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COMPARING CEPHALOMETRICS BASED CLINICAL DECISIONS AMONG EXPERIENCED ORTHODONTISTS AND TWO SOFTWARE PROGRAMS

by

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Submitted in partial fulfillment of the requirements for the Degree of Master of Science in Dentistry

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Abstract

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The purpose of the present study was to compare two popular, commercially available, cephalometric software packages (referred to as "Program A" and "Program B") to a panel of ten clinical experts, in the diagnosis of patients due to undergo orthognathic surgical procedures. Lateral and postero-anterior cephalograms were taken one week before surgery. A fourteen-question survey was developed to assess traits of the dentofacial deformity. Each question categorized the variable as mild, moderate or severe based on the expert's clinical judgment or for the computer programs on the number standard deviations from the norm. Simple frequency distributions were calculated for each patient and the percent agreement among clinicians and computer programs was calculated.

Program A agreed with the clinician diagnosis of the dentofacial deformity with greater frequency than Program B (62.1 % vs. 42.2%). Similar trends were observed for skeletal and dental variables as well as soft tissue profile.

However, both programs agreed with clinicians with much greater frequency when categories for individual traits, mild and moderate, and, moderate and severe were collapsed, indicating that both programs assessments lay within one clinical deviation with much greater frequency. Additionally, the inter-clinician agreement tests demonstrated that no clinician agreed with the rest of the group for every assessment made. The results suggest that computerized cephalometrics in the current state may, at best, be an accessory diagnostic aid and, at worst, be misleading to the naïve clinician.

DEDICATION

To my mom, for the sacrifices you have made over the years, for being the orthodontist you are, and guiding me to a career I am very proud of.

To my dad, for being an exemplary role model, tremendous father, and great friend. I hope I can be as good a father to my child.

To my teachers, for instilling in me the desire to learn and the might of knowledge.

To my sister, who held my hand as I took my first steps in life. Thank you for the love you have showered on me.

To my wife, for your unconditional love and support. Thank you for your patience.

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INTRODUCTION

Clinical orthodontists should follow a treatment plan aimed at addressing a problem list. Historically, this problem list was primarily derived from examination of a set of dental casts. Treatment was then prescribed to reach the norm or Class I aligned dental relationships. The advent of cephalometrics in the 1930's made the recognition of the skeletal basis for malocclusion possible. Cephalometric analyses led to quantitative decision making. With the integration of computers and cephalometric technology in the 1970s, statistical analyses of growth patterns and dentoskeletal relations were attempted. The speed of computerized cephalometrics helped streamline the laborious manual measurement of patient cephalograms and sped the creation of a diagnostic summary and thereafter a "problem list".

The improved coordination between orthodontists and oral surgeons in the treatment of severe malocclusion resulted in an integrated treatment approach during the 1960's. Cephalometrics used in diagnosis and prediction of outcome in surgical orthodontic treatment remains a valuable tool in the creation a Visualized Treatment Objective (VTO) of an orthognathic surgery case. The clinicians have traditionally used acetate templates of teeth and jaws to simulate the orthodontic and surgical movements needed to attain both esthetic and functional goals. Today, several commercially available software

packages assist in the creation of the Visualized Treatment Objective. In fact, over the last two decades several software packages, capable of analyzing digital and analogue cephalograms have become available for personal computers.

Three-dimensional imaging has been an area of interest and investigation for orthodontists over the last decade. At Case Western Reserve University, researchers developed three-dimensional tools to provide clinicians with a superior system, capable of assisting in the diagnosis, treatment planning and evaluation of treatment outcomes. The present study focused on the diagnosis of patient conditions. However, prior to testing the three-dimensional tools several questions needed to be answered. Firstly, what are the current two-dimensional methods employed by clinicians to arrive at a diagnosis? Clinicians routinely use angular and linear measurements from the lateral cephalogram of a patient, acetate templates, computerized cephalometrics, and plain visual examination as methods of examining cephalograms. Secondly, what kind of information do clinicians harness from the radiographic exam? Generally, orthodontists obtain information about the position of the dentition in relation to the bones in which they are housed, and the position of the maxilla and mandible in relation to the surrounding craniofacial structures. Thirdly, what has been published on the subject of computerized cephalometrics and diagnosis of a patient's condition? Interestingly enough, there were none.

The present study was therefore designed to compare the performance in diagnosis, of two popular, commercially available computerized cephalometric programs along with a group of experienced practicing orthodontists. Rocky Mountain Diagnostic Services and Quick Ceph™ were chosen to be compared to a panel of ten clinicians.

LITERATURE REVIEW

Need for Surgical Orthodontic Treatment

Orthodontics enjoys a unique place in the field of health care for several reasons. It is a specialty that incorporates the finer elements of two important entities that deeply influence the daily lives of people; function and esthetics. If teeth are profoundly irregular or protruding or there is an obvious jaw deformity, orthodontic treatment is sought to improve the condition. The more severe malocclusions that might require a combination of surgery and orthodontics have been termed dentofacial deformities to distinguish them from the less severe malocclusions that might be treated with orthodontics alone. Treatment for a dentofacial deformity is elective, meaning no-one dies from uncorrected orthodontic problems barring the occasional suicides in which depression may have been related to the facial appearance of the individual. The National Research Council (NRC), (Morris 1975), noted in its report that the psychological impact of a dentofacial deformity is usually more important than the physical disturbances caused. The physical ramifications of a dentofacial deformity include problems associated with speech, mastication and digestion, oral hygiene and possibly temporomandibular joint pain and dysfunction. The NRC report suggests that 5% of the population have an orthodontic problem of such significance that it should be considered

handicapping. Patients belonging to this group often require a combination of surgery and orthodontics.

Early Diagnostic Records and Treatment in Orthodontics

Careful clinical examination of the patient and a set of dental casts have historically served as the diagnostic method of choice. The classification of dental malocclusion by Angle (1899) has stood the test of time (even with its inherent limitations). Although Angle assumed placing the dentures in "normal occlusion" would yield ideal esthetic results, many orthodontists realized that facial features in individuals with normal occlusion were not necessarily beautiful (Angle 1907). One early rival of Angle, Calvin Case, was concerned with facial esthetics. In studying the facial profile he noted the relative position of the chin, the malar prominence, the forehead and the bridge of the nose; the relationship of the lower lip to the chin, the upper and lower lip to each other, lips in repose, talking, and smiling (Hambleton 1964). Case's influence probably initiated an awareness of facial esthetics, which has grown to a point that many orthodontists regard facial esthetics as the primary objective of treatment (Riedel 1950, 1957).

Cephalometrics in Diagnosis and Treatment Planning

In 1926, Broadbent (1931) introduced cephalometrics, which assisted in understanding the anatomical basis for malocclusion. In the next decade Downs (1948) developed a standard for comparative purposes based on skeletal and facial proportions. He used twenty-five untreated adolescent

whites, selected for their ideal occlusion. The norms were represented as angular and linear measurements recorded between various skeletal and dental landmarks. Thereafter numerous cephalometric analyses gained popularity among clinical orthodontists. Steiner (1960), Tweed (1954), Sassouni (1969), Jacobson (1975), Ricketts (1981), and McNamara (1983) are a few of the scientists who have a cephalometric analysis named after them.

Over the years, several soft tissue analyses have been developed for the purpose of diagnosis and treatment planning. Stoner (1955) reported a method of evaluating the soft tissue profile in a quantitative manner on a profile photograph or cephalometric radiograph. He used a sample of thirty-four individuals chosen on a subjective basis as far as esthetics was concerned. This evaluation, like all other soft tissue cephalometric evaluations presupposes that the soft tissue components are at rest.

