CEPHALOMETRIC CHANGE OF THE LOWER INCISOR POSITION DURING ORTHODONTIC TREATMENT

by

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Abstract

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Historically, the position of the lower incisor has been a matter of interest in clinical orthodontics. The purpose of the present study was to characterize the movement of the lower incisor in a sample of one hundred consecutively treated patients from four different clinicians (n = 400). Birth date, gender, and extraction/non-extraction treatment protocol were abstracted from the chart. Bjork's method of mandibular superimposition was used to measure changes in the angulation of the lower incisor (DIMPA), the position of the incisal edge of the lower incisor on the X-axis (delta X), and the position of the incisal edge of the lower incisor on the Y-axis (delta Y). The results showed mean changes in DIMPA of 0.7 ± 7.81°, in delta X of -1.33 mm ± 2.76 mm and in delta Y of 1.63 ± 2.26. The subsample of cases that underwent extraction of teeth had mean changes in DIMPA of -5.27 ± 2.18° in delta X of -4.20 ± 1.99 mm, and in delta Y of 0.85 ± 2.4 mm compared to non-extraction means of 3.19 ± 2.13 for DIMPA, -0.12 ± 2.06 mm for delta X, and 1.95 ± 2.21 mm for delta Y. Significant differences in all three variables were also found among the four clinicians. All

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INTRODUCTION

The position of the lower incisor has been controversial throughout the history of orthodontics. Angle's[1] philosophy was based on aligning all the teeth. As a result, extraction as a treatment modality to alleviate crowding was not considered a treatment option. A popular story relates that Angle had extracted teeth on his wife and could not close the space; thus, he concluded that extraction of teeth was not a sound physiologic practice.

Tweed,[2-4] on the other hand, based many of his decisions regarding diagnosis and treatment on the position of the lower incisor to the mandibular plane (IMPA) and went to the other extreme, justifying extraction of teeth to position the lower incisors "upright over the basal bone." He reasoned that good facial esthetics, stability of treatment, health of contiguous structures and function of the dentures depended on the position of the lower incisor. He goes on to say, in the successful treatment of malocclusion, the mandibular incisors must be positioned over basal bone. "So positioned, they are in mechanical balance, and will resist the forces of occlusion that will otherwise surely result in their displacement."

Weinstein et al.[5] advocated the equilibrium concept in 1963 suggesting that the lower incisors were in a state of balance between the muscles and surrounding alveolar bone, with the forces being transferred through the

periodontal ligaments. Since such forces in the periodontal ligament are the initiating factors in tooth movement, the physiologic sum of such forces should even out (balance) over time to attain a state of equilibrium, otherwise tooth movement would result.

Surprisingly, in 2002, we can still find orthodontic practitioners who follow each of these three approaches. Therefore, this study evaluated changes in lower incisor angulation and spatial position during orthodontic treatment. The purpose of the study was to determine whether or not the lower incisor changed during treatment, and, if changes were found, to identify the factors that influenced the changes.

REVIEW OF LITERATURE

The Normal Variation in IMPA

Kowalski and Walker,[6] in 1971, reported on the distribution of the measurement of the angle formed by the long axis of the most protruding lower incisor and the mandibular plane (IMPA) by age and sex in a study of 474 males and 630 females of Caucasian American school children with normal dental occlusion. The subjects age ranged from six to twenty-six years of age. The investigation was based on cephalometric data from radiographs. They were part of a survey of normal growth conducted at the Philadelphia Center for Research in Child Growth between 1948 and 1968, and were selected from a group of 2,500 Caucasian elementary and secondary school children. The study showed a chart of the mean IMPA for each age group separated by sex also. The male group of the ages between twelve to fourteen had 124 subjects and showed a mean of 97.79 ± 5.6 for the IMPA with a range from 90° to 123.3°. The same age group of the females had 159 subjects, and their mean IMPA was 97.96 ± 4.68° with a range from 90.1° to 119.4°. The researchers concluded that the distribution of the variable of their population was different than the distribution obtained by Downs.[7] Kowalski and Walker thought the difference may be indicative of the extent of the discrepancy between "excellent" and "normal" occlusion, and suggested that diagnostic analyses and treatment goals

involving these variables may have to be modified. Further analysis of the data showed no evidence of sexual dimorphism or a significant trend with age. The overall mean value of the IMPA was 97°, ranging from 90° to approximately 124.9°. This study's findings differed substantially from studies based on smaller sample size. Downs,[7] Margolis,[8] Noyes et al.,[9] and Speidel and Stoner[10] all agreed on a mean value near 90° and a range from roughly 82° to 98°. They also found no evidence of sexual dimorphism or significant trends with age. This difference was attributed primarily to the small size of the sampled populations. However, they also recognized that any norm or "ideal" value for IMPA might have to be modified by factors other than age, sex, and occlusal pattern, such as race.

The Value of IMPA in Selected Samples of "Normal" Children

According to Tweed,[2] Margolis[8] was the first to relate the mandibular incisors to the mandibular plane to create what he has termed the "incisor mandibular plan angle." In 1943, Margolis,[8] using cephalometric procedures, showed that the incisor mandibular plane angle changed during treatment and after treatment during retention in several of the cases he reviewed. In addition, using Broadbent's[11] untreated normals, he demonstrated that the range of normal angular variation in IMPA was 8°—from 85° to 93°.

Noyes et al.,[9] in 1943, conducted a study on the axial angulation of human central incisor teeth. The study sample included nine adult dry skulls from American Indians and four living Caucasian males between the ages of

twenty-two and thirty-four years. Both groups had a full complement of permanent teeth which were within normal limits of occlusal relations. Also included were thirty living Caucasian subjects, twenty-one males, and nine females, all over eighteen years of age with all permanent teeth present. Of this group, fifteen had class II, division 1 malocclusions, and fifteen had class III malocclusions. Standard cephalometric techniques were used. The IMPA was defined as the angle between the axis of the left mandibular central incisor and a line drawn tangent to the most inferior points upon the lower border of the mandible. The study found the mean IMPA for the living sample to be 89.4 ± 4.6° with a range from 78° to 100°. The mean IMPA for the skull group was 92 ± 4.2° with a range from 86° to 98°.

In an effort to present the variation of the mandibular incisor axis in adult "normal" occlusion, Speidel and Stoner,[10] in 1944, measured the IMPA angle in a sample of forty-two young male adults who had "definitely superior to almost ideal" dental occlusal relationships. The study used the line connecting menton to gonion in defining the mandibular plane. The study found that 80% of the IMPA values were in the 86° to 99° range, although the total range extended from 78° to 106°. The average was 92.6 ± 6.1°.

Downs,[7] in 1948, conducted a study on twenty Caucasians, ranging in age from twelve to seventeen years. The group was equally divided as to sex, and all subjects had "clinically excellent occlusion." The goal of this project was to come up with cephalometric standards for Caucasians. Downs' norm for the

to come up with cephalometric standards for Caucasians. Downs' norm for the IMPA angle was 91.4° with a range from 81.5° to 97°. The IMPA was defined as the angle formed between the long axis of the most protruding lower incisor and the mandibular plane. Downs compared his observed mean to the means of previous studies by Margolis,[8] Noyes et al.,[9] and Spiedel and Stoner.[10] He said:

> "The difference in the mean could be accounted for by a slightly different method of locating the mandibular plane. All previous studies have located the mandibular plane tangent to the lower border of the mandible at gonion and the lowest anterior point which usually is found beneath the premolars. As the latter point is not in the midline and serial observations indicate oppositional growth in this area causing an increasing bulge, the lowest point of the mandible in the midsagittal plane (menton) is used as the anterior tangent point for determining the mandibular plane."

Baum,[12] in 1951, emulated the 1948 work of Downs. His study attempted to establish the normal skeletal and denture patterns of children possessing excellent occlusions during the ages when orthodontic treatment is usually undertaken. Baum satisfied the central theorem by selecting sixty-two children from Seattle public schools. The sample was equally divided by the sex of the child. They had clinically excellent occlusion, based on tooth relationships only. An attempt was made to cover the eleventh, twelfth, and thirteenth years. The bulk of children fell between the twelfth and fourteenth years. The mean age of the males was twelve years, 8.5 months ± 1.29 months. The mean age of the females was twelve years, 7.5 months ± 1.56 months. All of the subjects were Caucasians. The study used standard cephalometric techniques and selected the same landmarks and planes employed by Downs. The mean of IMPA for

mean of the same angle for females was 95 ± 6.24 with a range extending from 84° to 108°. Baum reported that his sample had a more obtuse IMPA compared to the Downs standard, and he concluded that the younger group tended to have more convex profile and less upright incisors measured from either the occlusal plane or mandibular plane.

Tweed,[4] in 1954, reported that he selected ninety-five adults of random age and sex who met his requirements "of good balance in facial outline rather than ideal." In a study of their incisor mandibular plane angles, he found an average of 86.6° with a range of 76° to 99°. Tweed followed the standard cephalometric techniques, and his mandibular plane was a line extending from gonion to menton. In a later article published in 1956, Downs[13] tried to justify the validity of his standard for the IMPA by criticizing Tweed for being biased when Tweed selected his sample. Downs stated, "Knowing Tweed's avowed preference for a flat facial profile, it is not surprising that the majority of cases he selected possessed upright lower incisors." Nevertheless, Tweed continued to advocate an ideal IMPA at 90°.

Taylor and Hitchock[14] published their work on the Alabama analysis in 1966. Their hypothesis was that the ethnic background of southern Caucasian children was different enough from that of children in other sections of the country to warrant a separate cephalometric standard. They also felt that this new standard could be used to compare southern children to their Caucasian ancestors. Seventeen boys and twenty-three girls were selected based on the

presence of normal occlusion, acceptable profile and the absence of any previous orthodontic treatment. The final selected sample had to satisfy the condition of being a descendant of predominantly southern extraction of at least two generations. The subjects ranged in age from eight to twelve years. Standard cephalometric techniques were followed for thirty-two measurements. The study found the mean IMPA to be 97.3 ± 6.3 with a range extending from 83° to 110°. The study concluded that between the ages of eight to twelve, sex differences were minimal for this cephalometric analysis. The authors compared their results regarding the IMPA with another study performed by Gresham[15] on northern Americans and found their means for the IMPA were very similar. They concluded that their mean IMPA was very similar. They concluded that the mean IMPA in their study indicated a more procumbent lower incisor compared to the study performed by Margolis.[8]

Metzdorf,[16] in 1977, conducted a study in an effort to determine the morphology of the mandible and the cranial base, and then relate this information to the position of the mandibular incisors in untreated Class I individuals with full dentition. This study sample of ninety with age ranging from 12.6 years to 27.6 years (mean 18.5) consisted of forty-three males and forty-seven females. All cephalograms were taken from the records of the Department of Orthodontics of Ohio State University. There was no mention as to the racial distribution of the selected sample. The study reported the mean IMPA to be

96.32 ± 7.25. Metzdorf re-emphasized previous work about the wide range of lower incisor to mandibular plane measurement. He concluded:

> "Mandibular incisor positioning showed the greater variation when compared with previous work. Downs[7] mean of 91.4°, reported for individuals 14.6 years of age with ideal occlusion, was 4.92° less than ours. The increased angulation was expected and has been reported by other investigators. The lower incisor was shown to be related to the increasing or decreasing FMA in an inverse manner."

The Value of IMPA in Selected Samples Based on Race

Cotton et al.,[17] in 1951, chose twenty San Francisco Bay area African Americans (ten males and ten females) ranging in age from eleven to thirty-four years of age. The sample was equally divided. Their sample did not represent ideal occlusal relationship, but no person with a "real malocclusion" was included. The ten measurements that were used by Downs were repeated by Cotton and his coworkers on the African American sample, and the mean and range for each measurement was determined. The study found the mean IMPA for its subjects to be 96.6° ranging from 96.5° to 112°. They did not run any statistical tests.

A comparative study on different racial samples was conducted by Cotton, Takano, Wong, and Wylie[17] when they were graduate students. The goal of their efforts was to investigate the validity of the use of Downs norms for other ethnic groups. Cotton followed Downs methods and materials in selecting his African American sample. He had twenty African Americans from the San Francisco Bay area divided in half between males and females ranging in age

between eleven and thirty-four years. Cotton tried his best to select subjects with perfect occlusal relationships, and avoided all subjects with "real malocclusion." Cotton used standard lateral cephalograms. He concluded that the mean IMPA in African Americans was 96.6° with a range from 86.5° to 112°.

Takano, on the other hand, evenly divided Seattle Nisei (American-born Japanese) by sex and with a mean age of twenty-one. He described his material in a similar manner to Downs—clinically excellent occlusion with good facial balance. Takano subjected the data to the usual tests for significance of difference from the corresponding means for Caucasians. He concluded that the average of the IMPA in the Nisei population to be 96.5°, and he found that value to be significantly different from the Downs norm. His range for IMPA was 84° to 113°. The study did not furnish any information about the value of standard deviation.

Wong, in the same comparative study, selected twenty American-born Chinese from San Francisco's Chinatown, ten males and ten females ranging in age from eleven to sixteen years. In the examination of 650 Chinese children, he could not find "normals" as he had come to apply the term to Caucasians, but he chose as subjects only those having "normal arch relationship and good facial pattern." Wong used the same standard cephalometric technique to extract his skeletal and dental values. He found the mean IMPA for his sample to be 97.8 with a range from 90° to 108°. There was no mention for the value of standard deviation. Wong concluded, "Downs analysis did not hold true for the

Chinese of San Francisco Chinatown, and one should exercise caution when using Downs figures on the Chinese as to what is normal for the race."

In 1960, Altemus[18] compared the cephalometric relationships of the African American to the Downs analysis. North American African American children with normal occlusion were studied in an attempt to determine what is normal for the heads and faces of these children. Eighty children were used, equally divided as to sex. All had a Hellman's dental age of IV A, which means that all the permanent teeth were present except the third molars. This group represented a chronologic age of twelve to sixteen years. Only lateral views were taken, and for these, the Broadbent X-ray technique was used. The analyses of Downs[13] and Sassouni[19] were conducted, and the means, ranges, and standard deviations were determined. Altemus concluded that his findings were very similar to those reported by Cotton et al.. The skeletal pattern was more protrusive and the teeth were more procumbent in the African American group than in the Caucasian group of Downs. Altemus reported the mean IMPA in the North American African American to be 99.8 ± 5.95° with a range between 94.5° to 114.5°, which he described to be similar to the American Chinese and Japanese, and larger than the Caucasians.

Drummond,[20] in 1968, conducted a study to determine the cephalometric norms for the African American race and to find out if these measurements were statistically different from those of Caucasian children. The study used the standard lateral cephalogram taken on the Broadbent-Bolton cephalometer at

the Department of Orthodontics, Baylor University College of Dentistry. The study selected forty African American children based on their acceptable occlusion of a class I angle classification and normal faces without any form of deformation. The sample ranged in age from eight to twenty-three years to cover the ages at which most children are treated. The study defined IMPA angle as the angle formed between the long axis of the most protruding incisor and the mandibular plane. The mandibular plane was defined as a line connecting gonion and gathion. The study showed the mean IMPA angle to be 100 ± 5.0°, with a range of 88° to 109°. Drummond concluded that the lower incisor in the African American is more procumbent in relation to the mandibular plane with the $p \leq 0.001$.

Alexander and Hitchcock,[21] in 1978, studied fifty African American school children ranging in age from eight to thirteen years old in an effort to develop a cephalometric standard for African American children in the South which would be comparable in diagnostic and treatment-planning capability to the Alabama analysis for Caucasian children. The subjects were selected based on the presence of class I occlusion with acceptable profile and acceptable anterior relationship of the teeth. Previous orthodontic treatment was an exclusion criteria. The standard cephalometric technique was followed in this study. The IMPA was defined as the angle formed between the long axis of the most protrusive incisor and the line connecting menton and onion. Alexander and Hitchcock concluded that the lower incisors are more procumbent and protrusive

in African Americans, and found the IMPA to be 99.3 ± 5.91° ranging from 87° to 118°. Nevertheless, the study found no variation in IMPA with age, but it did not study variation in IMPA with gender.

