3.06
10.	0.66	2.00	1.34	-0.24	-1.41	-1.17
11.	-0.17	0.55	0.72	-0.52	-0.84	-0.32
12.	0.36	2.85	2.49	0.29	-1.04	-1.33
13.	0.32	2.88	2.56	0.53	-0.57	-1.10
14.	0.21	0.61	0.40	0.43	-0.10	-0.53
15.	-2.85	-3.28	-0.43	1.34	0.24	-1.10
N	12	14	11	12	14	11
MEAN	-0.34	0.68	1.10	0.44	-0.65	-0.94
STD DEV	1.12	1.83	1.07	0.55	0.92	0.91
MIN	-2.85	-3.28	-0.43	-0.52	-2.58	-3.06
MAX	0.79	2.99	2.56	1.34	0.70	0.11
t value	-1.06	1.38	3.41	2.76	-2.64	-3.44

TABLE XXXI C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

LOWER FIRST MOLAR MESIAL CUSP

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	1.21			1.05		
2.		0.78			0.42	
3.	0.76	3.15	2.39	0.12	-0.06	-0.18
4.	-0.48	1.44	1.92	1.05	-0.47	-1.52
5.	-1.41	0.80	2.21	-0.23	0.15	0.38
6.		2.12			-2.75	
7.	-0.79	0.49	1.28	1.04	1.75	0.71
8.		1.75			0.37	
9.	-0.30	1.96	2.26	0.87	-1.74	-2.61
10.	0.61	2.24	1.63	-0.28	-1.28	-1.00
11.	-0.58	-0.42	0.16	-0.73	-1.21	-0.48
12.	0.14	3.02	2.88	0.20	-0.98	-1.18
13.	-1.81	-0.80	1.01	-0.29	-1.03	-0.74
14.	0.31	0.72	0.41	0.47	-0.06	-0.53
15.	-2.86	-3.09	-0.23	1.34	0.25	-1.09
N	12	14	11	12	14	11
MEAN	-0.43	1.01	1.45	0.38	-0.47	-0.75
STD DEV	1.17	1.65	1.01	0.68	1.12	0.91
MIN	-2.86	-3.09	-0.23	-0.73	-2.75	-2.61
MAX	1.21	3.15	2.88	1.34	1.75	0.71
t value	-1.29	2.29	4.75	1.96	-1.59	-2.73

TABLE XXXII C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

LOWER FIRST MOLAR MESIAL APEX

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	0.80			1.15		
2.		-0.49			0.84	
3.	0.72	3.00	2.28	0.14	0.00	-0.14
4.	-0.97	0.31	1.28	1.31	0.08	-1.23
5.	-1.18	0.59	1.77	-0.31	0.26	0.57
6.		2.48			-2.90	
7.	-1.51	-1.39	0.12	1.34	2.25	0.91
8.		0.41			0.75	
9.	-0.27	-0.23	0.04	0.84	-0.11	-0.95
10.	0.67	1.97	1.30	-0.30	-1.18	-0.88
11.	-0.22	0.60	0.82	-0.91	-1.67	-0.76
12.	0.36	2.87	2.51	0.07	-0.88	-0.95
13.	0.47	2.99	2.52	-1.19	-2.98	-1.79
14.	0.22	0.63	0.41	0.51	0.00	-0.51
15.	-2.85	-3.29	-0.44	1.33	0.35	-0.98
N	12	14	11	12	14	11
MEAN	-0.31	0.75	1.15	0.33	-0.37	-0.61
STD DEV	1.12	1.82	1.04	0.89	1.44	0.79
MIN	-2.85	-3.29	-0.44	-1.19	-2.98	-1.79
MAX	0.80	3.00	2.52	1.34	2.25	0.91
t value	-0.97	1.54	3.64	1.29	-0.96	-2.57