Holdaway (1956) developed a method of analyzing the soft tissue profile both as a means of diagnosis and a method for determining changes in soft tissue profile induced by growth and treatment. He constructed the H angle as a straight line on a tracing from the point of the soft tissue chin tangent to the upper lip, creating an angle with the line NB. Holdaway proposed that when the measurements of the line NB to the lower incisor and to pogonion are equal, the facial contour is most ideal. He termed this proportion the Holdaway ratio. Ricketts (1957) selected forty esthetically acceptable faces and studied

incisor relationships consistent with ideal lip balance and facial harmony. He concluded that ideal lower incisor inclination to the AP line should be 0-1 mm anterior to it and ideal interincisor angulation should be 130°. Steiner (1960) used the S line to evaluate position of the lips in relation to the profile. Burstone (1959) had a panel of artists select fifteen white males and twenty-five white females with acceptable to excellent faces to describe a method of direct soft tissue analysis, employing readings that relate profile components to skeletal landmarks. In a later study, Burstone (1967) described an analysis of "lip posture" relying on cephalometric measurements to determine lip length, interlabial gap and lip to incisor relationships.

Surgical Procedures and Indications

The use of orthognathic surgery to correct malocclusion was first recorded in 1849 by Simon H. Hullihan of West Virginia (Virginia at the time) (Jacobson 1990). Angle in conjunction with Vilray Blair, a prominent plastic surgeon of the time presented a number of operative cases, including a body osteotomy of the mandible for the correction of an open bite. In 1942, Harold Delf Gillies of Great Britain performed the first LeFort III which caught the eye of a young surgeon by the name of Paul Tessier, regarded today as the father of craniofacial surgery. About the same time another great surgeon from Zurich was actively contributing to maxillary and mandibular surgeries. He was Hugo Obwegesser who is credited with having developed the popular technique of sagittally splitting the ramus of the mandible.

Maxillary Procedures

The down fracture osteotomy technique for the maxillary surgery originated with Cheever, (Moloney 1981), who perform the operation to remove a nasopharyngeal mass in two patients. In 1921, a German surgeon, Herman Wassmund, reported his initial attempt to correct a dentofacial deformity by a maxillary osteotomy. He used maxillary traction to position the maxilla post surgically and did not mobilize the maxilla during the surgical procedure. Before 1965, dentofacial deformities were corrected by mandibular surgeries alone. Today, the LeFort I osteotomy with maxillary down fracture allows the surgeon to position the maxilla in all three planes of space. If the maxilla has to be segmented to facilitate expansion or contraction, leveling of the occlusal plane, close space, further osteotomies may be done after the maxilla has been mobilized. Superior repositioning of the maxilla is frequently indicated in cases of open bites and long faces, and anterior repositioning of the maxilla is often undertaken in cases of maxillary deficiency (Proffit and White 1990). Maxillary procedures are also done in cases of skeletal asymmetries and deficiencies in width. Proffit suggests, following repositioning of the maxilla, stabilization should be accomplished with wire fixation or bony plates that are placed in the thick areas of the piriform region and the zygomatic buttress. Two bilateral plates usually will hold the maxilla firmly.

Mandibular Procedures

Surgical procedures to correct mandibular skeletal deformities were described early in this century (Blair 1909), but osteotomies to correct mandibular prognathism were not routinely done until the 1950's. Obwegeser popularized the bilateral sagittal split osteotomy of the ramus of the mandible when he toured the United States in 1965. Today, this is the surgical procedure of choice in most mandibular set back or advancement procedures. Modifications in the design of the surgical procedure, advancements in instrumentation and the versatility of the procedure allow for corrections in all three planes of space (Proffit and White1990). As intraoral orthognathic surgery became more popular, an intra oral approach to vertical sub-condylar osteotomy was described (Winstanly 1968). Procedures on the mandible are most often indicated in cases where the mandible may be diagnosed as prognathic (excessive) or retrognathic (deficient) and in cases of asymmetries.

Segmental Jaw Procedures

Improvements in instrumentation allowed surgeons to make the required precise bone cuts, minimizing damage to teeth, periodontal structures and surrounding soft tissue to accomplish subapical segmental osteotomies. Subapical procedures have limited but useful applications. Inferior border osteotomies of the mandible may be done to shorten or lengthen the jaw and may be performed alone or in conjunction with other orthognathic procedures.

Bone grafts (autogenous or allogeneic bone) and alloplastic graft materials may be incorporated to modify the shape of the jaw. Correction of an anterior mandibular inferior border asymmetry is usually accomplished following the release of the inferior border of the mandible by an osteotomy and shifting the segment as needed. Total subapical osteotomy involving the total mandibular alveolus allows for correction of mandibular dentoalveolar abnormalities.

Maxillary anterior segmental osteotomy which was used to improve occlusion but had poor esthetic results in the past (Proffit and White 1990), may be used in combination with the LeFort I osteotomy in special circumstances. Isolated posterior maxillary subapical osteotomies are undertaken to reposition dentoalveolar segments in cases of unilateral posterior cross bites or prior to prosthodontic therapy.

Cephalometrics for Planning and Assessing Surgical Treatment

Goldstein (1947) was the first to use tracing of lateral head films to describe skeletal and soft tissue changes that occur following surgical treatment of mandibular prognathism. From twenty cases treated surgically for mandibular prognathism, seven cases were traced to demonstrate the usefulness of cephalometric superimposition's in planning and assessing surgical correction of mandibular skeletal aberrations. However, it was not until 1963 that some guideline for surgical orthognathics was presented (Poulton et al. 1963). Thirty cases having undergone vertical ramus osteotomies were analyzed cephalometrically. Tracings before and after

surgery were superimposed on unaffected cranial and maxillary structures. A separate superimposition on the body of the mandible demonstrated the change in position of the condyle relative to the presurgical mandibular tracing. Stressing the importance of cephalometric landmarks N, A point and Po falling on a straight line, Poulton concluded that skeletal profile is as important as occlusion, and in many cases more important, in surgical treatment planning.

Although publications in the field of orthognathic surgery increased dramatically in the late sixties and early seventies, rarely were any criteria listed for making treatment decisions. Various authors implied the application of prediction tracings as part of their diagnostic work up in surgical orthodontic treatments. It was McNeill et al. (1972) who first demonstrated its practical use and method of implementation. The technique as described consisted of four steps. First, establishing a tentative post treatment dental relationship using dental casts. Second, construction of a partial overlay of the pretreatment cephalometric tracing including outlines of hard tissues that would be unaffected. Third, movement of the overlay tracing until the parts to be altered in treatment duplicated the proposed positions as obtained in the reoriented dental casts. Fourth, and lastly, completion of the prediction tracing by adding profile soft tissue outlines. McNeill used two cases to illustrate his proposed technique of superimpositions. However there was no mention of specific

"norms" to which an orthognathic patient should be treated. A recommendation was made to use established normal angular and linear values.

In most analyses a disturbing feature stands out. Cephalometric averages from a normal sample tend to describe a trait as it exists in a limited population. In doing so, these analyses do not allow for variations that occur within individual reference points. Importantly, the analyses tend to conceal the large variation that exists between the reference points of the individual normal people i.e. the standard deviation.

Treatment planning was essentially limited to the anterior–posterior movement of the mandible until Lines and Steinhauser (1974) expanded the role of cephalometrics to include its use in the treatment planning of all aspects of surgical orthodontic therapy. In a detailed article the authors went over the important aspects of diagnosis, treatment planning, steps in pre surgical orthodontics, surgical simulation based on records obtained prior to surgery, choice of operation, and finally the post surgical orthodontics. As part of diagnosis of a case, Lines and Steinhauser suggest an evaluation of the cephalometric profile and its relation to the underlying skeletal base to help locate the site for surgical intervention. The process is to be followed by a "mock" surgery performed on a set of mounted casts to assess the direction and extent of movement of teeth and the supporting structures necessary to achieve the best postoperative occlusion. The amount of movement required would be measured and used cephalometrically to produce the facial profile

that will result from the proposed surgery. The method of tracing to produce the Visualized Treatment objective was identical to McNeill's et al. (1972). The authors warn against disregard of the ratio of lower anterior facial height to total facial height in diagnosing and treatment planning surgical cases. Further, a clinical case was described to illustrate the interrelation between the anterior posterior position of the skeletal components and vertical facial proportions of the patient. The authors investigated and reported their findings with regard to the soft tissue changes produced by orthognathic surgery. Lowering or raising the vertical dimension had an inverse effect on fullness of the lips. Changes in the vertical dimension exerted an antero-posterior effect on the profile caused by rotation of the chin. Advancements of the mandible assumed a bone to soft tissue ratio of 1:1 agreeing with a study done in Minnesota (Robinson 1971). Lines and Steinhauser also reported that with orthodontic tooth movement of maxillary anterior teeth, the upper lip followed in a ratio of 2:1, teeth to soft tissue. The soft tissue of the lower lip seemed to advance at a ratio of 4:3, lower incisors to lower lip. However, there were no measurement guidelines mentioned besides those used in traditional cephalometric analysis.