Isiekwe,[22] in 1987, studied a convenient sample of 110 ethnic African Americans of Nigerian ancestry. The subjects were students and military personnel ranging in age from eleven to twenty-six years. The goal of the project was to use lateral cephalograms to determine the normal range of variation for upper and lower incisors. The results showed a mean value for IMPA to be 101.47 ± 6.76 with an estimated range of 80° to 120°. Iseikwe found no variation in IMPA with age although the sample sizes at younger ages were on the order of fifteen and, thus, did not satisfy the central limit theorem. He also did not study variations in IMPA with gender. Iseikwe concluded that his study showed a "normal range" of IMPA for a Nigerian sample.

Cooke and Wei,[23] in 1988, studied dento-skeletal and soft tissue profile cephalometric characteristics of 120 male and 120 female twelve-year-old Chinese school children in Hong Kong. None of the children had previous or current orthodontic treatment. Both parents of all subjects originally came from Guangdong, the adjoining southern province of China. Forty Caucasian twelve-year old males in Hong Kong, whose parents originally came from the United Kingdom, were also included in this study as a comparison group. Standard cephalometric techniques were followed in this study. The researchers reported a mean average of 100.9 ± 7° IMPA for Chinese males and 98.5 ± 7° for

Chinese females. They found these means to be significant at $p \leq 0.01$. The authors concluded that the study was the first to comprehensively analyze a true random population sample of southern Chinese, and showed significant differences between the Chinese males and a comparative Caucasian male sample at a p-value of < 0.05. There was no mention for the mean value of the control group..

Chan,[24] in 1972, reported on the Chinese (Cantonese) population in an effort to compare and find out how different the Cantonese are from the Caucasians and other races of previous studies. The sample used in this study consisted of thirty films. Twenty-four were from persons selected out of 300 Auxiliary Medical Service members at a parade arranged specifically for this purpose. The other six films were from normal patients attending the Government Dental Clinic at Yaumati, Hong Kong. They all had to satisfy the following criteria—males of Kwangtung Province origin (Cantonese), ages eighteen to thirty-three years with clinically excellent occlusion, and acceptable profiles. Subjects with a history of orthodontic treatment were excluded. Standard cephalometric techniques were followed. Downs landmarks and lines were used. The study found the mean IMPA to be 98.38 with a range extending from 80° to 109°. The study did not report any standard deviation. Chan used *t*-tests to compared differences between the means of his study and the Alabama analysis with a $p < 0.05$. He concluded that IMPA for the Chinese was significantly higher than the Caucasians.

In an effort to compare the Central Australian, an archaic Caucasoid, with other living races, Carven[25] conducted a study in 1958. He selected a total of fifty-six Central Australian aboriginals and divided the sample into two groups based on age. The first group included subjects with a mean age of 7.5 years and a range from four to eleven years. This group had twelve males and fifteen females. The other group had subjects with a mean age of fifteen years and a range from twelve to twenty years. There were nine males and twenty females in that group. Standard lateral cephalogram was obtained on every subject using the Broadbent cephalometer. Carven established the mean measurement and variation in the living Australian aboriginal head and compared his data with those of Bjork[26-29] in the Swede and Bantu studies. He pointed out the necessity to compare the two age groups of aboriginals with the age groups in Bjork's studies, since changes in measurements were observed between child and adolescent aboriginals. The study employed Downs analysis of the facial profile. The mean IMPA for the whole sample was 103.1 ± 6.11° with a range extending from 90° to 122°. The female subjects showed more procumbent lower incisors compared to the male group with means of 104 ± 6.5° and 101.5 ± 5.1° respectively. The study concluded that the lower incisors were more procumbent in the aboriginals compared to the American Caucasian norms reported by Downs.[30]

Sexual Dimorphism and IMPA

In a 1975 study, Harris and Kowalski[31] investigated the potential sexual differences for the mean IMPA. They studied the distribution of this measurement in selected Nubian school children ranging in age from six to eighteen years of age, which were selected as part of a study of the craniofacial morphology of ancient and modern Nubians. The study had a total of 264 subjects, 159 males and 105 females. The subjects were divided into various age groups. The study suggested a mean value of the IMPA to be 95°, with a range extending from 82° to 110°. *t*-test statistics comparing the observed male and female mean value indicated that there was no evidence of sexual dimorphism and no consistent developmental pattern. The researchers agreed on the presence of a considerable overlap of this distribution. The distribution of IMPA in the Nubian school children was somewhere in between those measurements found by Downs[7] (90° to 120°). Thus, although a comparison with Caucasian standards computed from children having excellent occlusion reveals a higher degree of bimaxillary protrusion among the Nubians, the mean difference between these groups was less than that exhibited within the Caucasian samples. Thus, the observed racial difference in IMPA was less than the difference in IMPA found between children of the same race having normal and excellent occlusion.

In an effort to determine the normal cephalometric measurements of the African American woman, Fonseca and Klein[32] performed a study in 1978.

Forty African American women with an age ranging from twenty to thirty years and a mean age of 24.6 years were selected for the study. All subjects has a class I molar and/or canine relationship, a clinically acceptable occlusion, and good general health with no obvious facial abnormalities. Standard cephalometric techniques were followed in this study. The results of the measurements were compared to a group of twenty Caucasian female subjects ranging in age from eighteen to twenty-five years. The mean age of the group was twenty years. The African American women group rendered a mean IMPA value of 101.2°, while the control group of Caucasian females had a mean value of 92.5°. The project did not mention any range values or standard deviations. The study concluded that the lower incisors in the African American female population were significantly more procumbent compared to the control group.

The IMPA as a Treatment Goal

Dr. Edward Angle[1] was an advocate of maintaining a patient's full dentition with the idea that humans were born with thirty-two teeth, and we should retain them and make them fit. Angle believed alveolar bone would follow the tooth. Angle expanded the dental arch and moved teeth beyond their original position buccally and labially. Later, this practice was challenged based on the lack of a sound physiologic concept, a high percentage of relapse, and less than acceptable profiles.

Tweed[33] believed that the diagnostic triangle concept was his most important contribution to clinical orthodontics. This triangle was formed by the

following three lines—the mandibular plan, the long axis of the most protruding lower incisor and the Frankfort horizontal plane. The three angles are FMIA, FMA, and IMPA (Figure. 1).

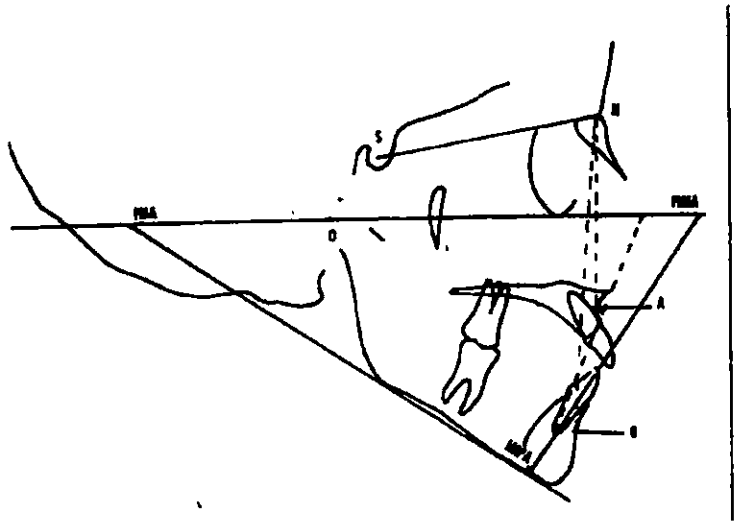


Figure 1. Tweed Triangle.

These three angles from the "Tweed Triangle' were presented as a diagnostic aid in order to position the lower incisors for optimal facial aesthetics and treatment stability by attempting to achieve a FMIA of 65°. This concept had evolved over many years and was based on lower incisor movement, which improved patient's esthetic and treatment stability. In a cephalometric analysis of a sample of 100 non-orthodontically treated patients selected for good profile aesthetics, Tweed found a mean value of the Frankfort plane-mandibular incisor axis angle (FMIA) of 69°. In addition, many cases exhibited a compensatory relationship between the mandibular incisor-mandibular plane angle (IMPA) and

the Frankfort-mandibular plane angle (FMA).[4] Given the FMA value, the value of IMPA is altered by treatment mechanics to affect the ideal FMIA. This principle was later modified by Tweed[34] in 1966 to consider vertical skeletal discrepancy—the desired FMIA for FMA angles beyond 30° is 65°. The FMIA goal increases when FMA becomes less than 20°, but the IMPA remains constant at 92°.

One of the drawbacks of this analysis was that it failed to be accurate in all cases. Tweed [3] stated that in about 25% of cases where mandibular growth was considered unfavorable (mainly downward with an increasing ANB angle), attainment of the FMIA goal of 65° was impossible. Such cases were therefore considered to be of poor prognosis. The method was limited to angular measurements and assumed that only tipping movement about the lower incisor apex was acceptable. It could also be argued that the Frankfort plane was an inappropriate reference line with which to assess the anteroposterior position of the lower incisor.

Litowitz[35] conducted a cephalometric study in 1948 on twenty non-extraction cases to determine the changes in position of the mandibular incisors and maxillary and mandibular molar teeth, which took place during treatment and one to five years after retention. His study indicated that in those cases where treatment resulted in an increase in the axial inclination of the teeth, half tended to regain their former inclination and half became more procumbent. In

the majority of cases where the treatment had resulted in a decrease in axial inclination, the angulation continued to decrease after retention.

Weinstein et al.,[5] in 1963, pointed out that the lower incisors are in a state of equilibrium as a result of muscular balance, not only intraoral forces acting upon the tooth crown, but also forces exerting upon the root of the tooth by its surrounding bony structures through the periodontal ligament. Since such forces in the periodontal ligament are the initiating factors in tooth movement, whether these factors are of orthodontic or non-orthodontic origin, this "equilibrium position" must be such that the average distributed force over any reasonably extended period of time at any point in the periodontal ligament is zero. He also pointed out the possibility for more than one position of minimum energy, which allows the tooth to maintain the state of equilibrium. He attributed these multiple equilibrium positions to the modification of the soft tissue and the bony structures surrounding the teeth. Weinstein et al. emphasized that this case of existence and modification of the surrounding structure was not predictable. He concluded the importance of maintaining the angulation of the lower incisor during treatment.

The Changes of the IMPA in the Absence of Orthodontic Treatment

Although there have been many growth studies and a large collection of data involving aspects of dento-facial development in orthodontics, most studies tend to be based on cephalometric radiographs. Broadbent[36] (1937) developed the concepts of proportionate enlargement of the face downward and forward

from the base of the skull in an incremental fashion. Using his templates the changes of the lower incisor during the years of active growth was estimated as the following—the lower incisor maintained the same angulation , and the tip of the incisal edge tended to move up on the Y axis on an average of less than 2.0 mm in a three-year period.

Later on, Enlow,[37] in 1968, recognized that the structures within the skull on which this proportionate enlargement concept was based may also change. Based on several growth studies using lateral cephalometric radiographs, Endow documented many regional changes in the anteroposterior and vertical direction. He emphasized the dynamic movement of every region in the facial complex during growth and development. As part of the increase in facial height, the regional changes in the mandibular teeth and the alveolar sockets consisted of upward growth movements. The lower incisors undergo a lingual tipping or retroclination. This involves a posterior rotation movement of the mandibular incisors as they simultaneously drift superiorly.

The work of Bjork,[28] in 1955, who used metallic implants in the mandible for the superimposition of radiographs, paved the way for more accurate vertical analysis. His method of superimposition on recognized anatomical landmarks in the mandible, based on earlier implant studies, had made valuable information available to the clinician.[27] This technique used the best fit of the superimposition of the tracing of the mandible on the following three structures—the mandibular nerve canal, crypt of the third molar, and inner

cortical line of the symphysis. This method is considered to be the best available for mandibular tooth movement analysis relative to the mandible.

Perera[38] conducted a cephalometric study in 1987, studying twenty-nine cases serially over nine years using the Bjork method in superimposition. The mean age was 11.21 ± 1.11 years when the initial radiograph was taken, and 19.0 ± 1.41 years when the final radiograph was taken. The study showed an average of 91.79 ± 7.10 ° for the IMPA angle. He found that the root apex of the lower incisor came forward, and the S-N-L angle increased by 1.7° (L = the point where the long axis of the most prominent mandibular incisor intersects the incisal edge). This is consistent with Bjork's[27] concept of an increase in forward mandible rotation with age. Surprisingly, however, the angle of the lower incisor to the mandibular plane showed little change. The IMPA kept a mean of 92.05 ± 7.69 at the end of the study. Based on the studies by Bazzucchi et al.[39] (1999) and Dietrich[40] (1992) on the treatment of open bite, both studies estimated the change of the incisor edge of the lower incisor on a vertical axis to increase in the amount of 0.7 mm per year between the age of eleven and fifteen years.

In summary, the lower incisor maintains a constant angulation during growth and tends to move in an upward direction to compensate for the facial height increase and to stay in contact with upper incisors. Knowing the previous few facts about the movement of the lower incisor in the absence of treatment, we would like to study the behavior of the lower incisor during orthodontic treatment, and try to compare these movements among different clinicians.

The Relationship Between Lower Incisor Proclination and Periodontal Tissue Condition

Tooth position has been suggested to be an important factor in gingival recession. In an attempt to determine the prevalence of etiologic factors associated with gingival recession, Prafitt and Mjor[41] examined 668 school children nine to twelve years of age. In this group, 8% of the children were found to have between 2.0 and 5.0 mm of gingival recession associated with the mandibular incisors. Of the factors considered, tooth arch discrepancies were found to be most commonly associated with the observed recession. In fact, the authors stated that 80% of the affected teeth had a tooth arch discrepancy.

In a similar study, Trott and Love[42] investigated a group of 766 high school students of ages fourteen to nineteen. The labial surfaces of the mandibular anteriors were examined for the incidence of recession and factors most commonly associated with the recession. Of the teeth examined, 1.8% were reported to have recession of greater than 3.0 mm. The factor most commonly associated with recession was tooth malposition.

Gorman[43] examined 164 subjects of ages sixteen to eighty-six years for recession. Recession was considered to be any amount of root exposure. In teeth with pronounced labioversion, 61% (thirty-two out of fifty-two) were found to have some degree of recession, and 15% in pronounced linguoversion had gingival recession. Of the factors examined, malposition of the teeth was the factor most frequently associated with recession.

Pearson[44] conducted a study on twenty-seven orthodontically untreated cases and forty-five treated cases. The untreated cases were considered normal, and the treated cases were selected because they exhibited the most severe amount of gingival recession out of a total of six hundred treated cases. The untreated cases were examined for the amount of recession initially and two years later. The treated group was examined for the amount of recession before and after orthodontic therapy. The position of the teeth was assessed by cephalometric tracing. The untreated cases showed an average of 0.04 mm gingival recession, and the treated group exhibited 1.1 mm recession; however, the author stated that no correlation could be found between the amount of labial and lingual tooth movement and the degree of recession.[43]

In conclusion, the studies by Prafitt and Mjor,[41] Trott and Love,[42] Gorman,[43] and Baatenhorst et al.[45] seemed to indicate that tooth malposition is often associated with gingival recession. This is contrary to the findings of Pearson.[44] Further, Dorfman[46] found no strong correlation between labial tooth movement and loss of keratinized gingiva.