TABLE XXXIII C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

POINT B

	X1-X2	X1-X4	X2-X4	Y1-Y2	Y1-Y4	Y2-Y4
1.	0.81			0.74		
2.		-0.34			-0.20	
3.	0.73	3.01	2.28	0.09	-0.18	-0.27
4.	-1.06	0.08	1.14	0.77	-1.01	-1.78
5.	-1.18	0.60	1.78	-0.02	-0.04	-0.02
6.		2.46			-2.48	
7.	-1.48	-1.27	0.21	0.50	0.32	-0.18
8.		0.22			-0.79	
9.	-13.66	-0.57	13.09	0.89	-2.93	-3.82
10.	2.87	1.97	-0.90	-0.22	-1.47	-1.25
11.	-6.89	0.47	7.36	-0.41	-0.55	-0.14
12.	14.38	2.87	-11.51	0.36	-1.08	-1.44
13.	-0.26	2.20	2.46	1.18	0.74	-0.44
14.	-2.64	0.61	3.25	0.41	-0.12	-0.53
15.	-2.85	-3.26	-0.41	1.35	0.17	-1.18
N	12	14	11	12	14	11
MEAN	-0.94	0.65	1.70	0.47	-0.69	-1.00
STD DEV	6.46	1.75	5.94	0.55	1.04	1.11
MIN	-13.66	-3.26	-11.51	-0.41	-2.93	-3.82
MAX	14.38	3.01	13.09	1.35	0.74	-0.02
t value	-0.50	1.38	0.95	2.99	-2.46	-3.01

TABLE XXXIV C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

LOWER FIRST MOLAR ANGLE TO FRANKFORT

	@ T1	@ T2	@ T4	T1-T2	T1-T4	T2-T4
1.	0.00	1.09		1.09		
2.	0.00		3.29		3.29	
3.	0.00	0.12	0.50	0.12	0.50	0.38
4.	0.00	1.40	3.37	1.40	3.37	1.96
5.	0.00	-0.68	0.70	-0.68	0.70	1.37
6.	0.00		-1.08		-1.08	
7.	0.00	1.95	4.95	1.95	4.95	3.01
8.	0.00		3.69		3.69	
9.	0.00	-0.10	6.64	-0.10	6.64	6.74
10.	0.00	-0.15	0.73	-0.15	0.73	0.88
11.	0.00	-1.09	-2.91	-1.09	-2.91	-1.82
12.	0.00	-0.61	0.45	-0.61	0.45	1.06
13.	0.00	-6.11	-10.37	-6.11	-10.37	-4.26
14.	0.00	0.26	0.30	0.26	0.30	0.04
15.	0.00	-0.03	0.54	-0.03	0.54	0.57
N	15	12	14	12	14	11
MEAN	0.00	-0.33	0.77	-0.33	0.77	0.90
STD DEV	0.00	2.03	4.07	2.03	4.07	2.74
MIN	0.00	-6.11	-10.37	-6.11	-10.37	-4.26
MAX	0.00	1.95	6.64	1.95	6.64	6.74
t value		-0.56	0.71	-0.56	0.71	1.09

TABLE XXXV C. DIFFERENCES BETWEEN SUPERIMPOSITIONS

LOWER INCISOR ANGLE TO MANDIBULAR PLANE

	@ T1	@ T2	@ T4	T1-T2	T1-T4	T2-T4
1.	0.00	-1.12		-1.12		
2.	0.00		-3.29		-3.29	
3.	0.00	-0.10	-0.49	-0.10	-0.49	-0.39
4.	0.00	-1.39	-3.34	-1.39	-3.34	-1.94
5.	0.00	0.67	-0.68	0.67	-0.68	-1.35
6.	0.00		1.09		1.09	
7.	0.00	-1.98	-4.97	-1.98	-4.97	-2.99
8.	0.00		-3.69		-3.69	
9.	0.00	0.09	-6.65	0.09	-6.65	-6.74
10.	0.00	0.17	-0.75	0.17	-0.75	-0.91
11.	0.00	1.11	2.92	1.11	2.92	1.82
12.	0.00	0.60	-0.43	0.60	-0.43	-1.03
13.	0.00	6.12	10.38	6.12	10.38	4.26
14.	0.00	-0.23	-0.27	-0.23	-0.27	-0.05
15.	0.00	0.03	-0.57	0.03	-0.57	-0.60
N	15	12	14	12	14	11
MEAN	0.00	0.33	-0.77	0.33	-0.77	-0.90
STD DEV	0.00	2.03	4.07	2.03	4.07	2.74
MIN	0.00	-1.98	-6.65	-1.98	-6.65	-6.74
MAX	0.00	6.12	10.38	6.12	10.38	4.26
t value		0.56	-0.70	0.56	-0.70	-1.09