An improved analyses came with a report by Burstone et al. (1978) describing cephalometrics for orthognathatic surgery (COGS), developed at the University of Connecticut specifically designed for the evaluation of patients in need of orthognathic surgery. The COGS system described the

horizontal and vertical position of the facial bones by use of a constant coordinate system; the size and shape of bones were represented by linear and angular measurements. The standards were derived from a sample obtained from the University of Colorado, School of Medicine. In addition to traditional parameters, COGS employs an arbitrary horizontal line (HP) that passes through S-N and a vertical line drawn perpendicular to HP at N. The author points out that S-N may demonstrate variability and therefore clinicians should "mentally proportion measurements to similar measurements from the standards". This may introduce an appreciable level of subjectivity in the diagnosis and treatment plan. Another, shortcoming of the COGS analysis (like most others) was the relatively small sample, in this case, sixteen women and fourteen men.

Delaire et al. (1981) introduced a new lateral cephalometric analyses aimed at providing superior assistance in diagnosis and treatment planning dentofacial deformities. The new technique was based on a study of balance between the base and calvarium of the cranium followed by a facial evaluation in relation to the cranium and craniospinal articulation. The dentition was placed within the cephalic context. Delaire's technique was interesting as he provided specific proportions and guidelines but there was no analysis of a sample. The author emphasized that no statistical averages or measures were used in this rather interesting analysis.

Given the numerous analyses being employed by clinicians and the obvious subjectivity involved in the diagnosis and treatment plans of patients with skeletal disharmonies, Wylie et al. (1987) compared five popular cephalometric analyses in ten individuals who underwent orthognathic surgeries. Pretreatment cephalograms were selected to represent different skeletal and dentoalveolar deformities, each of which was corrected by a different type of surgical procedure. One operator using each of the five analyses blindly assessed pretreatment cephalograms. Results of the analyses were then compared to each other and to the actual surgery performed. A second operator then made comparisons on a blinded basis. The study revealed that the cephalometric analyses did not correlate with the surgery performed. For example, in a class III malocclusion, two analyses suggested mandibular protrusion, two determined that the maxilla was retrognathic and one identified the problem as a short maxilla and a forward mandible. The author concluded that although much information could be gleaned from visually examining cephalograms, tracings and numeric data, the final diagnosis must be based on the evaluation of a complete set of diagnostic records.

Despite some of the inherent shortcomings of cephalometrics, pertinent data available from cephalograms, have made it an important diagnostic tool. With the integration of computers and cephalometric technology in the 1970s, statistical analyses of growth patterns and dentoskeletal relations were

established. The speed of computerized cephalometrics helped overcome the laborious manual measurement of patient cephalograms and sped the creation of a diagnostic summary. The discovery and mass production of silicon chips has reduced the cost and size of computers. Computerized digitization of cephalograms and the computer analysis of data have become easily accessible to the clinician. With all the sophisticated technology available, has orthodontics and orthognathic surgery become more scientific and less a creation of individual perception?

The Era of Computerized Cephalometrics

Cephalometric records, information stored as plaster casts, photographs, case histories, etc. were now beginning to accumulate at a rapid pace particularly in orthodontic departments. The analysis of the large amount of data required a more sophisticated and powerful analytical tool. Walker (1972) was one of the pioneers to discuss the new approach taking shape. It had two important features. Firstly, they developed mathematical models to describe and analyze craniofacial bones. Secondly, information in this format could be effectively analyzed using a digital computer. The lateral cephalogram was regarded as a shadow of the craniofacial bones seen in profile. Each bone was denoted by a set of landmarks recorded in the same sequence. In this study, they used a total of 177 landmarks to describe the skull in the profile view. In a similar manner, mathematical models for the posterior-anterior x-ray structures and for the dentition from the occlusal aspect were created. These

models could be analyzed independently for morphology and changes associated with growth or treatment. The mathematical information generated was too complex to be analyzed by conventional methods, prompting the analytical power of a digital computer to be employed. Walker gives credit to early work done in the fifties, in New Zealand, in developing a mathematical model to quantify shape and reducing it to punch cards. Working with Dr. Krogman, these two early investigators pioneered efforts in this area. A three-step process described by Walker could accomplish translation of a cephalogram to a coordinate model. The x-ray film was traced to record the bony outline. The recording points were then digitized. Finally, digitized tracing were placed on a scanning device and all points recorded as X-Y coordinates so the output could be recorded on punch cards.

Walker demonstrated the retrieval of data from computer memory, the ability to process group averages from large numbers of files, the ability to develop programs to extract any desired angular and linear measurement, and the development of composite vectorgrams from 177 landmarks to ultimately describe the growth dynamics of the face and cranium. However, the author pointed out problems associated with quality control and storage control. Besides, numerous studies on reliability of landmarks in lateral and frontal cephalograms have demonstrated the need to eliminate noisy or unreliable landmarks (Walker 1972). In that context, 177 landmarks may have introduced a higher chance of random error in the researchers findings.

The opportunities are unquestioned when any phenomena can be reduced to mathematical formulae. Ricketts (1972) in a comprehensive publication covered the utility of computers to handle the host of measurements which are of value in a clinical and research setting. Considering numerous factors required scrutiny, the anatomic factors were grouped in a cogent manner. A family of measurements was grouped into a "field" for a comprehensive descriptive analysis. A computer following the employment of coordinates from the lateral and frontal radiographs made the measurements. From the frontal x-ray, an axis drawn through the center of the two zygomatic arches formed the X -axis. This transverse axis is virtually on the Frankfurt horizontal plane. The central sagittal plane is drawn through the center of the nasal septum or through crista galli. In the lateral cephalogram, the Frankfurt horizontal was employed with a perpendicular line passing through the posterior margin of the pterygopalatine fossa.

The purpose was to provide answers to the orthodontist in the order in which usually they are asked during diagnosis. Therefore, the nature of the malocclusion was first in the order of things, followed by relationships of the jaws in three dimensions, the relation of dentition to skeletal base, esthetic determinations, jaw at fault in a skeletal disharmony and finally the diagnosis. Factors subject to clinical control were placed in the first four fields and factors outside the clinician control were placed in the last two fields.

Ricketts (1972) observed that certain measured values change with age, while others, which are a function of form rather than size, did not change with age. Sex of the individual affected the measurements being made. In addition, a method was needed to account for size values to be interpreted accurately. Since measurements of an individual may appear large for the population despite being corrected for age and sex, although it may not be large for that particular patient, measurements needed to be individualized. Correction for size was accomplished by subjecting the patient's measurements to a correction factor termed cube root index. A computer calculation is made of the facial volume, and the cube root is employed as an index for evaluation of seven of the fifty measurements.

The highly reliable and flexible set of norm values established were based on an extensive independent and intense study in order to program the consensus of the published scientific data available. The mean and range of variation needed to be corrected for ethnic type in addition to age, sex and size. In order to improve on the method of communication, a new classification system was devised. Having the normal being represented by the mean, the amount of variation around the mean acceptable to the clinician was denoted by the clinical deviation. This was based on the curves of distribution, the actual standard deviations, an arbitration of the reports in the literature and finally the examination of over two thousand successfully treated cases. Therefore clinical deviation provides the range of desirability for clinical

objectivity. Instead of reliance on the actual numerical value, the extent of dysplasia represented by a measurement was expressed by units of variation from the previous corrected norm. Descriptions were made by the location of a measurement on the clinical curve of distribution. The normal values and the number of deviations from the mean (Z score) were provided in a comprehensive descriptive analysis. By the application of asterisks in a printout sheet, the area and extent of dysplasia were located and vividly displayed. If the clinician did not wish to be involved with numbers, the written summary sheet was a descriptive analysis of the measurements in all planes of space.