Steier et al.[47] studied monkeys to examine the effect of labial tooth movement on changes in the marginal periodontium. Measurement of the gingival margins and the mucogingival junction were taken, and orthodontic forces were applied. The central incisors were moved labially a mean distance of 3.05 mm. Post-therapy measurements were performed to assess the change that occurred as a result of tooth movement. Significant recession at the

gingival margin, at the connective tissue level, and in the marginal bone was found.

Artun and Grobety[48] conducted a study recently trying to investigate whether pronounced orthodontic advancement of the mandibular incisors during class II correction in the mixed dentition resulted in gingival recession. The suggested method to advance the lower incisors was using reverse pull headgear to the mandibular dentition. The average advancement was 1.0 mm at the CEJ level and 2.0 mm at the incisal edge. It was concluded that pronounced advancement of the mandible incisors might be performed in adolescent patients with dentoalveolar retrusion without increasing the risk of recession.

Changes in the IMPA and Lower Incisor Crowding (Are Proclined Teeth Less Stable?)

Extended studies of orthodontically treated patients have shown a tendency to instability of the lower incisors, and the position of the lower incisors has become an important factor in the analysis and treatment of malocclusion. Mills,[49] in 1966, discussed the long-term results of the proclination of lower incisors. The study was based on fifty-six cases where the lower incisors were proclined by tipping. By comparing the study group and the control one, he concluded it seems that it is possible to procline the lower incisors to some extent—that is, to increase the angle between the long axis of the lower incisor and the mandibular plane. Following mild proclination (less than 10°), the lower incisors still retained an average 4.8° of proclination, although they had

relapsed through 2.4° from their most proclined position. With more severe proclination (10° or more), the lower incisors retained 8.6° of proclination, having relapsed to 5.6°. Such a proclination may be due to labial movement of the incisal edge or lingual movement of the root apex, and it would seem that during treatment both movements took place to varying extent. During the observation period following retention, both relapsed, with the labial movement of the incisal edge relapsing twice as much as the lingual movement of the root apex.

Little et al.,[50] in 1981, conducted a study to evaluate stability and relapse of mandibular anterior alignment ten years post orthodontic treatment. They concluded that crowding continued to increase during the ten to twenty years post retention phase, but to a lesser degree than from the end of retention to ten years post retention. The researchers evaluated the relapse based on the displaced anatomic contact points. The study did not have any cephalometric index to evaluate relapse, but the displaced contacts lingually can be explained as uprighting the lower incisors or reduction in the IMPA measurement.

The Difficulty of Locating the Apex of the Lower Mandibular Incisor

Recognizing the importance of locating the apex of the lower incisor, Phelps and Masri,[51] in 2000, conducted a similar study to the one Tng et al.[52] did, but they had a bigger sample (thirty-eight skulls). They concluded that the true location of the lower central incisor apex was most often found in an approximate 60:40 ratio from the external lingual parameter to the external labial

outline of the symphysis at the apical level. They related the discrepancy between their data and Fuhrman's[53] to the size of their sample. While the discrepancy between Tng's location of the apex and their location was explained by the difference of the size of the marker used, Phelps and Masri used a more finite marker.

In summary, the position of the lower incisor has been recognized as an important indicator to orthodontic diagnosis and treatment planning due to its effect on esthetics, stability, and space available in the mandibular arch. Most of the previous work had focused on positioning the lower incisor at a certain measurement at the end of treatment, or considering the anterior posterior position of the lower incisor. It was our objective to observe the changes in lower incisor movement during orthodontic treatment and to compare these changes among different orthodontists.

METHODS AND MATERIALS

Study Population

The study sample included five orthodontic practitioners. These five clinicians were willing to provide sample subjects necessary for the testing of the objectives. Approval to collect the data for this study was given by the Internal Review Board at Case Western Reserve University in May 2002.

One hundred consecutively treated cases were selected from each clinician's office, regardless of their age, sex or race. The inclusion criteria for case selection were as follows—to use cases with no previous orthodontic treatment, and to have lateral head films routinely obtained before and after treatment.

The exclusion criteria were as follows—cases with phase 1 orthodontic treatment (early treatment) were eliminated unless the selected clinician had treated each case with the presence of a pretreatment lateral head film. In such cases, pretreatment measurements were taken from the lateral head film that was exposed prior to phase 1 treatment (i.e., before any treatment was provided).

Collection of Data

Patient Records

The age of each patient, before and after treatment, was obtained from their chart. Gender, ethnicity, and whether the patient went through extraction or non-extraction were also obtained either from the treatment progress notes or by checking the panoramic film.

Cephalometric Technique

Using the pretreatment lateral cephalogram and acetate paper, the study traced the mandible, including the lingual cortex of the symphysis, the lower incisor and the mandibular canal. A 0.003-inch matte acetate paper with 0.3 mm H lead pencil was used for tracing. In tracing the lower incisor, the operator located the incisal edge of the most protruding lower incisor. (See Figure 2)



Figure 2. The tracing of the pretreatment mandible, including the mandibular plane which was defined as a line connecting menton (Me) to gonion (Go)

The apex was located based on the study by Phelps and Masri[51] in an approximate 60:40 ratio from the external lingual parameter to the external labial outline of the symphysis at the apical level. Afterwards. a plastic template manufactured by 3M[a] was used to trace the lower incisor. Next, using the study by Bjork[29] for mandibular superimposition, the pretreatment mandible tracing was superimposed on the post-treatment lateral cephalogram. Bjork's recommendation was to use the mandibular canal and lingual cortex of the symphysis. (Figure 3)



Figure 3. The superimposition points recommended by Bjork (shown in red.). The tracing of the pretreatment mandible superimposed on the post-treatment mandible.

The tracing of the pretreatment and the post-treatment cephalogram was then superimposed, and another tracing was done on the post-treatment lower incisor

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[a] 3M, Minneapolis, MN.

on the same tracing paper. This time, a different pencil color was used in tracing the post-treatment lower incisor. (Figure 4)



Figure 4. The tracing of the pretreatment mandible superimposed on the post-treatment mandible including the post-treatment lower incisor (green color). The line connecting Me to Go represents the mandibular plane of the pretreatment tracing.

The result provided us with a single sheet of acetate paper that had the tracing of the mandible pretreatment, including the mandibular canal and the symphysis, and the tracing of the lower incisor before and after treatment.

The following steps were taken to measure the difference in the angulation of the lower incisor before and after treatment. The operator located the mandibular plane on the pretreatment tracing by connecting a line between menton and gonion. Next, the long axis of both incisors' tracings was drawn using a ruler and the 0.3 mm H lead pencil. The pretreatment IMPA angle was calculated using the long axis of the most protrusive lower incisor and the

mandibular plane).[b] Post-treatment IMPA was measured as the angle formed between the long axis of the lower incisor after treatment and the pretreatment mandibular plane ($IMPA_1$). All angular measurements were recorded to the closest 0.5°. The difference between the pretreatment IMPA and the post-treatment IMPA was recorded (DIMPA) using a plastic protractor manufactured by 3M (see Figure 5). All the measurements were done under a 2X magnifier lens with an overhead lamp.

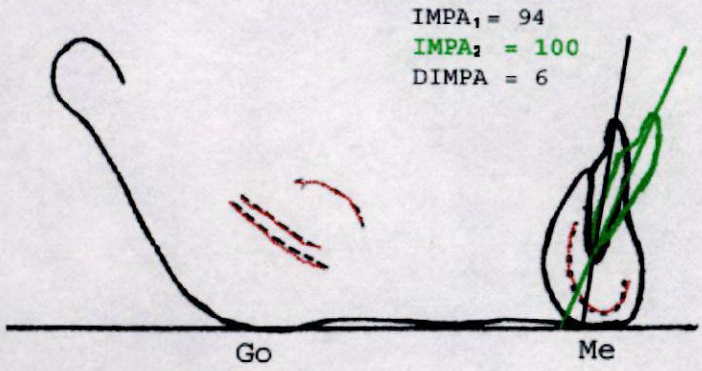


Figure 5. The measurement of the $IMPA_1$ (the angle formed between the long axis of the tracing of the lower incisor and the mandibular plane before treatment). The measurement of the $IMPA_2$ (the angle formed between the long axis of post-treatment tracing of the lower incisor and the mandibular plane of the pretreatment tracing). $DIMPA=IMPA_2-IMPA_1$.

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[b] Mandibular plane was defined by the line connecting menton to the average gonion.

The change in the position of the incisal edge was also measured to achieve this objective for our study. Standard millimetric graph paper, size 8 x 11 inches was used. One of the horizontal lines was picked as an X-axis, and one of the vertical lines as the Y-axis, thus forming a XY coordinate system with (0.0) as the pretreatment coordinate of the incisal tip. Next the tracing sheet was laid over the graph paper keeping the mandibular plane of the pretreatment tracing as the X-axis. The operator registered the XY coordinate for the incisal tip of the lower incisor before and after treatment, then the difference was calculated and entered on the spreadsheet. The standard principles of Cartesian coordinate geometry were followed, which meant any changes on the X-axis to the right of the coordinate were called positive, and to the left, negative. Furthermore, any changes on the Y-axis going upward were called positive, and the downward changes, negative. All the millimetric measurements were recorded to the closest 0.5 mm (see Figure 6). As before, all the previous measurements were done under a 2X magnifier lens with an overhead lamp[c] (Fig. 6). Thus, each patient had the change in x direction (delta X) and a change[d] in y direction (delta Y) recorded.

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c Dazor, St. Louis, MO. (USA model 8mc-200)

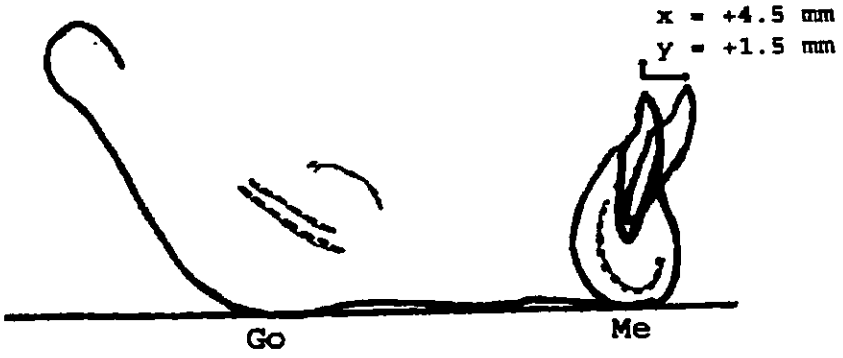


Figure 6. XY coordinate system (0.0) will represent the location of the incisal tip of the lower incisor before treatment. In this, the coordinate of the incisal tip of the lower incisor post-treatment will be (+4.5, +1.5) the tip moved forward on the X-axis in the amount of 4.5 mm and upward on the Y-axis in the amount of 1.5 mm

Operator Calibration and Measurement Error

Errors made in measuring the angular or the millimetric changes were estimated by examining duplicate tracings of twenty individuals. Selection of the tracings was randomly done at least two weeks apart. An intra-clinician correlation coefficient was computed to estimate reliability.

Interview Questionnaire

An interview was conducted with each clinician separately. The interview requested the clinicians to write a few statements regarding his/her treatment philosophy in general, and in regards to the position of the lower incisor position in particular. In addition, each participating orthodontist was asked to answer the following questions:

1. Optimal function, esthetics, and stability are three main treatment goals of orthodontics therapy. Please rank these goals from one to three.

2. What type of appliance are you using, fixed/0.018/0.022 slots?

3. Are removable appliances a major part of your philosophy?

4. Do you use preadjusted appliance or regular edgewise?

5. Do you use NiTi wire as a regular wire sequence?

6. Do you use round wire to level your case?

7. Is tie-back or cinch-back a routine procedure when placing a new wire?

8. What is your treatment philosophy regarding the IMPA angle?

9. If you happen to have a borderline case, do you tend to extract or flare the teeth?

Statistical Analysis Design

All measurements were entered in a spreadsheet (Microsoft Excel®[e]). The Statistical Package for Social Sciences (SPSS®)[f] was used for statistical analysis.

Descriptive Statistics

The outcome variables for the study included DIMPA (the difference in IMPA measurement before and after treatment), delta X, the change of the incisor tip of the lower incisor on the X-axis, and delta Y, the change of the

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[e] Microsoft, Inc, Seattle, WA.

[f] SPSS, Chicago, IL.

incisor tip on the Y-axis. The independent variables were as follows—questionnaire responses, clinicians, extraction/non-extraction, age, and duration of treatment, gender, and ethnicity.

Means and standard deviations were calculated for all continuous variables (DIMPA change, X change, Y change, age, duration of treatment). Frequencies were computed for gender, ethnicity, extraction, and questionnaire responses. All the four clinicians were white males, and their samples were tested for comparability for ethnicity, gender and extraction by using the chi-square.

Comparison of Equality of the Means

t-tests (equal variance) were used to compare outcome variables (IMPA change, X change, Y change) between two groups, extraction/non-extraction groups, males and females groups, Caucasian and African American groups, and between the groups formed, based on the responses to the questionnaire. Analysis of Variance (ANOVA) was computed to test the differences among clinicians for the following variables—IMPA change, X change, Y change, age before, age after, IMPA after, duration of treatment.

Correlation and Regression

Correlation was computed to find out if any of the independent variables were highly correlated with the dependent variables (delta IMPA, delta X, delta Y) questions. Those variables that were strongly correlated with dependent variables were entered into the regression model. Thus, the regression model

consisted of the following independent variables (extraction, race, change in age, clinician, and all interview questions. The step-wise regression method was used for selecting the most important independent variables that predicted the dependent variables.

RESULTS

Total Sample

A total of five hundred patients were selected through five clinicians, one hundred patients per clinician. Ninety-seven percent of the patients were of Caucasian descent, with females making up 58%. Twenty-nine percent of the patients went through some type of extraction during their orthodontic treatment (i.e., bicuspids or lower incisors). The average age at the time of pretreatment radiograph was 13.3 ± 6.0 years.

TABLE 1.--Population Description—Sample of 500 Patients.

Age at initiation of treatment	13.27 ± 6.03
Age at termination of treatment	16.61 ± 5.79
Treatment time	3.34 ± 1.70
Extraction cases	29%
Gender	42% males
Ethnicity	97% Caucasian

Based on the initial analysis, the values of the IMPA before for Clinician #4 were outliers. Also, the range for IMPA for the same clinician was different from the other clinicians.

TABLE 2.--The Mean Value for the Five Clinicians.

	All Clinicians n = 500	Clinician #1 n = 100 Mean ± SD	Clinician #2 n = 100 Mean ± SD	Clinician #3 n = 100 Mean ± SD	Clinician #4 n = 100 Mean ± SD	Clinician #5 n = 100 Mean ± SD
Age before TX	13.27 ± 6.03	12.32 ± 3.18	14.18 ± 6.05	13.14 ± 7.64	13.12 ± 6.10	13.5 7 ± 6.23
Range	6.00 - 56.00	6.00 - 30.00	7.00 - 43.00	7.00 - 56.00	6.67 - 50.00	7.00- 45.00
Age after TX	16.63 ± 5.70	15.88 ± 2.63	17.65 ± 5.99	16.67 ± 7.28	16.55 ± 5.93	16.31 ± 6.23
Range	10.33 - 58.67	12.00 - 33.00	12.40- 45.00	11.20 - 58.60	11.83 - 53.00	10.30 - 47.60
TX time	3.34 ± 1.70	3.57 ± 2.02	3.46 ± 1.15	3.53 ± 1.79	3.43 ± 2.13	2.47 ± 0.96
Range	0.67 - 12.17	0.67 - 9.50	1.67 - 8.00	1.00 - 8.25	1.25 - 12.17	1.17 - 5.50
Angle before TX	93.69 ± 7.13	94.99 ± 7.40	95.09 ± 7.43	93.45 ± 7.21	92.00 ± 6.46	92.90 ± 6.74
Range	68 - 115	78 - 115	73 - 113	71 - 111	72 - 106	68 - 112
Angle after TX	94.50 ± 8.33	98.12 ± 7.79	88.52 ± 6.60	98.90 ± 7.45	93.30 ± 8.56	93.68 ± 6.76
Range	71 - 124	80 - 117	71 - 105	82 - 124	72 - 114	73 - 110
DIMPA	0.82 ± 7.77	3.13 ± 7.06	-6.58 ± 5.79	5.45 ± 7.21	1.30 ± 7.59	0.79 ± 5.34
Range	-24 - 25	-14 - 22	-24 - 6	-16 - 23	-19 - 25	-14 - 15
Delta X	-1.27 ± 2.72	-0.70 ± 2.63	-4.16 ± 1.97	0.28 ± 2.34	-1.03 ± 2.56	-0.74 ± 1.76
Range	-10 - 5.57	-6.5 - 5.6	-10 - 0.25	-6.0 - 5.5	-7.0 - 5.00	-6. 0- 2.5
Delta Y	1.51 ± 2.32	1.93 ± 2.36	0.36 ± 2.04	2.37 ± 2.52	1.05 ± 2.50	1.86 ± 1.47
Range	-4.75 - 11.0	-3.7 5 - 8.00	-4.8 - 6.0	-4.00 - 11.0	-4.25 - 8.50	-1.0 - 6.0

After committee discussion, Clinician #4 was removed from subsequent analyses because the sample may have been selected based on good results. This resulted in having only four clinicians participating in the study with a total of four hundred patients, and Clinician #5 was renamed Clinician #4. Table 3 demonstrates minor changes in the gender and ethnicity percentage in the sample as a whole. Clinician #2 had the highest number of African Americans in his sample, a total of 12%. At the same time, he decided to remove teeth on 77% of his cases. Clinician #4, on the other hand, had the least number of patients who went through extraction (see Table 3).

TABLE 3.--Population Distribution--Sample of 400 Patients.

N = 400	All	Clinician #1	Clinician #2	Clinician #3	Clinician #4
Age before treatment	13.30 ± 6.01	12.32 ± 3.18	14.18 ± 6.05	13.14 ± 7.64	13.57 ± 6.23
Age after treatment	16.63 ± 5.76	15.68 ± 2.63	17.65 ± 5.99	16.67 ± 7.28	16.31 ± 6.04
Treatment time	3.32 ± 1.58	3.57 ± 2.02	3.46 ± 1.15	3.53 ± 1.79	2.74 ± 0.96
Extract	29.5%	27%	77%	9%	5%
Males	42.0%	46%	41%	37%	44%
Caucasians	96.5%	99%	88%	100%	99%

Chi-square statistical test was performed to test the comparability of the samples of the different clinicians. The groups were significantly different in ethnicity and extraction, but they were comparable in gender proportion (See Table 4).

TABLE 4.--Chi-square Test Comparing Proportions Among Clinicians.

	Clinician #1	Clinician #2	Clinician #3	Clinician #4	p-value
Males	46%	41%	37%	44%	0.595
Caucasians	99%	88%	100%	99%	0.0000*
Extraction	27%	77%	9%	5%	0.0000*

* significant at $p < 0.05$.

Based on the preliminary data analysis, which dealt with all patients as one sample, the mean for the IMPA angle was 94.11 ± 7.13° The range extended from 68° to 115°. The measurement of the IMPA post-treatment was 94.5 ± 8.33, with a range from 71° to 124°.

The mean change of the incisor tip of the lower incisor on the X-axis between pretreatment and post-treatment was -1.33 mm ± 2.76 (delta X). In other words, the incisal tip tended to move posteriorly during orthodontic treatment (Table 5). The mean change of the lower incisor tip on the Y-axis was 1.63 ± 2.26 mm (delta Y). The change or the difference in the lower incisor angulation between pre-treatment and post-treatment was 0.70 ± 7.81 (DIMPA).

TABLE 5.--Mean Outcome Values
for the Entire Sample.

n = 400	Mean± SD	Range
Angle before	94.11 ± 7.24	68-115
Angle after	94.80 ± 8.25	71-124
Delta IMPA°	0.70 ± 7.81	-24.00 - 23.00
Delta X mm	-1.33 ± 2.76	-10.00 - 5.57
Delta Y mm	1.63 ± 2.26	-4.75 - 11.00

Table 6 presented the mean values for the four clinicians. For clinician #1, the mean value for IMPA before treatment was 94.99 ± 7.4° with a range from 78° to 115°. Clinicians #2 and #3 had a mean similar to Clinician #1's sample (see Table 6). Clinician #4's sample had a mean value for IMPA before treatment of 92.9 ± 6.7°. This mean was the lowest. ANOVA was performed to find out if the means are significantly different.

Analysis of Variance

Analysis of variance (ANOVA) was computed among the four clinicians for the following variables—age before, age after, the IMPA angle before, IMPA

angle after, DIMPA, delta X, delta Y. All outcome variables (IMPA after, delta X, delta Y, DIMPA) were significantly different at a p-value of < 0.05. (See Table 6)

TABLE 6.--The Mean Values for the Four Clinicians and the (ANOVA) results.

	All Clinicians n = 400	Clinician #1 n = 100 Mean ± SD	Clinician #2 n = 100 Mean ± SD	Clinician #3 n = 100 Mean ± SD	Clinician #4 n = 100 Mean ± SD	ANOVA p-value
Age before TX	13.30 ± 6.00	12.32 ± 3.18	14.16 ± 6.05	13.14 ± 7.64	13.57 ± 6.23	0.1360
Range	6.00 - 56.00	6.00 - 30.00	7.00 - 43.00	7.00 - 56.00	7.00 -4 5.00	
Age after TX	16.63 ± 5.70	15.88 ± 2.63	17.65 ± 5.99	16 67 ± 7.28	16.31 ± 6.23	0.1642
Range	10.33 - 58 67	12.0 0- 33.00	12.40 - 45.00	11.20 - 58.60	10 30 - 47.60	
TX time	3.32 ± 1.58	3.57 ± 2.02	3.46 ± 1.15	3.53 ± 1 79	2.47 ± 0.96	0.000*
Range	0.67 - 9.50	0.67 - 9.50	1.67 - 6.00	1.00 - 8.25	1.17 - 5.50	
Angle before TX	94.11 ± 7.24	94.99 ± 7.40	95.09 ± 7.43	93 45 ± 7.21	92.90 ± 6.74	0 0726
Range	68 - 115	76 - 115	73 - 113	71 - 111	66 -112	
Angle after TX	94.60 ± 8.25	98.12 ± 7.79	88.52 ± 6.60	98.90 ± 7.45	93.68 ± 6.76	0.000*
Range	71 - 124	80 - 117	71 - 105	82 - 124	73 - 110	
DIMPA	0.70 ± 7.81	3.13 ± 7.06	-6.58 ± 5.79	5 45 ± 7.21	0.79 ± 5 34	0 000*
Range	-24 - 23	-14 - 22	-24 - 6	-16 - 23	-14 - 15	
Delta X	-1.33 ± 2.76	-0.70 ± 2.63	-4.16 ± 1.97	0.28 ± 2.34	-0.74 ± 1.76	0.000*
Range	-10 - 5 57	-6.5 - 5.6	-10 - 0.25	-6.0 - 5.5	-6.0 - 2.5	
Delta Y	1.63 ± 2.26	1.93 ± 2.36	0.39 ± 2.04	2.37 ± 2.52	1.66 ± 1.47	0 000*
Range	-4 8 - 11.0	-3.75 - 8.00	-4 8 - 6.0	-4 00 - 11.0	-1.0 -6.0	

* significant at p < 0.05

Regarding the measurement of IMPA after treatment or IMPA prime, Clinician #3 maintained the highest mean value of 98.9 ± 7.4° with a range extending up to 124° followed by Clinician #1 with a value of 98.12 ± 7.79°. Clinician #2 had the lowest value for IMPA post-treatment. Clinician #2's mean IMPA prime was 88°. This clinician maintained the lowest range, extending from 71° to 105°. All IMPA post-treatment mean values were significantly different among clinicians (see Table 6). Concerning the change in IMPA or DIMPA, Clinician #3 had the highest positive change with mean of 5.45 ± 7.21°, while Clinician #2 maintained the most negative value of -10.0 mm on the X-axis.

Too, the DIMPA mean values were significantly different among the four clinicians. Clinician #2 had the most negative change on the X axis with a mean value of -4.16 mm, while Clinicians #1 and #4 had a very close value of less than 1.0 mm of a negative change on the X axis. Also the mean value of delta X was significantly different among the clinicians.

The changes on the Y-axis were as follows: Clinician #2 had the least amount of change on the y-axis. His mean change was 0.35 ±2 .04 mm; Clinician #3 had the highest mean of Y change. Delta Y mean values were significantly different among the clinicians (Table 6).

t-test Analysis Results

t-test (equal variance) was computed to compare the outcome variables (DIMPA, delta X, delta Y) between groups of extraction/non-extraction, the groups of Caucasians and African Americans, the groups of males and females, and the groups formed based on the responses to the questionnaire. All the outcome variables (DIMPA, delta X, delta Y) were significantly different between the two groups of extraction and non-extraction (Table 7).

TABLE 7.--*t*-test Comparing Outcome Variables between Extraction and Non-extraction Groups.

Variables	Extraction (n - 118)	Non-extraction (n = 282)	p-value
DIMPA	-5.27 ± 2.18	3.19 ± 2.13	0.000 *
Delta X	-4.20 ± 1.99	-0.12 ± 2.06	0.000 *
Delta Y	0.85 ± 2.40	1.95 ± 2.21	0.000 *

* significant at $p < 0.05$.

The outcome variables DIMPA and delta X were also significantly different between Caucasians and African Americans, but not delta Y.

TABLE 8.--*t*-est Comparing Outcome Variables between Caucasians and African Americans.

Variables	Caucasians n = 386)	African Americans (n = 14)	p-value
DIMPA	1.01 ± 2.41	-8.00 ± 2.60	0.000 *
Delta X	-1.19 ± 2.66	-5.16 ± 2.85	0.000 *
Delta Y	1.65 ± 2.26	0.84 ± 2.15	0.1829

* significant at $p < 0.5$.

On the other hand, *t*-test showed no significant differences in DIMPA or X change between males and females group. The change in Y value was significant.

TABLE 9.--*t*-test Comparing Outcome Variables between Males and Females.

Variables	Males (n = 168)	Females (n = 232)	p-value
DIMPA	1.08 ± 2.26	0.40 ± 2.61	0.401
Delta X	-1.43 ± 2.68	-1.26 ± 2.68	0.5425
Delta Y	2.35 ± 2.37	1.10 ± 2.03	0.000 *

* significant at $p < 0.05$.

The study conducted a personal interview with each clinician and had each participating orthodontist answer a questionnaire of nine points. The list

of the questions can be found in the Methods and Materials section. The goal of this questionnaire was to find out the reason for the differences among clinicians, if any. Clinician #1 gave priorities to the upper incisor in his decision and treatment planning. Placing the upper incisors where they belong in the face, and trying his best to get the lower anterior teeth to couple the upper anterior teeth regardless of the measurement of the IMPA. Clinician #2 regarded the IMPA highly, and based most of his decisions on keeping this angle at a certain measurement. He believed in the importance of keeping the mandibular plane angle from increasing, and he practiced anchorage preparation to achieve his goals.

Clinician #3 considered himself to be a believer of the importance of the balance of the physiology, meaning he accepted a wide range for the value of IMPA, and tried his best to modify the physiology of the mouth to create this balance. Clinician #3 strived to fit all teeth in the face favoring wider smiles. Clinician #4 valued the IMPA to a degree, and would rather create space laterally by expanding the dental arch than flaring the lower anterior teeth. Clinician #4 routinely placed lingual crown torque in his lower anterior teeth.

The following table demonstrates the distribution of clinician's responses to the interview questionnaire (Table 10).

TABLE 10.–Distribution of Clinician's Responses to the Interview Questionnaire.

Question	Clinician #1	Clinician #2	Clinician #3	Clinician #4
No. 1, part I: Stability my primary goal	No	Yes	No	No
No. 1, Part II: Esthetics are my primary goal	Yes	No	No	Yes
No. 1, Part III: Function is my primary goal	No	No	Yes	No
0.018 slot = yes 0.22 slot = no	Yes	No	Yes	Yes
Removable appliance use	No	No	Yes	Yes
Straight wire use = yes Standard edgewise = no	Yes	No	Yes	Yes
NiTi use	No	No	Yes	Yes
Round wire use for leveling	Yes	No	Yes	Yes
Cinch-back	Yes	Yes	No	Yes
Values IMPA	No	Yes	No	No
In border line case: Tend to extract = yes Tend to flare = no	No	Yes	No	No

t-test statistics were computed between the two groups based on the responses to the questionnaire.

The first question was to see if the main goal in orthodontic treatment was the same among all four clinicians (function, esthetics, and stability). Stability was a priority to one of the clinicians, while the rest values this aspect the least. The *t*-test results between clinicians who value stability as their main goal versus clinicians who value esthetics were presented in Table 11.

TABLE 11.—The Mean Differences between the Clinicians Who Value Stability as Their Priority vs. Esthetics as Their Priority.

Variables	Stability (n = 100)	Esthetic (n = 200)	p-value
DIMPA	-6.58 ± 1.83	1.96 ± 2.00	0.000 *
Delta X	-4.16 ± 1.96	-0.72 ± 2.23	0.000 *
Delta Y	0.36 ± 2.40	1.89 ± 1.96	0.000 *

* significant at $p < 0.05$.

There was one clinician who valued stability as his main priority, while two clinicians considered esthetics their primary goal. All variables were significantly different between these two groups (p-value 0.05). The clinicians who valued stability had a larger change of IMPA in the negative direction, compared to the clinicians who valued esthetics. The same thing applied to the X and Y changes (see Table 11).

Running a similar *t*-test among clinicians who valued stability as their primary goal versus the rest of the clinicians with a primary goal of esthetics or function gave us similar data. This time the *t*-test was among one clinician versus the other three (Table 12).

TABLE 12.—The Mean Differences between Clinicians Who Value Stability as Their Priority vs. Clinicians Who Do Not.

Variables	Stability (n = 100)	Esthetic/Function Is a Priority (n = 300)	p-value
DIMPA	-6.57 ± 1.83	3.12 ± 2.16	0.000 *
Delta X	-4.16 ± 1.96	-0.39 ± 2.31	0.000 *
Delta Y	0.36 ± 2.04	2.05 ± 1.96	0.000 *

* significant at $p < 0.05$.

We analyzed the same variables among clinicians based on the second question. The question read—did the clinicians used a 0.018 slot size, or a 0.22 slot size, giving yes for the 0.018 slot size? The results matched totally with Table 11, because the clinician who valued stability was the only one who used 0.22-inch slot size. Table 13 summarizes the mean differences for the IMPA, X, and Y changes for the clinicians who used removable appliances vs. those who did not.

TABLE 13.—The Mean Differences between Clinicians Who Use Removable Appliances in Their Practices vs. Clinicians Who Do Not.

Variables	Mean ± SD Use (n = 200)	Mean ± SD Do Not Use (n = 200)	p-value
DIMPA	3.11 ± 2.13	-1.72 ± 2.55	0.000 *
Delta X	-0.23 ± 2.13	-2.43 ± 2.89	0.000 *
Delta Y	2.11 ± 2.07	1.15 ± 2.33	0.000 *

* significant at $p < 0.05$.

The clinicians who used removable appliances had more positive change in the IMPA angle and moved the incisal tip of the lower incisor less backward compared to their counterparts, who did not use the removable appliance.