Ricketts went on to describe the application of computer technology to provide rendering on growth probabilities in patients with or without treatment. Predictions were based on the peak and central tendency of a normal curve of distribution. By adding the objective features in treatment and weighing the effects of treatment necessary to satisfy the objectives, the rendering could be provided of the patients behavior with treatment.

Ricketts strongly proposed the use of a service organization to have more complete and accurate measurements. He suggested the orthodontists time had become too valuable to spend on making tracings, measurements and attempting to forecast growth. Additionally, the orthodontists tracings of the outcome usually had an intuitive perception in contrast to a computer generated tracing which provides a probability based outcome including

standard objectives. Technicians and tracing analysts were specially selected and trained and were accountable for cross checking and quality control. The tracings were suitable for superimposition's and overhead projections. Artistic renderings were made of the analysis of the treatment objectives. Special technicians were taught the adaptive changes to be expected in soft tissue following orthodontic treatment. Finally, another important advantage in the use of a service organization was the availability of vast data for research purposes.

By enlisting the entire service, the orthodontist would receive back his original films, tracings of the films (black transparency), a growth forecast (red transparency), growth and treatment projection (green transparency), a summary analysis sheet and the analysis of the forecast of soft tissue change, change in the mandible, maxilla and upper and lower incisors. No claim for positive dependability was made. All predictions were based on the most common treatment procedures and their typical responses. Information derived by the use of the service organizations were useful to the clinician as an aid in diagnosis and treatment planning, a visual aid in patient education, prediction of treatment outcome, and research. Rocky Mountain Diagnostic Services provides the service as advocated by Ricketts.

Bergin et al. (1978) had been working towards the creation of a program capable of delivering diagnostic information from radiographs. The group in Sweden believed the system proposed by Walker (1972) was too

comprehensive to be routinely used by a clinician. Ricketts design also suffered from the same shortcomings in the authors' view. The authors developed and described a new program where the user directs the system by giving the computer commands from the keyboard of the terminal. The analysis starts with marking the reference points on a tracing film placed on a graphic table. The points would then be marked with a marking pen belonging to the digitizer unit and then entered into the system as coordinates. The results of the analyses, angular and linear measurements, were immediately available on the screen and could be transferred to an on line printer. The computer used was a NORD 10 with a word length of 16-bits (binary units). Floating point numbers were represented by three full words (48 bits). The program was written in FORTRAN and used a memory of about 45k words. Besides the standard peripheral units (printers and disc storage) the system used a Tektronix 4012 graphic screen, a Tektronix 4953 digitizer unit and a hard copy unit and paper plotting devise a Versatec 1200A printer/plotter using an electrostatic method.

The digitizing procedure commenced by plotting the landmarks 1 (S), and 2 (N), which established the orthogonal coordinate system with the origin at S and the X-axis towards N. Twenty-two skeletal landmarks were employed and thirty-one points were to be marked for soft tissue evaluation. Angular and linear measurements were printed in digital format within a minute of registration of all points. The numbers of landmarks were drastically less than

the 177 landmarks suggested by Walker therefore reducing errors in landmark identification.

The measuring errors were calculated in three trails. The first trail was concerned with the accuracy of transferring landmarks from the tracing to the system via the digitizer and included the rounding errors of the computer. Four dentists made ten repeated registrations each on the same tracing with the use of a pencil at the digitizing board. The variances of all angular and linear measurements were calculated. The second trail concerned the accuracy of determining the reference points on the radiograph. The material comprised five cephalometric radiographs randomly selected. The errors of the method, which included the errors described in the first trail, were estimated by double registrations of the reference points of the five cephalograms by the five different dentists. All reference points were transferred to the computer by one of the dentists. The third trial was to calculate the errors in angular and linear measurements that would appear if point two (N) were picked within a circle with a radius of one mm.

Variances of the angular and linear measurements due to errors when transferring reference points to the computer and to rounding errors in the computer were in the class of 0-0.25 mm. Errors made in pinpointing reference points were far greater, reaching a maximum of 3.25 mm. Thus errors made when pinpointing reference points strongly dominate the rounding errors. Results of the third trial demonstrated misplaced landmarks did not influence

angular measurements and that linear measurements differed with a maximum value of 1.5% from the true value. Further, in a clinical study performed by six orthodontic residents, the computerized process was twenty minutes faster than conventional cephalometric methods. The authors concluded the restrictions of computerized cephalometrics were the limitations inherent in the radiographic technique itself. Several investigators have confirmed the lack of accuracy in pinpointing landmarks (Baumrind and Frantz 1971 a, Mitgard et al. 1974, Richardson 1966, and el-Mangoury et al. 1987).

Cleall and Chebib (1971) suggested a computerized method for analyses of the orthodontic data digitizable into coordinates in two dimensions. The computer programs developed at that time required the digitization of the records onto punch cards and later batch processing of these punch cards (a time consuming method where one submitted the cards at the local computer center and waited several hour for the cards to be processed). Cleall and Chebib (1976) described an dynamic interactive system whereby the records were digitized directly into the computer (and most errors noticed corrected immediately) and then, from a remote terminal in one's office, various analyses and facial plots could be retrieved in an immediate conversational manner at any desired moment. The on line computer system "Cephalometric Records Analysis Program (C.R.A.P) was developed with the objective of immediate clinical analysis of radiographs for diagnosis and case progress assessment.

Thirty-seven pre-selected landmarks were used and were selected on the basis of those most used in conventional cephalometrics.

Baumrind and Miller (1980) at the University of California in San Francisco developed a computer program for the purpose of research and clinical use. It focused on the problems of increasing measurement reliability, making of between time point comparisons and the evaluation of grouped data rather than on problems of prediction or treatment planning from single films. In addition to twenty-one anatomic landmarks, four corner pinholes (used later for registering different tracings of the same film) were permanently marked on the non-information bearing areas of the film with a steel dress makers pin. Six more holes (used later to superimpose between films) represented three anatomic planes. The four corner fiducials were used only for within film superimposition while the anatomic plane registration points were used for between film superimposition. Describing the process of superimposition between cephalograms taken at different time points, it becomes clear that a summary may be derived without the loss of information. The manual method is described followed by computer application of the idea. The use of the four corner fiducials has distinct advantages over other employed techniques. The use of the four corner fiducials surrounding the anatomic area of interest undoubtedly protects against the impact of rotational errors. Additionally the author emphasizes the importance of acquiring data without loss of information from tracings of the same head film made at different times.

The 1980's witnessed a rapid influx in the programs developed to aid in computerized cephalometrics. Konchak and Koehler (1985) described a new program for cephalometric analyses that employed a commonly available computer and a digitizing pad. Fifteen landmarks were used to produce a meaningful analysis, which could be printed out and saved as a hard copy. The entire program was written in a dialect of Pascal developed at the University of California at San Diego. One of the problems encountered was the determination of the correct quadrant for an angle. Defining the cephalometric quantities in terms of vectors and then using vector algebra instead of linear algebra to solve the quadrant problem implicitly tackled the problem. The vector "dot" product, for example, is proportional to the cosine of the angle between the two vectors while the "cross" product is proportional to the sine of that angle. These principles and other vector functions can be used as the basis for cephalometric analyses in other programs written in common high level languages. In the authors opinion the properties of Pascal make the program much easier to write and understand than a similar program written in Fortran or Basic language.

An English group from Torquay (Walters and Walters 1986) described a program which could undertake the two-dimensional planning of a complete maxillofacial reconstruction using Le Fort I, II & III, Wassund, Schuchardt, Kufer, Kole, Dingman, Obewegeser and VSS osteotomies with augmentation or reduction genioplasty and rhinoplasty. The program suggested an operation

that could be used to alter the patient's esthetics. The standards applied were the proportional systems similar to those of Delaire et al. (1981) with numerical population mean values suggested by Fish and Epker. The program was written in BBC Basic and was 19K in size.

As several programs were developed and publicized, it was natural that at the technology transfer stage, many would not survive the fierce competition of the consumer market. Today, Rocky Mountain Diagnostic Services stands alone in rendering the service as originally described by Ricketts (1972). Among the numerous commercially available programs Quick Ceph™, DentoFacial Planner® and Dolphin Imaging Systems© have withstood the test of time with differing levels of success. There does not exist a monopoly of the computerized cephalometric programs available to clinicians. However, in the transient world of computer technology, new versions and later revisions are constantly on the rise and decline.

Reliability of Computerized Cephalometrics

Radiographic errors fall into two major categories, systematic and random. Systematic error implies a bias in the recording and measuring system to produce apparent measurements predictably different from the true values. Systematic errors depend on factors such as geometric magnification of the cephalometric image and distortion due to the differential magnification between planes. Both magnification and distortion can be calculated from the geometry of the apparatus. Random error arises primarily through uncertainty

in the identification of radiographic landmarks. Poor reliability in identifying landmarks may depend on sharpness (rate of change of density across the boundary of a point of interest and the surrounding area), the penumbra effect, as the anode of the X-ray machine is not a point but a appreciable area (Bjork 1962, Brodie 1949 and Salzmann 1949). Adams (1940) and Vogel (1967), beside others, have attempted to introduce correction factors for some of these sources of error, but the cumbersomeness of the computations has restricted regular use. The use of intensifying screens (to reduce X-ray exposure) produces a loss of sharpness, as light from them tends to diffuse and screens contribute to coarse graininess of the image known as quantum mottle. Contrast, defined as the difference in density between adjacent areas (dependent on the KVP) also affects the quality of the radiograph.

Random error in cephalometrics refers to variation in identification of cephalometric landmarks. It has been recognized since the invention of the cephalometer that precision with which various landmarks are identified varies from point to point. The first attempt to quantitatively measure the nature and magnitude of the differences in precision in picking various landmarks used in cephalometrics is credited to Baumrind (1971 b). Twenty lateral cephalograms were selected at random. Transparent plastic templates having four needle point perforations in a rectangular configuration at known distances from each other were overlaid on each head film individually, and the four points were registered on the head films by perforating them with a sewing needle. Five

post-graduate students traced each of the twenty radiographs. Each operator identified sixteen standard cephalometric landmarks. On the one hundred acetate tracings, twenty points (including the four reference points) had been located. Therefore for each of the sixteen landmarks, one hundred independent estimates were available. A computational method of superimposition was developed employing a specially designed program. The coordinates for each of twenty points were determined with respect to arbitrary X and Y axes using an Oscar K coordinatograph (a device which measures linear distances as a function of variations in the voltage of an electric circuit). The landmark coordinate values for all five tracings for each x-ray film were then mathematically superimposed, registered on the four reference points. The five sets of X and Y coordinates were then averaged, providing a best estimate for that landmark for that film. For each film, the X-axis was then redefined as the line connecting the best estimates of S and N. There now existed for each cephalogram sixteen small five point scattergrams, oriented to the SN line. Each of the twenty films yielded a set of sixteen scattergrams. The twenty small five point scattergrams for each landmark were then superimposed mathematically with their origins and axes being common. This resulted in a sixteen "hundred point scattergrams", each representing the dispersion of estimating errors for a single landmark around the best estimate for that landmark and each oriented to the SN line. Tracing values were mathematically translated, rotated and superimposed on the four registration

points using a "least squares best fit" program. Errors in landmark location introduced by errors in tracing superimposition were by reasons of geometry, smaller than the superimposition errors themselves. Simple statistics were used to calculate the means, standard deviations and standard errors. Dental and skeletal landmarks were listed separately. X and Y components of the total variance were isolated for each landmark, yielding separate standard deviations in the X and Y directions.

The following inferences made from this study of landmarks are important. First, when one is replicating assessments of the same head film, errors in landmark identification are too great to be ignored. Second, the magnitude of error varies greatly from landmark to landmark and third, the distribution of errors for most landmarks is not random but rather systematic, in that each landmark has its own characteristic and usually noncircular envelope of error. Lastly, a suggestion was made whereby the impact of the observed errors could be reduced through routine use of replicated estimates for each landmark.

Cohen (1984) carried out a study to assess and compare reliability of different techniques in the analysis of lateral cephalograms. Twenty lateral head films were used and conventional tracings were done twice on each film, at two separate time points. Thirteen landmarks were utilized in the study. All landmarks were identified using a digitizer plotting table, which recorded the points in terms of coordinates. The location of landmarks employing a

computer program was also repeated twice at separate times. In addition, direct digitization and dot tracings were used as distinct techniques in landmark identification. Therefore, each cephalogram was digitized four times, twice off the tracing and twice direct, and traced four times (two dot tracings and two line tracings). Differences between pairs of readings were noted. Cohen found mean coordinate errors differed between the X-axis and the Y-axis. Certain points showed similar reliability in both axes, for example, S. Other points were far more reliable in one plane or the other. The author concluded by recommending direct digitization of an untraced x-ray, with a further comment that the greatest accuracy could be obtained by taking measurements at right angles to the plane of greatest error. For example, since B point was far more accurate in the A-P plane than the vertical plane, it would be more reliable to use B point for A-P measurements.

The results of the first investigation on the reliability of landmarks in the posterior-anterior view were published in the late eighties el-Mangoury et al. (1987). Employing an interactive computer graphic package called, Error Analysis of Postero-Anterior cephalometric x-rays (EA-PAX), the authors attempted to determine the direction and magnitude in the variation of landmarks and to establish the reliability of these points in the posterior-anterior view. Thirteen landmarks were registered on a random sample of forty frontal radiographs in a coordinate system. A month later the same orthodontist repeated the recording. For each identified landmark, the radii

joining the first and second readings were measured. Further, the smaller angle formed by the intersection of the first and second reading to each plane was registered. The mean, standard deviation and 95% confidence interval were then computed for each variable. All x-rays were taken on the same cephalometer, with identical exposure time, and a constant mid-sagittal plane to film distance. The study focused on the reliability of landmark identification on the same cephalogram. The investigators ranked the landmarks in order of reliability in the vertical and radial direction. The more important conclusions were; skeletal landmarks are more reliable than dental landmarks, and most cephalometric landmarks have their own peculiar noncircular envelope of error.

In a study designed to quantify the intraexaminer and interexaminer reliability of fifty-two posterior-anterior landmarks, Major et al. (1994) used a sample of thirty-three skulls and twenty-five patients. Identification errors were recorded horizontally and vertically. Landmarks were digitized directly off the radiographs using a digitizer in conjunction with a custom made program developed using Basic TM. An individual coordinate system was established for each cephalogram by including two fiducial points placed on the medial and superior aspects of the ear rods. The two pinholes were digitized first and formed the X-axis of the Cartesian coordinate system. The Y-axis was constructed perpendicular to the X-axis at the mid-point between the pinholes. Thirty-six of the fifty-two landmarks were bilateral structures.

Each cephalogram was randomly digitized five times by the principle investigator and no single x-ray was digitized more than once in a day. Deviations from each landmark mean value was analyzed to obtain the standard deviation from the mean, which was considered the landmark identification error in millimeters. To determine interoperator landmark reliability each radiograph was digitized once by four graduate students. The reliability of the method was calculated using the generalizability theory that uses an analysis of variance to separate total variance into its component parts. Total variance is the combination of variation due to each factor and variation due to combination of all factors. Major concluded that the identification errors for skull and patient radiographs were similar with the skull values being smaller than when soft tissue was superimposed. Landmarks varied in the pattern of error, either along the X-axis or Y-axis. Landmark identification error was generally larger when four clinicians were used, with the error for the patient sample larger than the skull sample. When the landmarks used in the el Mangoury et al. study (1987) were matched, the errors in landmark identification were similar (0.37-1.10 mm). Interesting enough, the error in landmark identification reported by Baumrind and Frantz (1971) where multiple operators were used was in the range 0.34-3.71 mm, which was similar to the range of error reported by Major et al. (1994). Considering that the orthodontic clinician eye has been trained to observe lateral cephalograms, the finding was suprising.