The interview's fourth question was—did the clinicians use a straight wire appliance or did they use the standard edgewise? Table 14 summarized the mean differences of the IMPA, X, and Y changes between the two groups based on the response to the question. All outcome variables were significantly different between the two groups. Clinicians who used straight wire appliance tended to increase the IMPA on an average of 3.12°, while clinicians who used standard edgewise upright this angle on an average of 6.56°. Regarding the changes on the X-axis, straight wire users kept the tip of the lower incisor almost unchanged with an average of -0.39 mm, while clinicians who used standard edgewise moved the tip backward on an average of 4.16 mm. However, clinicians who used edgewise appliances kept the changes on the Y-axis minimal with an average of 0.036 mm, while clinicians who used straight wire had a positive change on an average of 2.05 mm.

TABLE 14.--The Mean Differences between Clinicians Who Use Pre-adjusted (Straight Wire) vs. Clinicians Who Use Standard Edgewise.

Variables	Mean ± SD Standard Edgewise (n = 100)	Mean ± SD Straight Wire (n = 300)	p-value
DIMPA	-6.57 ± 1.83	3.12 ± 2.16	0.000 *
Delta X	-4.16 ± 1.96	-0.39 ± 2.31	0.000 *
Delta Y	0.36 ± 2.04	2.05 ± 2.17	0.000 *

* significant at $p < 0.05$.

The fifth question in the interview questionnaire was—did the clinicians use NiTi wire as routine wire sequence? *t*-test analysis between the two groups formed, based on the response to the above question, showed a significant difference in IMPA change. Clinicians who used NiTi increased this angle in an average of 3.11° ± 2.13°. On the other hand, the clinicians who avoided NiTi wire use tended to decrease the IMPA measurement during treatment (Table 15).

TABLE 15.--The Mean Differences between Clinicians Who Use NiTi Wire as a Routine Wire Sequence vs. Clinicians Who Do Not.

Variables	Mean ± SD Use (n = 200)	Mean ± SD Do Not Use (n = 200)	p-value
Delta IMPA	3.11 ± 2.13	-1.72 ± 2.55	2.31E-10 *
Delta X	- 0.23 ± 2.13	-2.43 ± 2.89	1.21E-16 *
Delta Y	2.11 ± 2.07	1.15 ± 2.33	0.0001 *

* significant at $p < 0.05$.

Table 16 demonstrated the mean differences for the changes in IMPA, X, and Y between the clinicians who used round wire for leveling and the clinicians who did not (question #6 of the questionnaire).

TABLE 16.--The Mean Differences between Clinicians Who Use Round Wire During Leveling vs. Clinicians Who Do Not.

Variables	Mean ± SD Use (n = 100)	Mean ± SD Do Not Use (n = 300)	p-value
DIMPA	-6.57 ± 1.83	3.12 ± 2.16	0.0000 *
Delta X	-4.16 ± 1.96	-0.39 ± 2.31	0.0000 *
Delta Y	0.36 ± 2.04	2.05 ± 1.96	0.0000 *

* significant at $p < 0.05$.

Clinicians who did not use round wire for leveling tended to keep the changes of the IMPA angle in the negative direction and moved the incisal tip of the lower incisor on the negative on the X-axis.

Question seven in the questionnaire divided the study sample into two groups, a group treated by clinicians who tend to tie-back or cinch-back routinely when placing a new arch wire, and a group treated by clinicians who do not cinch- or tie-back. The study performed *t*-test analysis to compared the outcome variables between the above two groups. The mean differences were significantly different with a p-value of ≤ 0.05. Clinicians who cinch-back their wires had a much less forward movement of the lower incisor and maintained a negative mean of the changes on the X-axis (Table 17).

TABLE 17.--The Mean Differences between Clinicians Who Tie-back Wire as a Routine Procedure vs. Clinicians Who Do Not.

Variables	Mean ± SD Do Tie-Back (n = 300)	Mean ± SD Do Not Tie-Back (n = 100)	p-value
DIMPA	-0.88 ± 2.23	5.45 ± 2.28	0.0000 *
Delta X	-1.87 ± 2.70	0.27 ± 2.34	0.0000 *
Delta Y	1.38 ± 2.11	2.37 ± 2.52	0.0001 *

* significant at $p < 0.05$.

Table 18 presented the *t*-test analysis of the outcome variables between clinicians who valued the IMPA angle and the clinicians who did not.

TABLE 18.--The Mean Differences between Clinicians Who Value the IMPA Angle vs. Clinicians Who Do Not.

Variables	Mean ± SD Value (n = 100)	Mean ± SD Do Not Value (n = 300)	p-value
DIMPA	-6.57 ± 1.83	3.12 ± 2.16	0.0000 *
Delta X	-4.16 ± 1.96	-0.39 ± 2.31	0.0000 *
Delta Y	0.36 ± 2.04	2.05 ± 2.17	0.0000 *

* significant at $p < 0.05$.

Again, the clinicians who valued the IMPA angle maintained a negative mean change of this angle and moved the tip of the lower incisor an average of 4.0 mm more negatively compared to their counterparts who did not value this angle (see Table 18). *t*-test analysis was performed between the two groups based on the response to the last question in the questionnaire.

TABLE 19.–The Mean Differences between Clinicians Who Tend to Extract in Borderline Cases vs. Clinicians Who Tend to Flare the Lower Incisor.

Variables	Mean ± SD Tend to Extract (n = 100)	Mean ± SD Tend to Flare (n = 300)	p-value
DIMPA	-6.57 ± 1.83	3.12 ± 2.16	0.0000 *
Delta X	-4.16 ± 1.96	-0.39 ± 2.31	0.0000 *
Delta Y	0.36 ± 2.04	2.05 ± 2.17	0.0000 *

* significant at $p < 0.05$.

Table 19 demonstrated that the clinicians who tend to extract reduced the IMPA angle on an average of 6.57°. At the same time, they moved the incisal tip of the lower incisor backward on the X-axis an average of 4.16 mm . It was noticed during a committee meeting that the outcome variables of Clinician #2 were very different from the rest. The committee raised the question, "were the outcome variables for Clinician #2 different because most of his patients went through extraction?" *t*-test analysis was performed to compare the outcome variables between the patients who went through extraction and treated by Clinician #2, and the patients who went through extraction and were treated by the rest of the clinicians.

TABLE 20.--*t*-test Comparing Outcome Variables between the Patients Who Went through Extraction by Clinician #2 and the Patients Who Went through Extraction by the Rest of the Clinicians.

Variables	Mean ± SD Extraction by Clinician #2 (n = 100)	Mean ± SD Extraction by the Rest of Clinicians (n = 300)	p-value
DIMPA	-7.35 ± 1.78	-1.34 ± 2.32	0.0000 *
Delta X	-4.63 ± 1.80	-3.39 ± 2.09	0.0005 *
Delta Y	0.38 ± 2.09	1.74 ± 2.09	0.0005 *

* significant at $p < 0.05$.

t-test analysis results presented in Table 20 showed that the outcome variables were significantly different between the above two groups. Clinician #2 tended to upright the lower incisor on an average of 6° more than the rest of the clinicians. At the same time, Clinician #2 moved the incisal tip of the lower incisor on an average of 1.0 mm more backward, and the same clinician showed less upward movement on the Y-axis compared to the rest of the clinicians.

Regression

The forced entry model of regression showed that some of the independent variables were highly correlated with each other, so step-wise model of regression was used. The step-wise model of regression showed that 42% of the variance in IMPA change was predicted by slot size, extraction decision, treatment time, tie-back, or clinicians; 29% of the previous variables belonged to slot size (Table 21).

TABLE 21.--Step-wise Regression Predicting Delta IMPA.

Variables	b ± Std. Error	R^2	p-value
Slot size	6.014 ± 0.890	29.0%	0.000 *
Extraction	-5.340 ± 0.850	4.5%	0.000 *
Age	0.860 ± 0.200	4.0%	0.000 *
Tie-back	-3.260 ± 0.760	4.0%	0.000 *
Clinician	-0.930 ± 0.294	1.5%	0.002 *
Constant	-0.337 ± 1.630		0.840

* significant at p <0.05.

Table 22 gives the step-wise regression results of the independent variables predicting delta X. The total R^2 for the model was 53.5% with extraction contributing the most variance (45%).

TABLE 22.--Step-wise Regression Predicting X
Predictors of X Change (Variance).

Variables	b ± Std. Error	R^2	p-value
Extraction	-3.05 ± 0.27	45.0%	0.000 *
Slot size	1.55 ± 0.29	5.0%	0.000 *
Tie-back	-0.89 ± 0.24	2.0%	0.000 *
Clinician	-0.24 ± 0.09	1.0%	0.000 *
Caucasian/African American	1.32 ± 0.54	0.5%	0.014 *
(Constant)	-1.60 ± 0.66		0.016 *

* significant at p <0 .05.

Finally, we used the same statistical test to find out about the percentage of the variables predicting the changes of the incisal tip of the lower incisor on

the Y-axis. Only two variables were found to predict the delta Y. The age of the patient predicted 14% of the delta Y value, followed by slot size (Table 23).

TABLE 23.–Step-wise Regression Predicting Delta Y.

Variables	b ± Std. Error	R^2	p-value
Age	0.57 ± 0.062	14.0%	0.000 *
Slot size	1.80 ± 0.230	12.0%	0.000 *
Constant	-1.61 ± 0.300		0.000 *

* significant at $p < 0.05$.

DISCUSSION

The purpose of the present study was to determine if changes in the position and angulation of the lower incisor during orthodontic treatment were related to the philosophy of the clinicians who were performing the treatments, the removal of bicuspid teeth, or other variables such as the slot size used or the age of the patient.

The wide range of DIMPA presented in our data indicated that, for better or for worse, incisor position could be modified during treatment. With this great power comes great responsibility, so the historical focus on lower incisor position in orthodontic care is justified. For example, if a clinician wants to avoid increases in DIMPA with treatment, he/she can extract teeth, use an 0.22 slot, and/or cinch back the archwire. Conversely, if the clinician would like to increase the IMPA during treatment, he/she can treat non-extraction, use an 0.018 slot and not tie-back archwires during leveling and aligning of the teeth. Importantly, these types of decisions are all up to the practitioner. So, it would appear that DIMPA is a useful indicator if we are interested in measuring cephalometric changes in dental position during treatment that are, at least in part, under operator control.

Overall, the average DIMPA was +1°. Interestingly, changes in DIMPA were always positive in non-extraction cases, and the mean value for non-

extraction cases was 3.19°. In contrast, the mean DIMPA value for extraction cases was -5.27°. This result agreed with the findings of Hagler et al.[54], who studied thirty African Americans who went through extraction. They found that the IMPA was reduced an average of 6.8°. One fact that is worth noting in our sample is that, although the mean was negative, there were individual extraction cases in which DIMPA was positive. Hagler et al. did not report on the range of values in their study, so we cannot say whether their findings were in concordance with ours. We also found that certain modifications in mechanics or treatment philosophy affected IMPA. For example, the use of an 0.22 slot, or tying back the wire were clinician-controlled variables that influenced IMPA. In conclusion, one can say that IMPA tended to increase during orthodontic treatment, and that extracting teeth was the most effective way to limit increases in IMPA.

Over all, the mean value of delta X was 1.33 mm. The impact of the extraction decision on this variable is also worth noting. In the extraction group, the incisal tip moved backward an average of 4.2 mm. In contrast, the incisal tip moved forward a small amount in the non-extraction. Interestingly, there were no cases in the non-extraction group where delta X was negative. This is in contrast to the findings for DIMPA. DIMPA was increased in some extraction cases because it was possible for a clinician to keep the incisal edge in the same position but still have an increase in IMPA. Such increases in IMPA in extraction cases occurred when the clinician used reverse curve of Spee in a

round archwire in low angle deep bite cases. Importantly, the extraction of teeth was the only way clinicians in this sample could move the incisal tip backward.

Comparing the value of DIMPA and delta X agreed with Tweed's recommendation[33,34] recommendation of multiplying the angular change in IMPA by 0.8 to estimate the movement of the incisor tip in millimeters. We might assume from the agreement of our mean values for DIMPA and delta X that the center of movement of the lower incisor was always located at the apex (this is what was indicated by Tweed). But when comparing the individual values for DIMPA and delta X in each case for each clinician, we found instances where delta X was negative and DIMPA was positive. In other words, the center of rotation or movement of the lower incisor was not at the apex. Clinician #1's sample had a mean delta X of -0.70 mm on the X-axis, while the mean DIMPA was +3.13°. Some of the explanations of the behavior of the tip of the lower incisor are as follows: Clinician #1 tended to use round wire for leveling but, at the same time, he cinched the wire back routinely. If the wire is cinched back, there is really no place for the tip of the lower incisor to move forward, so the apex compensates by moving lingually. This movement agreed with a recent study by Al Qabandi et al.,[55] who suggested that lower incisor proclination occurred by uncontrolled tipping around a center of rotation slightly apical to the center of resistance. Clinician #2 moved the tip of the lower incisor backward on the X-axis the most. The average value for delta X was -4.16mm. The IMPA angle was reduced on an average of 6.58°. These values don't match with the

formula suggest by Tweed, so the lower incisor moved backward with the center of rotation, not at the root apex but somewhere above it. In conclusion, the direction and amount of DIMPA does not match with delta X, and the regression showed that slot size might influence DIMPA the most, while extracting teeth is the largest predictor for delta X.

The average change of the incisal edge on the Y-axis was +1.63 mm. This change was similar to what Bazzucchi[39] and Dietrich[40] estimated as the change during normal growth. They suggested 0.6-0.8 mm per year as the average upward movement of the incisal tip on a line vertical to line of the horizon. Understanding that these averages represent a sample of both males and females, our data presented in Table 9 supported the idea of males tend to grow more than females. By accepting that orthodontic tooth movement is an extrusive movement in general and by comparing delta Y values among the four clinicians, delta Y for Clinician #2 was remarkably lower than the rest. Clinician #2 considered stability as his main priority and strived to avoid any sort of dental alveolar expansion. In addition, he followed a stringent protocol to control vertical and to avoid any increase in the mandibular plane or occlusal plane angles. Being a believer in the importance of the IMPA angle, following the discipline of anchorage preparation, using rectangular wire for leveling and using 0.22-inch slot size were all possible explanations for a distinguishable effect on controlling the movement of the lower incisor. The regression results were helpful in explaining the exceptional outcome values of Clinician #2. This

clinician started his patients on an average of one year later than the other clinicians. This might mean less movement on the Y-axis due to the decrease of growth. This difference was estimated from Bazzucchi et al. and Dietrich of about 0.6 mm per year in the years between 12 and 15. Using 0.22 slots and starting the patient at a later age are possible recommendation to minimize the extrusion movement of the lower incisor during orthodontic treatment.

APPENDIXES

Case Western Reserve University
Institutional Review Board
NOTICE OF APPROVAL

Responsible Investigator: Mark Hans
Department: DEN -Dental Clinic Ortho
IRB Protocol #20020317
Title: The Difference in Incisor Mandibular Plane Angle during Orthodontic Treatment (DIMPA)
[Co-Investigator: Nawaf Masri]

Approval Date: Tuesday, May 14, 2002
Continuing Review Deadline: Tuesday, April 29, 2003
Expiration Date: Tuesday, May 13, 2003

The Institutional Review Board (IRB) has APPROVED the above new protocol through the expedited review process.

It has been determined that this study involves minimal risk, and that the following vulnerable populations will be involved: minors.

As an investigator of human subjects, your responsibilities include the following:

1. Report all adverse events and unanticipated problems involving human subjects to the Office of Research Administration (ORA) within three (3) days of your knowledge of the occurrence.
2. Provide the ORA with a complete Continuing Review form (available at the CWRU IRB Web Pages, or from the ORA) by the continuing review deadline noted above, and when the study is terminated.
3. Discontinue all work pertaining to this protocol if a continuing review approval is not finalized by the expiration date noted above.
4. Submit all proposed changes to the protocol to the ORA, and receive approval from the IRB, before implementation of the change.
5. Keep all research data and consent documents in your possession for at least three (3) years after the completion of the research activity.