During the eighties, it had become clear that the quality of digital images could be altered by contrast enhancement and sharpening of the edges, a property used with success in caries detection. However, in digital image cephalometry, the accuracy of the measuring device is determined by the matrix resolution of the digital system. In a study designed to evaluate the reliability of landmark location in digitally processed cephalograms in comparison to that obtained on the films using a digitizer, Marci and Wenzel (1993) used twenty cephalograms, fifteen landmarks and three observers. Two methods were used to identify landmarks by the observers. Images underwent contrast enhancement and filtering to enhance edges for the first pass. Replicate landmark identification was performed after an interval of at least two weeks. Reliability in landmark positioning was compared between over-exposed and normally exposed images and showed a highly significant difference in favor of the over exposed images for five of the landmarks. Thereafter, the X-Y coordinates of these selected landmarks were transferred by the computer from the over-exposed images to their corresponding normally exposed images. Digitization of landmarks on the analogue films were done a month later and repeated two weeks later. The authors concluded that the reliability of landmark location using low cost digital equipment was inferior to direct digitization. The problem of the digital system was insufficient spatial resolution.

More recently, Nimkaran and Miles (1995) published the results of a study aimed at establishing the reliability of computerized cephalometric methodology. The investigator employed a customized cephalometric analysis of forty measurements based on twenty-two landmarks. Forty cephalometric radiographs were analyzed. Computer generated measurements were compared to conventional hand derived measurements. Reproducibility studies were performed. The investigators found that measurements obtained by the computerized method were reproducible for most parameters although point B was found to be unreliable in the vertical plane. The authors reported the combined error of converting the analogue film to its digital version and the subsequent digitization of the image was not significant. However, the absolute values of all parameters related to the horizontal plane in the computerized method were 0.7 to 1.0 mm greater than conventional hand measured methods, indicating that horizontal magnification had occurred.

It is obvious that despite several programs capable of analyzing cephalograms mushrooming, reliability of these systems should be questioned.

Use of Computerized Cephalometrics in Orthognathic Surgery

Orthodontists from the fifties have been inextricably involved with cephalometrics. Surgery remained more an art form. Later, surgeons got intrigued by the cephalometric parameters and diagnostic applications. Through the eighties and early part of the nineties, several software packages

capable of diagnosing and treatment planning dentofacial deformities were developed based on similar guidelines used by orthodontists (Bhatia and Sowray 1984, Harradine and Birnie 1985, Cutting et al. 1986, Hiranaka and Kelly 1987). Several studies of stability after orthognathic surgical correction of dentofacial deformities, employing computerized cephalometrics, have been reported (Ellis and Gallo 1986, Proffit et al.1987, Welch 1989).

Other studies in the field of computerized cephalometrics and orthognathic surgery have focused on the evaluation of surgical precision, i.e. a comparison of preoperative prediction to postoperative result. Donatsky et al. (1992) used the records of ten consecutive patients admitted for orthognathic surgery. A computerized cephalometric program, TIOPS, was evaluated in surgical simulation, predictive and postoperative assessment of surgery. The predicted and postoperative positions of the maxilla and mandible were compared with angular and linear measurements. No statistically significant differences could be demonstrated between predicted and postoperative positions. The same group published their results on a sample of forty consecutively treated patients requiring bimaxillary orthognathic surgery (Donatsky et al. 1997). All patients required maxillary superior repositioning combined with mandibular advancements or setbacks. Preoperative lateral cephalograms were digitized and morphologic tracings as well as numerical values were obtained. Orthognathic surgical simulation was performed on the monitor and a surgical treatment plan was printed. The lateral cephalogram obtained five weeks after

surgery was traced and numeric measurements derived. The postoperative tracing was then superimposed on the surgical treatment plan for evaluation. The authors found in the mandibular advancement group, the anterior maxilla had been placed too far superiorly, with an inaccuracy of 0.5 mm. The posterior maxilla and anterior mandible were placed in the planned positions. The lower part of the mandibular ramus was placed too far anteriorly, with an inaccuracy of 2.0 mm. In the mandibular setback group, the maxilla was placed too far superiorly and posteriorly, with a vertical and sagittal inaccuracy of 1.0 mm and 0.7 mm respectively. The posterior part of the maxilla was placed in a posterior position with an inaccuracy of 2.0 mm. The anterior mandible was placed too far anteriorly with an inaccuracy of 0.9 mm.

Few studies have been reported to evaluate consistency between different computerized cephalometric programs. Significantly, no studies are reported on the agreement between the clinicians diagnosis of dentofacial deformities requiring orthognathic surgical correction and the diagnosis generated by computerized cephalometric programs.

Interclinician Agreement Studies

The stress given to cephalometric analysis in diagnosis and treatment planning seem to vary considerably. Some practitioners find them indispensable for every case while others find them useful in specific cases. In a study designed to test the degree of usefulness of cephalometric analyses in arriving at diagnostic decisions for various types of

malocclusions, Silling et al. (1979) selected six cases of malocclusion to be examined by twenty-four clinicians. The first two of the six cases were class II division II cases, the next two class I malocclusions and the last two were class II division I cases. The clinicians varied in their educational backgrounds and level of experience. All clinicians were chosen on a random basis from a fifty square mile radius surrounding New York City. Models, facial photographs, periapical x-rays, cephalograms and a tracing were presented to the examiners in a stratified manner. Each individual examined all six cases, three with a cephalogram and three without. The clinicians were required to answer six questions for each case. Thus twelve orthodontists examined each case with access to the cephalograms and twelve that did not. The differences in the percentages of replies were tested for statistical significance. Of the thirty-six comparisons, only three of the differences were statistically significant. This was no greater then could be ascribed to chance. The three significant replies were in regard to anchorage requirements of the class II division I cases, with clinicians having access to the cephalograms demonstrating greater concern. The majority of the clinicians felt they could arrive at a satisfactory diagnosis and treatment plan with or without the radiographs. Responses relating to assessment of growth pattern were also found to be significant. Although there were differences in the treatment plans, the degree of variation was the same in the ceph-available group and the no-ceph group. The only

orthodontist who consistently felt the need for a cephalogram for diagnosis and to arrive at a treatment plan had the least experience. The authors concluded by advising the profession to reassess their routine use of head films.

Baumrind et al. (1984) made an attempt to determine how effective five clinicians would be at differentiating "forward rotation" from "backward rotation" of the mandible based purely on head-film information. The sample consisted of 238 treated class II patients divided into fourteen groups, each of which contained two or three forward rotators and two or three backward rotators. Each of the clinicians had practiced orthodontics for at least twenty-three years, were board certified and had served as instructors in the field. The results revealed that none of the experts performed at a level higher than was statistically better than by chance.

In an effort to validate the clinical efficacy of diagnostic records in orthodontics, Han et al. (1991) selected fifty-seven orthodontic patients according to specified criteria. The study sample was limited to class II division I malocclusion and the cases were chosen by stratified randomized sampling. The three strata were determined by the dental age with a late mixed dentition stage, early permanent dentition stage and an adult stage. Five experienced orthodontists were selected to exam the cases chosen. Clinicians were to follow a logical sequence of treatment decision making, starting with a strategy, followed by a treatment plan and finally a decision

on whether to extract or not. Five combinations of diagnostic records were presented to each clinician for each case: Study models only, models with facial photographs, models with photographs and a panograph, models photographs, panograph and a lateral cephalogram and lastly the tracing supplemented the rest. Interpretation with the clinician having access to all diagnostic material was used as the diagnostic standard. Therefore a diagnostic standard for each of the cases and each of the clinicians was established. With the presentation of diagnostic records to the participating orthodontists, a proportion of the treatment plan equivalent to the diagnostic standard was calculated and the change in treatment decision attributable to each additional incremental record was estimated. Clinicians were tested for reliability by repeating examination of fifteen cases when provided with all the diagnostic information available. The proportions of agreement between the sessions were then analyzed. Clinicians were required to decide on whether they would treat or not, choose the appliance and lastly whether extractions were required or not. Analysis of variance was conducted to establish the whether the variation in outcome and was because of the differences in the combination of diagnostic records employed or the dentition status of the cases. Very interesting results were obtained. Firstly, on the basis of the fifteen cases repeated, the average proportions of consistent treatment plan decisions made over a period of four to six weeks ranged from 53-73% with an average of 65%. Reliability

was higher for the adult dentition group (76%) than the late mixed dentition group (56%) or the early permanent dentition group. There was marked variation among orthodontists in the pattern of agreement with the diagnostic standard. In a majority of the cases (54.9%), study models alone provided treatment strategies that were equal to the diagnostic standard. The overall proportions of agreement indicated the lateral cephalogram made a large difference. Additional information made small differences. The ANOVA indicated the number of records did not influence the proportions of agreement, which was confirmed by the variation within each session being greater than among sessions.

A review of orthodontic textbooks reveals that most texts do not make recommendations for a standard radiographic survey. The books describe films that may be useful in diagnosis and treatment plan. Guidelines published by the American Association of Orthodontists (1988) recommended that a lateral cephalogram and a panograph or complete intra-oral radiographs should be used for orthodontic diagnosis and treatment planning of comprehensive cases. A questionnaire distributed to dental schools and orthodontic practitioners by Atchison (1986) confirmed that more than ninety percent of the orthodontists ordered a lateral cephalogram and a panoramic x-ray of patients with permanent dentition. Seventy percent reported requesting them on patients in the mixed dentition, with educators ordering 1.4 times as many radiographs as private

practitioners. Atchison et al. (1991) designed a study to quantitate the amount of diagnostic information gained by orthodontists by radiographs added to a set of orthodontic records. Thirty-nine orthodontists were asked to diagnose and treatment plan six cases. Each orthodontist was presented with study models first, followed by intraoral and extraoral photographs. They were asked to formulate a diagnosis and recommend a treatment plan. Each orthodontist was then requested to estimate their degree of confidence for the diagnosis and treatment plan furnished. The recording of personal confidence was done using a visual analogue scale ranging from 0-100%. The process was repeated for the treatment plan. The orthodontists were provided with radiographs upon request. Each participant was asked to explain the reason for ordering each radiograph. To establish the diagnostic information gained by examination of the radiographs, the orthodontist's new degree of confidence was recorded in relation to diagnosis and the treatment plan. Recordings were made for any change in the diagnosis or treatment plan. The process was repeated for any additional radiograph requested to estimate the gain in confidence resulting from examination of successive, selected radiographs till they felt confident they had all diagnostic information needed to recommend a treatment plan.

The authors were stuck by the confidence of the orthodontists in diagnosis and treatment planning cases on the basis of non-radiographic

information. The clinicians were on average seventy-five percent certain of their diagnosis before reviewing any radiographic information. The confidence level for the treatment plan was found to be lower at sixty-nine percent. This brings up an important question of the degree of uncertainity clinicians are willing to accept before being comfortable to treat a patient? Although the majority reported confidence gains from viewing radiographs, thirty percent expressed certainty based on clinical information and did not change their certainty level despite requesting radiographs. The most frequently ordered radiographs were the lateral cephalograms followed by a panoramic x-ray. These two x-rays accounted for a large proportion of the gain in confidence levels as well as the majority of the changes in diagnosis. The individual orthodontist and the specific case were both important factors in the explaining the different number of radiographs ordered, with the individual orthodontist being a more important variable. The difficulty of the case did not have a bearing on the number of x-rays ordered. Seventy-four percent of the radiographs examined did not produce any change in either diagnosis or treatment plans. However, approximately one change per case was observed.

STATEMENT OF THESIS

The aim of the present study was to compare two popular cephalometric software packages (Rocky Mountain Diagnostic Services and Quick Ceph™), used for diagnosis of orthognathic surgery cases, to a panel of experts.

Specifically, we used a sample of twenty consecutive adult patients who underwent surgical procedures, at the University Hospitals of Cleveland, for the correction of poorly aligned jaws. A minimum of five experienced clinicians (ten years or more teaching experience and fifteen years in private practice) analyzed pre-surgical lateral and frontal cephalograms and presented their diagnoses as answers to a questionnaire consisting of fourteen variables. The results from the clinicians were used for comparison to the computer-generated data. Additionally, inter clinician agreement was calculated and compared to the agreement obtained by the computers.

MATERIALS AND METHODS

Sample Selected

Fifteen of twenty consecutive adult patients who underwent orthognathic surgery at University Hospitals were used in the present study. Five cases suffered craniofacial anomalies and were not included in the sample. All patients were operated at the University Hospitals in Cleveland, between December 1, 1997 and January 31, 1999. The surgical procedures are listed in Table 1.

Table 1. List of surgical procedures

Patient ID	Surgical Procedure
1	Le Fort 1
2	Le Fort 1
3*	Le Fort 1
4	Le Fort 1
5	BSSO
6	Le Fort 1, BSSO
7*	Le Fort 1
8	Le Fort 1, BSSO, GP
9*	Le Fort 1, BSSO, GP
10	Le Fort 1, GP
11	Le Fort 1
12	Le Fort 1, GP
13	BSSO
14	Le Fort 1, BSSO
15*	Le Fort 1, BSSO, GP
16	Le Fort 1
17*	VRO
18	BSSO
19	BSSO
20	Le Fort 1

* Patients not included in the sample

Pre-Surgical Cephalograms

A week prior to surgery, each patient was brought to the Department of Orthodontics at the School of Dentistry in Case Western Reserve University, Cleveland, Ohio. The purpose of the study was explained and formal consent obtained (Appendix 1). Patients used lead aprons to minimize exposure to X-ray radiation. Two radiographs of the head were taken. The lateral cephalogram and frontal cephalograms were registered in the Broadbent Cephalometer. A single trained operator collected all cephalograms. Identical exposure times were used for all patients. Patients were brought back within two weeks of surgery and postoperative x-rays were taken in identical manner. The post-surgical radiographs were not used in the present study. Kodak fast screen film cassettes were used with Kodak 8 x 10 inch double emulsion films. Individual patients names, date of birth, date of x-ray, and distance from the film holder to the head holder was imprinted on the films for identification. Each radiograph was then numerically coded prior to analysis.

The rationale for the use of cephalograms to evaluate patients with skeletal imbalances was derived based on the studies of Atchison (1986) and Atchison et al. 1991) and Han et al. (Han 1991). Based on the studies, the authors established that the lateral cephalogram was the most ordered radiographic image in cases where skeletal aberrations were suspected.

Questionnaire

The questionnaire (Appendix 2) was prepared based on the five major characteristics of malocclusion as suggested by Ackerman and Proffit (1969). Fourteen questions were used in the questionnaire. Nine questions categorized problems based on the severity of the condition into mild, moderate or severe. Mild was considered less than one clinical deviation (Ricketts 1972) above or below the norm, moderate as at least one clinical deviation but less than two clinical deviations above or below the norm and severe as at least two clinical deviations above or below the norm. Posterior occlusion, overjet, profile and maxillary and mandibular midlines were broken down into three categories because the computer programs could not generate seven categories.

As recommended by Ackerman and Proffit (1969) the questionnaire covered all three planes of space; antero-posterior, vertical and transverse. Six questions related to the antero-posterior dimension, two related to vertical and two to transverse. In addition one question each, on asymmetry, profile, upper midline to facial midline and lower midline to facial midline were incorporated. Questions were answered by checking appropriate answer boxes provided in the questionnaire.

Clinician's Data

All clinicians selected had over ten years of teaching experience in an accredited orthodontic training program (CWRU) in addition to being in private practice for at least fifteen years. We contacted ten clinicians. All participated in the evaluation of cephalograms. The clinicians were informed about the purpose of our study and the questionnaire explained. Coded pairs of cephalograms along with copies of the questionnaires were provided for clinicians to report their findings. Each clinician was also provided with a view box, a ruler and protractor, and a copy of the Bolton Standards (acetate templates of the norm) to assist in evaluation. No information was provided to the clinicians about the kind of surgery performed on the patients. No effort was made to guide the clinicians during their examination of cephalograms.