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CWRU Institutional Review Board
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TABLE 24.--Clinician #1 Measurement Samples

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
1	1001	99	88	-4.00	3.75	1	0	1	-11	15.00	18.00	3.00
1	1002	96	114	4.50	1.00	0	0	1	18	24.00	26.00	2.00
1	1003	106	104	-3.50	5.50	1	0	1	-2	12.00	16.00	4.00
1	1004	95	109	1.00	0.00	0	0	1	14	8.00	17.00	9.00
1	1005	93	97	3.00	4.00	0	0	1	4	11.50	14.50	3.00
1	1006	101	103	-2.75	1.50	1	0	1	2	12.00	15.00	3.00
1	1007	102	100	-1.75	2.75	0	1	1	-2	10.00	12.00	2.00
1	1008	95	98	1.75	2.00	0	0	1	3	14.00	18.00	4.00
1	1009	82	95	-4.00	2.75	1	1	1	13	14.50	17.00	2.50
1	1010	86	86	0.00	0.00	0	0	1	0	14.00	15.00	1.00
1	1011	108	107	-2.00	0.75	1	0	1	-1	12.00	17.00	5.00
1	1012	105	100	-3.00	2.25	1	0	1	-5	11.00	13.00	2.00
1	1013	110	105	-1.00	0.50	0	0	1	-5	14.00	15.00	1.00
1	1014	96	95	-3.50	0.00	1	1	1	-1	12.00	15.00	3.00
1	1015	105	110	-1.00	1.75	0	1	1	5	11.42	14.42	3.00
1	1016	97	102	-0.25	-0.50	0	1	1	5	12.00	14.00	2.00
1	1017	93	94	-3.50	-0.25	0	0	0	1	11.00	14.00	3.00
1	1018	104	107	2.50	1.25	0	0	1	3	12.50	14.50	2.00
1	1019	90	98	0.75	2.00	0	0	1	8	12.00	16.00	4.00
1	1020	94	95	-0.75	-0.75	0	0	1	1	15.33	18.00	2.67
1	1021	84	97	2.75	3.00	0	1	1	13	13.42	16.00	2.58
1	1022	105	106	1.50	0.00	0	0	1	1	12.00	14.00	2.00
1	1023	94	100	2.50	2.75	0	1	1	6	14.42	15.42	1.00
1	1024	90	87	-2.50	0.75	0	0	1	-3	11.42	14.00	2.58
1	1025	87	108	3.00	2.00	0	1	1	21	10.00	14.00	4.00
1	1026	97	99	-2.50	0.50	1	0	1	2	10.42	13.42	3.00
1	1027	94	95	1.75	-0.75	0	0	1	1	13.42	16.00	2.58
1	1028	88	90	-2.75	7.00	0	1	1	2	9.42	15.42	6.00
1	1029	99	90	-5.50	-0.50	1	0	1	-9	12.00	14.42	2.42
1	1030	95	114	2.75	2.00	1	0	1	19	8.00	16.00	8.00
1	1031	100	97	-3.00	8.00	0	1	1	-3	8.00	15.00	7.00
1	1032	97	100	-0.75	2.75	0	1	1	3	10.00	12.00	2.00
1	1033	96	97	-2.00	6.25	0	1	1	1	10.00	16.00	6.00
1	1034	85	88	-2.50	3.25	0	0	1	3	9.00	16.00	7.00
1	1035	86	99	2.00	2.75	0	1	1	13	12.00	16.00	4.00
1	1036	97	108	3.00	7.00	0	0	1	11	7.00	13.00	6.00
1	1037	90	97	-1.50	0.25	1	1	1	7	13.00	16.00	3.00
1	1038	84	80	-5.25	2.00	1	1	1	-4	12.00	17.00	5.00
1	1039	98	103	1.25	4.00	0	1	1	5	12.00	14.00	2.00
1	1040	91	90	-3.00	1.50	1	1	1	-1	12.00	14.00	2.00
1	1041	105	103	-2.50	1.00	0	1	1	-2	13.00	15.00	2.00
1	1042	100	92	-5.25	2.75	0	1	1	-8	14.00	17.00	3.00
1	1043	100	110	1.25	6.50	0	1	1	10	10.42	16.42	6.00
1	1044	100	104	-2.00	-0.75	1	0	1	4	12.00	17.00	5.00
1	1045	90	99	1.25	6.00	0	1	1	9	11.00	17.00	6.00
1	1046	96	98	-1.00	3.00	0	0	1	2	9.42	16.42	7.00
1	1047	91	96	-1.25	5.50	0	1	1	5	8.42	14.42	6.00
1	1048	94	95	1.50	0.50	0	0	1	1	12.00	15.00	3.00
1	1049	94	102	2.50	5.50	0	0	1	8	10.42	13.00	2.58

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
1	1050	94	96	-2.25	3.50	1	0	1	2	9.00	14.00	5.00
1	1051	107	109	1.00	-2.50	0	0	1	2	11.00	15.00	4.00
1	1052	93	95	-1.00	3.00	0	1	1	2	15.00	17.00	2.00
1	1053	83	91	0.50	-1.50	0	0	1	8	15.42	17.42	2.00
1	1054	90	104	1.25	0.50	0	1	1	14	13.42	15.42	2.00
1	1055	93	104	5.57	2.25	0	1	1	11	10.00	15.00	5.00
1	1056	90	94	0.00	-1.00	0	0	1	4	12.00	14.00	2.00
1	1057	93	98	-3.75	2.25	1	1	1	5	13.00	16.00	3.00
1	1058	86	84	-4.00	5.50	1	1	1	-2	12.00	16.00	4.00
1	1059	91	100	0.00	0.50	0	0	1	9	15.00	17.00	2.00
1	1060	95	89	-4.00	6.25	1	0	1	-6	7.67	17.08	9.42
1	1061	87	95	1.30	1.30	0	1	1	8	14.00	16.00	2.00
1	1062	93	100	0.75	2.00	0	1	1	7	13.25	16.00	2.75
1	1063	100	103	1.50	0.50	0	0	1	3	13.50	18.00	4.50
1	1064	94	90	-2.00	0.50	0	1	1	-4	12.00	15.00	3.00
1	1065	109	100	1.00	0.75	0	1	1	-9	14.75	17.33	2.58
1	1066	84	83	-2.50	7.00	0	1	1	-1	10.00	16.42	6.42
1	1067	85	88	-5.00	5.75	1	1	1	3	9.00	18.42	9.42
1	1068	113	117	1.00	1.50	0	1	1	4	16.42	18.42	2.00
1	1069	95	92	-3.25	2.00	1	0	1	-3	11.33	13.58	2.25
1	1070	86	85	-3.25	3.25	1	1	1	-1	11.00	14.00	3.00
1	1071	92	93	1.00	1.25	0	0	1	1	12.75	15.00	2.25
1	1072	94	106	1.50	2.00	0	0	1	12	14.00	16.50	2.50
1	1073	78	100	3.25	4.50	0	1	1	22	12.58	17.75	5.17
1	1074	90	108	4.75	6.00	0	1	1	18	11.50	15.00	3.50
1	1075	99	100	1.75	1.00	0	0	1	1	12.75	14.00	1.25
1	1076	103	103	-1.00	1.25	0	0	1	0	12.17	14.08	1.92
1	1077	101	109	2.00	1.25	0	0	1	8	14.50	15.92	1.42
1	1078	102	103	-0.50	3.00	0	0	1	1	13.00	15.00	2.00
1	1079	90	80	-4.75	0.75	1	0	1	-10	14.33	16.58	2.25
1	1080	88	106	2.50	-1.50	0	0	1	18	11.00	14.00	3.00
1	1081	97	88	-6.00	1.25	1	0	1	-9	14.00	16.67	2.67
1	1082	97	98	1.50	1.25	0	0	1	1	15.00	18.00	3.00
1	1083	86	96	-1.75	2.50	0	1	1	10	15.00	17.00	2.00
1	1084	97	96	-1.50	2.00	0	1	1	-1	14.58	18.00	3.42
1	1085	92	95	-2.50	4.00	0	0	1	3	9.42	16.42	7.00
1	1086	115	115	-1.25	0.75	0	0	1	0	10.17	14.67	4.50
1	1087	107	101	-4.00	4.00	1	1	1	-6	9.00	14.00	5.00
1	1088	100	99	-3.50	2.50	1	0	1	-1	13.50	16.25	2.75
1	1089	95	97	-0.75	-0.75	0	1	1	2	12.17	14.75	2.58
1	1090	90	91	-1.25	0.75	0	0	1	1	11.00	19.00	8.00
1	1091	88	89	1.25	-1.75	0	0	1	1	20.00	21.00	1.00
1	1092	112	98	-6.50	-3.75	1	1	1	-14	30.00	33.00	3.00
1	1093	96	102	-1.25	-3.00	0	0	1	6	9.33	12.00	2.67
1	1094	95	99	1.00	3.50	0	1	1	4	8.67	13.42	4.75
1	1095	80	82	-0.50	-0.50	0	0	1	2	18.33	20.33	2.00
1	1096	96	95	-3.00	1.25	0	1	1	-1	11.00	14.00	3.00
1	1097	99	97	-4.50	0.50	1	0	1	-2	12.00	15.00	3.00
1	1098	95	109	2.50	-1.00	0	1	1	14	6.00	15.50	9.50

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
1	1099	90	90	0.00	0.00	0	1	1	0	14.33	15.00	0.67
1	1100	90	99	2.00	1.75	0	0	1	9	12.50	15.00	2.50

TABLE 25.--Clinician #2 Measurement Samples

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
2	2001	104	90	-5.00	2.25	1	1	1	-14	12.00	14.50	2.50
2	2002	84	80	-5.00	2.00	0	0	1	-4	13.00	16.00	3.00
2	2003	103	90	-5.50	-2.75	1	0	0	-13	27.00	32.00	5.00
2	2004	99	95	-3.00	-2.50	1	0	1	-4	10.00	13.00	3.00
2	2005	97	90	-5.00	0.05	1	1	1	-7	10.17	15.17	5.00
2	2006	95	91.5	-2.50	2.00	1	1	1	-3.5	16.00	18.00	2.00
2	2007	102	96	-2.50	0.75	1	0	1	-6	9.42	12.42	3.00
2	2008	109	97	-2.00	-1.50	0	0	1	-12	43.00	45.00	2.00
2	2009	102	90	-5.00	-2.00	1	1	1	-12	12.25	15.00	2.75
2	2010	88	82	-2.75	-2.50	1	0	1	-6	15.42	17.42	2.00
2	2011	105	94	-4.75	1.50	1	1	1	-11	11.25	15.25	4.00
2	2012	103	92	-5.00	-3.00	1	0	1	-11	14.00	17.00	3.00
2	2013	88	83	-4.25	-1.50	0	0	1	-5	10.00	14.00	4.00
2	2014	85	91	-4.00	2.25	1	1	1	6	15.00	21.00	6.00
2	2015	88	82	-3.50	1.50	1	1	1	-6	28.00	31.00	3.00
2	2016	90	91	-2.50	2.75	1	1	1	1	10.33	15.33	5.00
2	2017	85	85	-2.00	2.25	0	1	1	0	13.67	16.67	3.00
2	2018	94	86	-5.00	2.25	1	0	1	-8	11.00	14.00	3.00
2	2019	87	87	-2.50	-0.50	1	0	1	0	11.00	15.00	4.00
2	2020	103	95	-6.50	0.75	1	0	0	-8	10.00	13.00	3.00
2	2021	102	78	-10.00	-1.50	1	0	0	-24	18.00	21.00	3.00
2	2022	92	91	-4.00	3.00	1	1	1	-1	12.00	15.00	3.00
2	2023	105	94	-8.00	1.25	1	1	0	-11	24.00	29.00	5.00
2	2024	105	103	-2.75	2.75	1	1	1	-2	13.58	16.58	3.00
2	2025	95	94	-3.00	-0.25	1	0	1	-1	12.33	15.33	3.00
2	2026	90	81	-5.50	-0.50	1	1	0	-9	13.17	17.17	4.00
2	2027	97	95	-3.00	3.75	1	1	0	-2	12.00	18.00	6.00
2	2028	90	91	-4.00	1.00	1	1	1	1	13.67	16.67	3.00
2	2029	103	94	-5.25	-1.00	1	1	0	-9	13.83	15.50	1.67
2	2030	101	105	0.00	0.50	0	0	1	4	12.00	14.42	2.42
2	2031	94	95	0.25	1.00	0	1	1	1	12.42	15.00	2.58
2	2032	102	96	-6.00	1.50	1	1	1	-6	12.25	16.00	3.75
2	2033	91	86	-3.00	2.25	1	0	1	-5	11.75	15.00	3.25
2	2034	104	95	-6.00	-3.00	1	0	1	-9	15.00	18.42	3.42
2	2035	88	77	-2.50	-2.00	1	0	1	-11	35.00	37.50	2.50
2	2036	97	90	-4.00	-2.50	0	1	1	-7	14.42	16.58	2.17
2	2037	105	95	-5.50	-1.50	1	0	1	-10	15.67	18.67	3.00
2	2038	93	92	-1.25	2.50	0	0	1	-1	12.00	14.67	2.67
2	2039	90	84	-5.00	0.50	1	1	1	-6	11.42	15.25	3.83
2	2040	94	86	-7.50	6.00	1	0	1	-8	7.00	15.00	8.00
2	2041	96	94	-2.00	-4.75	1	0	1	-2	18.00	21.00	3.00
2	2042	97	97	-1.50	-2.25	1	1	1	0	11.00	17.75	6.75
2	2043	107	94	-2.25	-2.25	1	0	1	-13	26.00	29.00	3.00
2	2044	92	88	-3.25	1.00	1	0	1	-4	10.00	16.00	6.00
2	2045	94	83	-5.50	3.00	1	0	1	-11	11.00	13.00	2.00
2	2046	93	98	-3.00	-1.75	1	1	1	5	11.58	16.00	4.42
2	2047	94	88	-2.00	-3.00	0	0	1	-6	13.00	16.00	3.00
2	2048	106	96	-4.00	1.50	0	1	1	-10	11.33	14.33	3.00
2	2049	96	92	-1.00	-0.25	0	1	1	-4	12.50	14.75	2.25

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
2	2050	105	90	-3.00	-3.00	1	0	1	-15	17.00	21.00	4.00
2	2051	102	90	-4.00	0.25	1	0	1	-12	10.00	14.75	4.75
2	2052	91	89	-3.00	1.75	0	1	1	-2	13.00	16.50	3.50
2	2053	85	87	-0.75	-1.00	0	1	0	2	14.00	16.42	2.42
2	2054	106	93	-4.25	0.00	1	0	1	-13	12.00	15.33	3.33
2	2055	106	96	-4.00	1.00	1	1	0	-10	13.00	16.67	3.67
2	2056	85	71	-7.50	2.50	1	0	1	-14	8.25	15.00	6.75
2	2057	92	84	-5.00	1.25	1	1	1	-8	12.00	16.67	4.67
2	2058	104	90	-5.00	-0.50	1	0	1	-14	12.33	15.25	2.92
2	2059	73	71	-6.00	2.50	1	1	1	-2	13.42	15.17	1.75
2	2060	93	95	-1.50	-1.00	0	0	1	2	11.42	15.00	3.58
2	2061	89	82	-5.00	3.50	1	1	1	-7	13.33	16.42	3.08
2	2062	86	71	-9.50	4.50	1	1	0	-15	12.00	16.00	4.00
2	2063	92	93	-0.50	2.50	0	0	1	1	12.00	15.00	3.00
2	2064	102	90	-3.75	2.00	1	0	1	-12	10.00	14.00	4.00
2	2065	96	90	-5.00	0.25	1	0	1	-6	11.00	17.00	6.00
2	2066	90	91	-2.00	-1.75	0	0	1	1	24.00	27.00	3.00
2	2067	92	88	-3.00	-0.75	0	1	1	-4	12.67	16.00	3.33
2	2068	88	87	-2.25	2.00	0	0	1	-1	10.00	14.00	4.00
2	2069	97	84	-6.25	3.00	1	0	0	-13	11.17	14.42	3.25
2	2070	90	85	-6.00	-1.50	1	0	1	-5	12.33	15.58	3.25
2	2071	88	78	-6.00	-1.75	1	0	1	-10	12.50	16.50	4.00
2	2072	93	92	-5.00	-3.00	1	0	1	-1	13.00	16.67	3.67
2	2073	93	90	-4.00	-1.25	1	0	1	-3	14.50	17.50	3.00
2	2074	84	80	-4.00	0.25	1	0	1	-4	12.58	15.58	3.00
2	2075	92	88	-3.75	3.50	1	1	1	-4	12.25	16.50	4.25
2	2076	102	90	-4.50	-0.25	0	0	1	-12	12.00	15.00	3.00
2	2077	96	87	-6.00	0.75	1	1	1	-9	12.58	15.42	2.83
2	2078	93	80	-6.50	2.50	1	0	1	-13	11.17	14.00	2.83
2	2079	87	86	-3.00	-2.50	1	0	1	-1	11.00	15.00	4.00
2	2080	93	85	-5.50	3.50	0	1	1	-8	11.75	15.75	4.00
2	2081	92	80	-5.25	-1.25	1	0	1	-12	18.00	20.58	2.58
2	2082	90	73	-5.75	2.75	1	0	1	-17	10.17	13.17	3.00
2	2083	98	88	-5.00	2.00	1	1	1	-10	12.58	14.58	2.00
2	2084	94	93	-2.50	0.25	1	0	1	-1	11.17	14.75	3.58
2	2085	93	83	-4.00	3.00	0	0	0	-10	12.17	14.00	1.83
2	2086	95	91	-4.25	0.50	1	0	1	-4	11.58	14.58	3.00
2	2087	103	95	-6.00	1.00	1	1	1	-8	11.67	14.92	3.25
2	2088	93	87	-5.00	0.00	1	0	1	-6	10.42	13.00	2.58
2	2089	108	91	-4.00	-1.00	0	0	1	-17	38.00	41.00	3.00
2	2090	104	85	-8.50	-1.00	1	0	1	-19	10.50	14.00	3.50
2	2091	91	84	-2.50	1.00	1	1	1	-7	15.33	17.33	2.00
2	2092	77	73	-4.00	0.25	1	0	1	-4	13.00	16.00	3.00
2	2093	80	81	-2.00	-0.25	1	1	1	1	14.83	17.17	2.33
2	2094	105	93	-6.00	-0.50	1	0	1	-12	12.75	16.00	3.25
2	2095	90	91	-2.75	-1.25	0	0	1	1	14.00	18.00	4.00
2	2096	113	93	-8.50	0.50	1	0	1	-20	35.00	40.17	5.17
2	2097	90	85	-5.57	1.00	1	0	1	-5	12.92	16.75	3.83
2	2098	96	92	-3.75	2.00	1	1	1	-4	13.42	17.17	3.75

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
2	2099	96	95	-1.50	-2.00	1	0	1	-1	21.00	25.00	4.00
2	2100	92	86	-4.75	1.00	1	1	1	-6	13.00	16.00	3.00

TABLE 26.--Clinician #3 Measurement Samples

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
3	3001	89	104	0.50	2.00	0	0	1	15	10.50	15.92	5.42
3	3002	86	89	-2.50	3.75	0	1	1	3	10.08	15.08	5.00
3	3003	103	102	-2.00	3.15	0	1	1	-1	10.75	13.17	2.42
3	3004	94	105	5.50	6.25	0	1	1	11	9.67	14.92	5.25
3	3005	89	94	-1.00	5.00	0	1	1	5	9.00	16.33	7.33
3	3006	98	105	0.50	4.50	0	0	1	7	9.00	13.00	4.00
3	3007	98	112	1.25	5.45	0	0	1	14	8.33	14.58	6.25
3	3008	92	96	-1.50	3.45	0	0	1	4	9.92	17.00	7.08
3	3009	111	118	1.00	4.00	0	1	1	7	9.33	17.58	8.25
3	3010	98	104	2.25	5.25	0	0	1	6	7.75	13.00	5.25
3	3011	93	98	1.00	5.25	0	0	1	5	9.83	14.42	4.58
3	3012	92	100	-1.75	3.25	0	0	1	8	11.00	16.00	5.00
3	3013	88	101	0.50	4.50	0	0	1	13	9.00	15.42	6.42
3	3014	95	107	2.00	-0.50	0	1	1	12	13.50	16.00	2.50
3	3015	71	91	-1.00	7.00	0	1	1	20	10.08	16.50	6.42
3	3016	95	102	1.00	2.00	0	1	1	7	11.83	15.58	3.75
3	3017	91	95	-0.75	3.00	0	1	1	4	11.67	13.92	2.25
3	3018	96	104	2.00	1.25	0	0	1	8	12.17	14.00	1.83
3	3019	103	106	1.50	2.00	0	0	1	3	14.00	16.25	2.25
3	3020	92	92	0.00	0.00	0	0	1	0	14.25	15.25	1.00
3	3021	91	93	-1.50	3.50	0	1	1	2	7.92	14.00	6.08
3	3022	87	98	1.25	2.50	0	0	1	11	12.50	15.08	2.58
3	3023	76	92	2.50	7.00	0	0	1	16	7.00	13.00	6.00
3	3024	95	104	1.00	6.00	0	1	1	9	8.58	14.58	6.00
3	3025	92	99	0.00	3.00	0	0	1	7	12.08	14.08	2.00
3	3026	94	94	-2.00	1.75	0	1	1	0	9.67	13.17	3.50
3	3027	88	101	3.50	8.00	0	0	1	13	9.17	14.75	5.58
3	3028	93	95	1.00	-1.25	0	0	1	2	37.00	40.25	3.25
3	3029	89	105	2.50	-4.00	0	1	1	16	34.50	37.00	2.50
3	3030	98	107	1.50	1.00	0	0	1	9	10.00	13.83	3.83
3	3031	82	91	1.00	3.50	0	0	1	9	14.75	17.08	2.33
3	3032	92	112	3.50	1.50	0	0	1	20	12.42	15.08	2.67
3	3033	107	124	4.00	-2.00	0	1	1	17	7.08	14.67	7.58
3	3034	105	106	0.50	3.75	0	1	1	1	12.83	15.50	2.67
3	3035	101	102	0.25	0.25	0	0	1	1	15.83	16.83	1.00
3	3036	99	100	1.25	1.25	0	0	1	1	11.50	13.58	2.08
3	3037	98	113	4.50	-0.25	0	0	1	15	30.75	33.67	2.92
3	3038	94	114	4.75	1.25	0	0	1	20	7.33	12.92	5.58
3	3039	101	102	2.00	10.25	0	1	1	1	7.58	15.00	7.42
3	3040	99	87	-5.00	-1.00	1	1	1	-12	33.17	35.67	2.50
3	3041	97	106	3.50	2.50	0	1	1	9	11.17	14.92	3.75
3	3042	93	99	2.50	-1.25	0	1	1	6	35.42	38.00	2.58
3	3043	95	96	0.00	2.00	0	1	1	1	12.92	14.67	1.75
3	3044	90	92	-3.00	0.00	1	0	1	2	11.17	13.00	1.83
3	3045	94	92	-3.75	0.50	0	1	1	-2	12.58	14.67	2.08
3	3046	94	107	2.50	3.75	0	0	1	13	9.00	13.00	4.00
3	3047	87	87	-1.50	2.00	0	0	1	0	12.83	15.92	3.08
3	3048	90	99	2.00	6.00	1	1	1	9	8.17	13.50	5.33
3	3049	106	90	-6.00	-0.50	1	0	1	-16	13.42	15.42	2.00

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
3	3050	95	93	-2.00	1.50	0	0	1	-2	11.33	13.50	2.17
3	3051	94	101	2.50	1.75	0	0	1	7	11.17	15.25	4.08
3	3052	104	104	-1.00	-0.50	0	0	1	0	12.50	15.25	2.75
3	3053	98	105	2.00	3.00	0	0	1	7	11.67	14.25	2.58
3	3054	74	97	3.50	4.00	0	0	1	23	12.25	15.67	3.42
3	3055	89	100	2.00	2.00	0	0	1	11	13.17	15.33	2.17
3	3056	84	93	-0.50	6.00	0	1	1	9	11.00	14.00	3.00
3	3057	94	102	1.25	2.00	0	0	1	8	10.00	13.83	3.83
3	3058	102	95	1.00	11.00	0	1	1	-7	7.58	15.00	7.42
3	3059	95	110	4.00	1.25	0	0	1	15	7.33	12.92	5.58
3	3060	83	97	3.00	5.25	0	1	1	14	8.42	14.83	6.42
3	3061	94	101	2.50	5.00	0	1	1	7	9.58	13.75	4.17
3	3062	98	106	2.50	1.00	0	0	1	8	11.42	13.42	2.00
3	3063	110	111	1.50	2.00	0	0	1	1	11.42	13.42	2.00
3	3064	92	94	-0.75	0.00	1	0	1	2	11.67	13.00	1.33
3	3065	90	92	-1.00	-0.75	0	0	1	2	10.75	12.67	1.92
3	3066	84	100	4.00	5.50	0	0	1	16	10.25	15.33	5.08
3	3067	94	94	-2.00	3.50	0	1	1	0	9.50	16.92	7.42
3	3068	99	99	-1.25	2.00	0	0	1	0	13.92	15.25	1.33
3	3069	80	82	-1.25	2.00	0	0	1	2	13.00	16.92	3.92
3	3070	98	101	0.00	0.25	0	1	1	3	15.67	17.75	2.08
3	3071	96	104	1.00	3.00	0	0	1	8	12.83	15.33	2.50
3	3072	90	93	1.00	4.50	0	1	1	3	12.00	13.83	1.83
3	3073	81	90	2.00	-0.50	0	0	1	9	12.92	15.92	3.00
3	3074	88	94	0.75	1.75	0	0	1	6	11.42	14.42	3.00
3	3075	85	86	-5.00	0.75	1	0	1	1	10.00	13.00	3.00
3	3076	104	103	0.50	1.25	0	0	1	-1	13.83	14.83	1.00
3	3077	91	94	0.75	2.00	0	1	1	3	10.67	13.00	2.33
3	3078	103	88	-3.50	1.25	0	0	1	-15	10.92	13.17	2.25
3	3079	88	103	1.00	1.75	0	0	1	15	13.17	15.25	2.08
3	3080	93	98	-1.00	1.25	0	0	1	5	13.92	15.50	1.58
3	3081	92	85	-4.50	1.50	1	0	1	-7	10.67	15.00	4.33
3	3082	96	92	0.75	4.00	0	0	1	-4	11.25	13.42	2.17
3	3083	91	96	1.50	3.50	0	1	1	5	11.42	14.00	2.58
3	3084	90	90	0.25	0.25	0	0	1	0	56.00	58.67	2.67
3	3085	89	91	1.00	0.50	0	0	1	2	14.67	16.17	1.50
3	3086	107	103	-1.50	0.25	0	1	1	-4	14.08	16.17	2.08
3	3087	84	92	0.50	5.75	0	1	1	8	12.75	17.00	4.25
3	3088	94	93	-1.75	1.00	0	1	1	-1	21.00	23.42	2.42
3	3089	90	100	-2.50	-1.00	0	1	1	10	43.00	46.00	3.00
3	3090	102	106	-1.25	-1.00	0	0	1	4	12.00	13.50	1.50
3	3091	100	107	1.00	-0.25	0	0	1	7	13.17	15.50	2.33
3	3092	88	92	-1.00	1.50	0	0	1	4	8.17	11.25	3.08
3	3093	99	101	-2.00	-0.25	0	0	1	2	11.58	14.08	2.50
3	3094	105	96	-5.00	1.75	1	1	1	-9	14.25	16.42	2.17
3	3095	92	94	-5.50	1.75	1	0	1	2	9.67	14.00	4.33
3	3096	90	102	1.00	2.00	0	0	1	12	10.58	13.00	2.42
3	3097	92	95	-0.75	5.00	0	0	1	3	10.67	16.33	5.67
3	3098	91	104	1.00	0.75	0	0	1	13	11.83	14.58	2.75

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
3	3099	90	90	-1.75	1.75	0	1	1	0	12.33	14.42	2.08
3	3100	92	99	-0.50	2.25	0	0	1	7	9.92	15.00	5.08

TABLE 27.--Clinician #4 Measurement Samples

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
4	4001	100	110	2.50	-0.50	0	1	1	10	13.00	14.50	1.50
4	4002	94	95	0.00	0.50	0	1	1	1	15.75	17.83	2.08
4	4003	99	100	0.25	0.50	0	1	1	1	12.17	14.25	2.08
4	4004	93	92	-3.00	1.50	0	1	1	-1	12.00	14.75	2.75
4	4005	105	105	-1.00	1.00	0	1	1	0	12.67	13.92	1.25
4	4006	94	91	-2.00	-1.00	1	0	1	-3	22.75	27.67	4.92
4	4007	88	113	5.00	3.75	0	0	1	25	9.50	16.50	7.00
4	4008	102	103	1.25	2.50	0	0	1	1	37.50	41.83	4.33
4	4009	88	90	-1.50	-2.00	0	0	1	2	14.00	16.25	2.25
4	4010	91	92	-1.00	1.00	0	0	1	1	13.50	14.75	1.25
4	4011	97	99	-3.00	-1.50	1	0	1	2	11.83	14.50	2.67
4	4012	94	75	-6.50	-1.00	1	1	1	-19	11.08	13.42	2.33
4	4013	85	85	1.25	0.50	0	0	1	0	14.08	16.42	2.33
4	4014	97	99	1.25	-0.50	0	0	1	2	9.83	12.67	2.83
4	4015	90	88	-1.00	8.50	0	1	1	-2	10.58	15.92	5.33
4	4016	91	83	-3.50	8.50	0	1	1	-8	8.33	17.42	9.08
4	4017	95	90	-1.75	-1.75	0	0	1	-5	13.17	15.50	2.33
4	4018	100	98	-3.00	1.00	1	0	1	-2	10.08	12.25	2.17
4	4019	89	95	1.25	0.25	0	0	1	6	12.17	13.67	1.50
4	4020	72	84	1.25	3.25	0	0	1	12	12.75	15.25	2.50
4	4021	80	80	-1.00	3.00	0	0	1	0	11.75	13.33	1.58
4	4022	101	95	-3.25	3.00	0	1	1	-6	12.25	14.58	2.33
4	4023	82	83	0.50	0.50	0	0	1	1	12.25	15.58	3.33
4	4024	88	100	2.50	0.75	0	0	1	12	9.92	11.83	1.92
4	4025	99	110	1.00	2.50	0	1	1	11	12.17	14.17	2.00
4	4026	87	89	1.50	0.00	0	0	1	2	11.25	17.42	6.17
4	4027	90	92	-1.00	0.50	0	0	1	2	12.67	16.42	3.75
4	4028	89	98	1.25	3.00	0	0	1	9	9.42	12.83	3.42
4	4029	106	99	-2.25	2.50	0	0	1	-7	13.25	15.75	2.50
4	4030	96	99	1.50	3.25	0	1	1	3	14.50	16.00	1.50
4	4031	85	87	-0.25	3.00	0	0	1	2	10.75	15.25	4.50
4	4032	92	94	1.25	0.75	0	0	1	2	13.25	15.33	2.08
4	4033	90	90	-0.75	-1.25	0	1	1	0	11.42	13.17	1.75
4	4034	89	92	-1.00	-1.50	0	0	1	3	10.50	13.00	2.50
4	4035	92	90	-1.00	-0.75	0	0	1	-2	10.83	12.67	1.83
4	4036	103	104	-1.50	-1.25	0	1	1	1	11.00	13.00	2.00
4	4037	85	92	1.00	1.00	0	0	1	7	12.75	14.75	2.00
4	4038	98	89	-5.00	6.00	1	1	1	-9	8.25	15.58	7.33
4	4039	98	105	1.00	2.50	0	1	1	7	9.00	13.50	4.50
4	4040	88	91	-1.00	-1.25	0	1	1	3	15.83	17.17	1.33
4	4041	85	83	-1.50	3.00	0	1	1	-2	13.92	16.58	2.67
4	4042	101	90	-5.50	3.50	1	1	1	-11	10.83	13.75	2.92
4	4043	81	73	-6.25	3.00	1	1	1	-8	14.08	16.67	2.58
4	4044	90	89	-4.00	-0.25	1	1	1	-1	16.92	18.92	2.00
4	4045	82	85	-3.00	8.00	1	1	1	3	8.92	18.33	9.42
4	4046	93	94	-1.00	7.00	1	1	1	1	9.58	15.50	5.92
4	4047	90	83	-5.00	4.00	1	0	1	-7	11.17	15.42	4.25
4	4048	99	97	-2.00	1.50	0	0	0	-2	14.00	18.75	4.75
4	4049	93	113	2.50	-1.00	0	1	1	20	11.92	13.50	1.58

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
4	4050	96	97	0.50	0.50	0	0	1	1	10.83	12.42	1.58
4	4051	93	83	-2.00	1.50	0	1	1	-10	13.50	15.50	2.00
4	4052	91	90	-0.75	1.50	0	0	1	-1	10.50	14.50	4.00
4	4053	104	106	2.00	-0.25	0	0	1	2	14.00	16.50	2.50
4	4054	81	84	-2.75	-2.00	1	1	1	3	16.25	20.75	4.50
4	4055	85	92	3.00	-3.00	0	0	1	7	11.25	12.83	1.58
4	4056	101	92	-4.00	-0.50	1	0	1	-9	12.00	14.50	2.50
4	4057	92	101	1.50	-1.00	0	1	1	9	15.17	16.83	1.67
4	4058	89	86	-2.00	-2.00	0	1	1	-3	10.75	13.83	3.08
4	4059	97	110	1.75	-0.25	0	0	1	13	11.58	13.42	1.83
4	4060	99	105	-0.75	1.75	0	1	1	6	11.83	13.92	2.08
4	4061	93	102	0.50	3.00	0	0	1	9	8.42	14.42	6.00
4	4062	80	95	1.25	5.00	0	0	1	15	7.75	16.00	8.25
4	4063	104	100	-3.50	-4.25	1	0	1	-4	12.17	14.67	2.50
4	4064	89	91	-1.00	5.00	1	0	1	2	8.58	14.92	6.33
4	4065	92	90	-1.00	1.25	0	0	1	-2	10.92	13.00	2.08
4	4066	89	89	0.25	0.25	0	0	1	0	12.67	14.92	2.25
4	4067	96	88	-6.25	2.50	1	1	1	-8	8.42	16.83	8.42
4	4068	92	114	4.00	1.00	0	0	1	22	8.50	13.58	5.08
4	4069	93	89	-2.00	1.00	0	1	1	-4	14.42	16.92	2.50
4	4070	101	103	1.75	-1.25	0	0	1	2	12.00	14.50	2.50
4	4071	95	80	-7.00	1.00	1	1	1	-15	14.17	16.75	2.58
4	4072	99	90	-3.25	-3.25	1	0	1	-9	40.00	43.00	3.00
4	4073	90	105	-4.00	-2.50	0	0	1	15	12.50	14.92	2.42
4	4074	87	89	1.00	2.00	0	0	1	2	50.00	53.00	3.00
4	4075	93	92	-2.25	-0.75	1	1	1	-1	13.33	15.67	2.33
4	4076	100	102	1.00	-0.75	0	1	1	2	12.50	15.92	3.42
4	4077	94	85	-3.00	-0.50	1	1	1	-9	13.17	15.67	2.50
4	4078	90	91	0.75	0.50	0	0	1	1	12.00	14.58	2.58
4	4079	82	81	-4.00	-3.50	1	0	1	-1	18.00	21.00	3.00
4	4080	92	98	1.00	0.25	1	0	1	6	16.42	19.25	2.83
4	4081	92	94	2.00	4.25	0	1	1	2	9.33	16.83	7.50
4	4082	89	93	-1.25	0.00	0	0	1	4	13.00	17.00	4.00
4	4083	82	96	-5.50	3.75	0	1	1	14	11.00	13.83	2.83
4	4084	95	96	-0.75	1.50	0	0	1	1	16.00	17.25	1.25
4	4085	90	94	-3.00	4.25	1	0	1	4	8.00	15.00	7.00
4	4086	80	84	-1.00	2.50	0	0	1	4	7.75	14.00	6.25
4	4087	89	87	-2.00	1.75	0	1	1	-2	13.58	15.67	2.08
4	4088	91	82	-5.50	1.25	1	0	1	-9	11.75	14.17	2.42
4	4089	91	98	1.00	5.00	1	1	1	7	9.33	17.00	7.67
4	4090	91	102	2.25	1.00	0	0	1	11	13.75	15.42	1.67
4	4091	95	85	-4.00	-2.50	1	0	1	-10	15.25	17.75	2.50
4	4092	86	87	0.75	1.00	0	1	1	1	30.00	32.00	2.00
4	4093	85	95	-0.75	1.00	1	0	1	10	10.00	16.83	6.83
4	4094	83	72	-6.00	1.00	0	1	1	-11	6.67	18.83	12.17
4	4095	100	95	1.00	-1.00	0	1	1	-5	11.75	14.00	2.25
4	4096	91	104	3.25	0.25	0	1	1	13	11.00	15.17	4.17
4	4097	97	91	-2.00	-0.50	0	0	1	-6	14.33	17.33	3.00
4	4098	90	94	-2.50	-3.00	1	0	0	4	12.33	16.25	3.92

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
4	4099	98	97	-4.50	0.25	1	0	1	-1	9.58	13.42	3.83
4	4100	90	91	0.75	1.00	0	1	1	1	13.00	14.50	1.50

TABLE 28.--Clinician #5 Measurement Samples

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
5	5001	92	90	-1.00	0.75	0	1	1	-2	13.00	15.25	2.25
5	5002	94	99	1.25	1.50	0	0	1	5	11.00	13.67	2.67
5	5003	92	101	-0.50	1.50	1	1	0	9	12.00	15.00	3.00
5	5004	95	95	-4.00	0.00	1	0	1	0	12.00	15.00	3.00
5	5005	112	107	-1.00	4.00	0	0	1	-5	12.00	16.25	4.25
5	5006	90	89	-1.50	1.25	0	1	1	-1	13.00	15.17	2.17
5	5007	89	88	-0.50	1.50	0	0	1	-1	14.00	16.42	2.42
5	5008	100	95	-1.50	2.00	0	1	1	-5	17.00	19.17	2.17
5	5009	83	90	-0.75	4.00	0	1	1	7	14.00	16.83	2.83
5	5010	100	101	1.00	2.75	0	0	1	1	7.00	11.00	4.00
5	5011	89	91	-0.75	-0.25	0	0	1	2	13.00	15.33	2.33
5	5012	96	108	2.00	3.50	0	1	1	12	9.00	13.75	4.75
5	5013	90	91	-1.00	2.50	0	1	1	1	13.00	15.17	2.17
5	5014	100	105	0.00	2.25	0	1	1	5	14.00	16.50	2.50
5	5015	90	91	-0.50	0.75	0	0	1	1	12.00	14.33	2.33
5	5016	91	93	-1.25	2.00	0	1	1	2	13.00	15.42	2.42
5	5017	98	98	-0.50	1.00	0	0	1	0	13.00	15.75	2.75
5	5018	68	79	1.00	3.75	0	1	1	11	13.00	15.50	2.50
5	5019	92	92	-2.00	5.00	0	1	1	0	11.00	15.50	4.50
5	5020	88	92	0.75	2.50	0	0	1	4	11.00	13.00	2.00
5	5021	92	92	0.00	0.50	0	0	1	0	13.00	15.50	2.50
5	5022	80	90	1.75	1.50	0	0	1	10	12.00	14.00	2.00
5	5023	92	90	-1.50	2.50	0	1	1	-2	15.00	17.17	2.17
5	5024	94	96	-0.50	1.50	0	1	1	2	10.92	13.08	2.17
5	5025	94	92	-1.00	1.75	0	1	1	-2	10.00	12.58	2.58
5	5026	94	94	-1.00	2.00	0	1	1	0	10.00	13.58	3.58
5	5027	96	95	-0.75	3.00	0	1	1	-1	12.00	14.58	2.58
5	5028	90	91	-1.00	1.25	0	0	1	1	11.00	13.58	2.58
5	5029	107	105	-2.50	4.50	0	1	1	-2	11.00	13.50	2.50
5	5030	85.5	90	-2.50	5.00	0	1	1	4.5	12.00	14.42	2.42
5	5031	88	91	-0.50	2.50	0	0	1	3	13.00	15.17	2.17
5	5032	85	90	-1.00	3.00	0	0	1	5	12.00	13.92	1.92
5	5033	89	89	-3.00	3.25	0	1	1	0	14.00	16.67	2.67
5	5034	95	95	1.25	3.00	0	0	1	0	10.00	13.50	3.50
5	5035	90	91	-2.25	1.00	0	0	1	1	13.00	14.58	1.58
5	5036	86	95	2.50	1.00	0	0	1	9	14.00	16.58	2.58
5	5037	95	102	1.00	-0.50	0	0	1	7	12.00	14.50	2.50
5	5038	91	81	-2.00	1.25	0	0	1	-10	11.00	13.33	2.33
5	5039	82	94	2.25	-1.00	0	0	1	12	43.00	45.00	2.00
5	5040	89	90	-0.75	2.75	0	0	1	1	11.00	13.25	2.25
5	5041	97	86	-3.50	2.00	0	0	1	-11	8.00	10.33	2.33
5	5042	95	94	1.25	3.25	0	1	1	-1	10.00	15.33	5.33
5	5043	98	99	-0.50	6.00	0	1	1	1	13.00	15.58	2.58
5	5044	102	89	-3.50	0.50	0	0	1	-13	14.00	16.58	2.58
5	5045	85	88	-1.50	3.00	0	0	1	3	11.00	16.00	5.00
5	5046	95	110	-2.50	0.25	0	0	1	15	14.00	16.17	2.17
5	5047	102	105	-0.75	1.25	0	1	1	3	11.00	16.00	5.00
5	5048	105	100	-2.00	0.25	0	1	1	-5	12.00	14.17	2.17
5	5049	93	98	0.25	1.75	0	1	1	5	14.00	16.25	2.25

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
5	5050	105	105	0.25	0.25	0	0	1	0	13.00	15.50	2.50
5	5051	99	101	2.50	4.00	0	1	1	2	12.00	14.58	2.58
5	5052	78	73	-5.25	4.50	0	1	1	-5	14.00	16.50	2.50
5	5053	95	96	0.50	2.00	0	1	1	1	12.00	14.50	2.50
5	5054	92	105	2.00	-0.25	0	0	1	13	14.00	16.42	2.42
5	5055	101	102	0.50	1.25	0	1	1	1	13.00	14.17	1.17
5	5056	98	94	-2.25	2.25	0	1	1	-4	14.00	16.42	2.42
5	5057	94	90	2.50	0.00	0	0	1	-4	14.00	16.00	2.00
5	5058	104	102	0.25	1.50	0	1	1	-2	14.00	16.50	2.50
5	5059	95	94	-1.00	1.75	0	0	1	-1	12.00	14.33	2.33
5	5060	96	90	-1.50	1.00	0	1	1	-6	14.00	16.67	2.67
5	5061	88	88	-3.00	3.75	0	1	1	0	10.00	15.25	5.25
5	5062	81	84	-1.75	4.00	0	0	1	3	12.00	14.50	2.50
5	5063	89	91	1.50	0.50	0	0	1	2	14.00	15.67	1.67
5	5064	95	97	-1.00	6.00	0	1	1	2	12.00	14.83	2.83
5	5065	96	93	-2.50	2.00	0	1	1	-3	13.00	15.00	2.00
5	5066	88	98	1.50	2.50	0	0	1	10	11.00	16.50	5.50
5	5067	100	96	-1.75	3.25	0	1	1	-4	12.00	14.17	2.17
5	5068	100	105	1.00	2.00	0	0	1	5	12.00	14.50	2.50
5	5069	91	90	-0.25	0.25	0	1	1	-1	15.00	17.25	2.25
5	5070	92	99	1.50	1.25	1	0	1	7	11.00	16.42	5.42
5	5071	93	82	-2.00	-1.00	0	0	1	-11	14.00	16.83	2.83
5	5072	94	95	-0.75	2.25	0	0	1	1	12.00	15.25	3.25
5	5073	94	83	-6.00	2.00	1	0	1	-11	12.00	14.50	2.50
5	5074	89	87	-2.00	2.25	0	0	1	-2	14.00	16.25	2.25
5	5075	94	96	-1.00	0.50	0	1	1	2	16.00	18.00	2.00
5	5076	90	90	-3.50	4.00	0	1	1	0	13.00	15.83	2.83
5	5077	90	93	0.50	0.50	0	0	1	3	15.00	16.17	1.17
5	5078	102	88	2.25	0.50	0	0	1	-14	45.00	47.67	2.67
5	5079	102	99	-2.00	0.75	0	1	1	-3	14.00	16.00	2.00
5	5080	91	94	-0.50	0.00	0	0	1	3	12.00	14.75	2.75
5	5081	90	100	0.50	1.50	0	1	1	10	13.00	15.00	2.00
5	5082	82	80	-3.00	4.25	0	0	1	-2	11.00	13.50	2.50
5	5083	90	92	-2.50	2.00	0	0	1	2	11.00	13.17	2.17
5	5084	97	94	-3.00	2.00	0	0	1	-3	14.00	16.33	2.33
5	5085	90	89	-3.00	1.25	1	0	1	-1	13.00	16.00	3.00
5	5086	89	89	-1.00	1.75	0	0	1	0	12.00	17.00	5.00
5	5087	95	98	-0.25	0.50	0	0	1	3	9.00	14.50	5.50
5	5088	92	93	-0.50	2.25	0	1	1	1	13.00	15.50	2.50
5	5089	97	100	-0.50	1.75	0	0	1	3	10.00	14.67	4.67
5	5090	94	95	-0.50	1.50	0	0	1	1	15.00	17.25	2.25
5	5091	78	76	-3.50	2.00	0	0	1	-2	13.00	15.50	2.50
5	5092	89	89	1.00	0.50	0	0	1	0	40.00	42.00	2.00
5	5093	91	94	2.00	2.00	0	1	1	3	10.00	13.25	3.25
5	5094	86	88	-0.50	1.25	0	0	1	2	15.00	17.42	2.42
5	5095	102	98	-3.50	0.50	0	0	1	-4	12.00	14.42	2.42
5	5096	86	88	1.00	1.00	0	1	1	2	11.00	13.42	2.42
5	5097	103	95	-2.50	-1.00	0	0	1	-8	43.00	44.75	1.75
5	5098	98	98	-1.00	1.50	0	0	1	0	9.00	13.00	4.00

Clinician	ID	Angle Before	Angle After	Δ x	Δ y	Extract	Sex	Ethnicity	Δ Angle	Age Before	Age After	Δ Age
5	5099	99	101	1.25	0.25	0	0	1	2	12.00	14.00	2.00
5	5100	90	94	1.50	3.25	0	1	1	4	12.00	14.25	2.25

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