4.5 Data Entry

After obtaining the completed questionnaires (10 clinicians x 20), numerical values were assigned to the categories mild, moderate and severe on an ordinal scale on either side of normal, i.e., clinical deviations determined to be greater than the ideal were assigned positive values, whereas, clinical deviations less than ideal were assigned negative values. A mildly protrusive mandible was assigned +1, whereas, a mildly deficient mandible assigned a –1. In all, 2,800 entries were made and entered in Excel spreadsheet (Appendix 3). All entries were rechecked for errors.

Rocky Mountain Diagnostic Services Data

Rocky Mountain Diagnostic Services is the sole provider of cephalometric diagnostic services as described by Ricketts (1972). We requested their participation in our study. In addition, we recommended a single operator analyze the pairs of cephalograms. The operator selected was a senior technical analyst with eight years of experience in tracing and analyzing cephalograms. The operator was not an orthodontist. Twenty pairs (lateral and frontal cephalograms) of presurgical cephalograms were coded and sent along with twenty copies of the questionnaire. Individual patient's dates of birth, race, sex and date of x-ray registration were provided to RMDS. All questionnaires were completed and returned. The information of all patients was coded numerically as outlined and entered in the Excel™ spreadsheet.

Rocky Mountain Diagnostic Services utilized twenty-nine landmarks in the lateral cephalogram and twenty eight in the frontal cephalogram to compute the seventy cephalometric measurements needed to answer the questionnaires. Figures 1A and 1B are examples of lateral and frontal tracings respectively, completed by RMDS.

Data Capture Using Quick Ceph

A single operator (Manish Valithan) using the Quick Ceph® software installed on an Apple® PC in the Department of Orthodontics digitized all twenty pairs of cephalograms. Each cephalogram was taped to a digitizing

table to avoid shifting of the radiograph. Direct digitization of the cephalograms was followed as recommended by Cohen (1984). In the lateral cephalogram twenty-nine landmarks were digitized using a digitizing mouse. Landmarks were identified in the order recommended by the software manufacturer. A tracing of the cephalogram appeared on the monitor (Figure 2 A) and various analyses were available. The frontal cephalogram was then taped to the digitizing table and thirty landmarks were identified. A single analysis was available in the antero-posterior view (Figure 2 B). A comprehensive diagnostic summary, available for each view, answered the questionnaire. Asterisks in the diagnostic summary, provided information about the number of clinical deviations from the norm, each variable was. Twenty questionnaires were completed by the digitization of the twenty pairs of radiographs. Information obtained was then numerically coded and entered in Excel™ spreadsheet.

Analysis of Clinician Opinion

To facilitate a preliminary review of the data collected from orthodontists, descriptive analyses were done for each variable of individual patients (Appendix 4). The standard deviations of each variable were averaged across the fifteen cases to estimate the variance among the variables. Variables were then arranged in descending order based on the variation exhibited by clinicians.

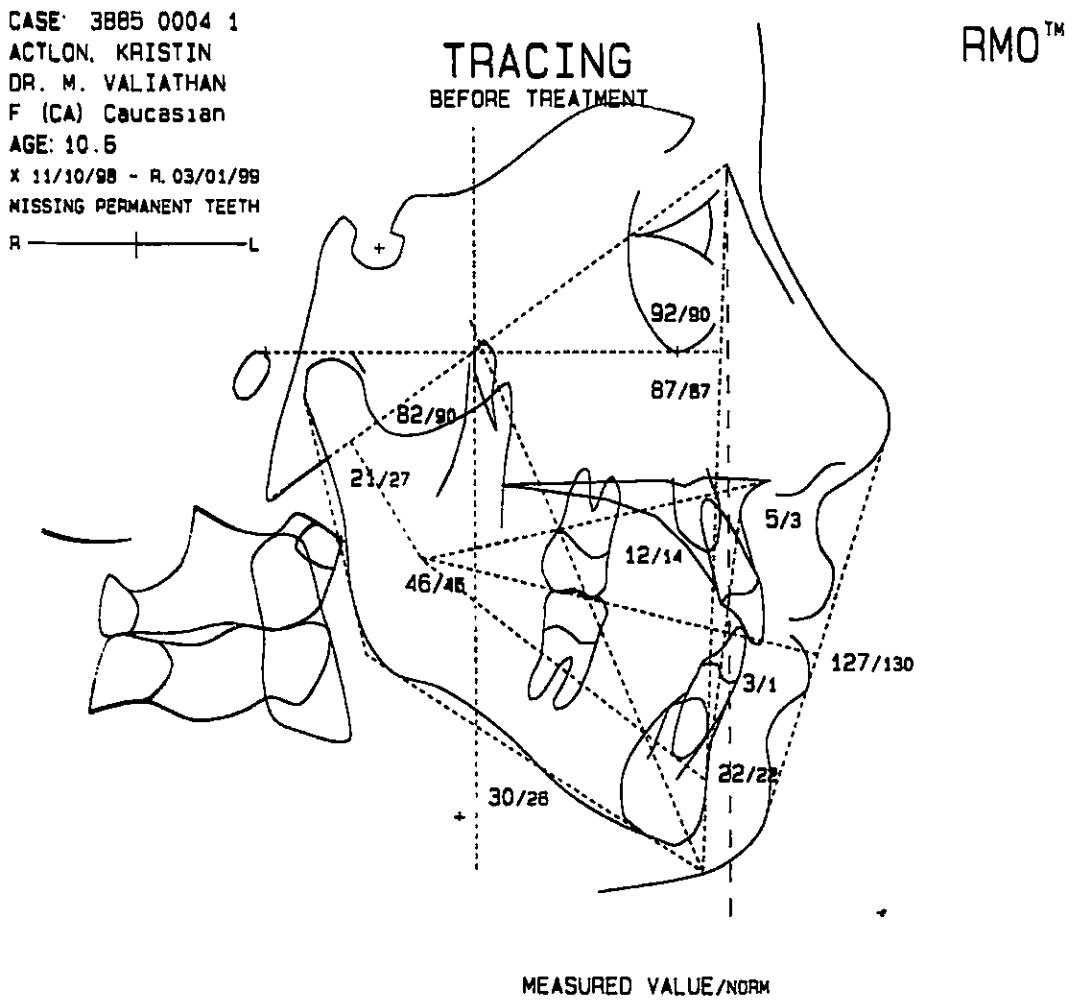
Frequency distribution tables for each variable in each case was created. For ease of visualization, it was then represented in the form of bar charts. We decided to use four skeletal variables, which are used most often to determine the surgical procedure, to create a test sample. The four skeletal variables employed were maxillary antero-posterior position, mandibular antero-posterior position, lower anterior facial height and asymmetries. Using the bar charts to visualize the distribution of clinical opinion for the four variables in each case, we were able to correctly identify the surgical procedure most likely to have been carried out in all fifteen cases (Figure 3). Therefore, all fifteen cases were used for comparison with computer generated data.

Comparison of Clinician Opinion to Computer Generated Data

Three comparisons were carried out. First, we employed the mode i.e. the most frequent opinion amongst the ten clinicians, for each variable in each case and compared it with data obtained from the computer software packages. Second we used the mode ±1 clinical deviation to establish whether the computer programs would demonstrate a marked increase in agreement with the clinicians. However, the use of the mode ± 1 on a seven point ordinal scale would mean that the computer assessments would have a 3/7 (42.6%) chance of randomly agreeing with the clinicians. This led to the third test, where we compared the computer generated diagnosis for each variable in each case to the mean ± 1 standard deviation. Unless the

standard deviation was equal to or greater than 1, we would minimize the agreement expected solely by chance.

Lastly, three similar comparisons were conducted for each clinician opinion in relation to the opinion expressed by the other nine clinicians i.e., a clinicians opinion of a variable was compared to the mode, mode ± 1 clinical deviation and the mean ± 1 standard deviation, formed by the other nine clinicians. The final test was completed to find whether or not any clinicians demonstrated similar variation patterns as the computer programs. It was limited to the four skeletal variables utilized to characterize the surgical procedures.

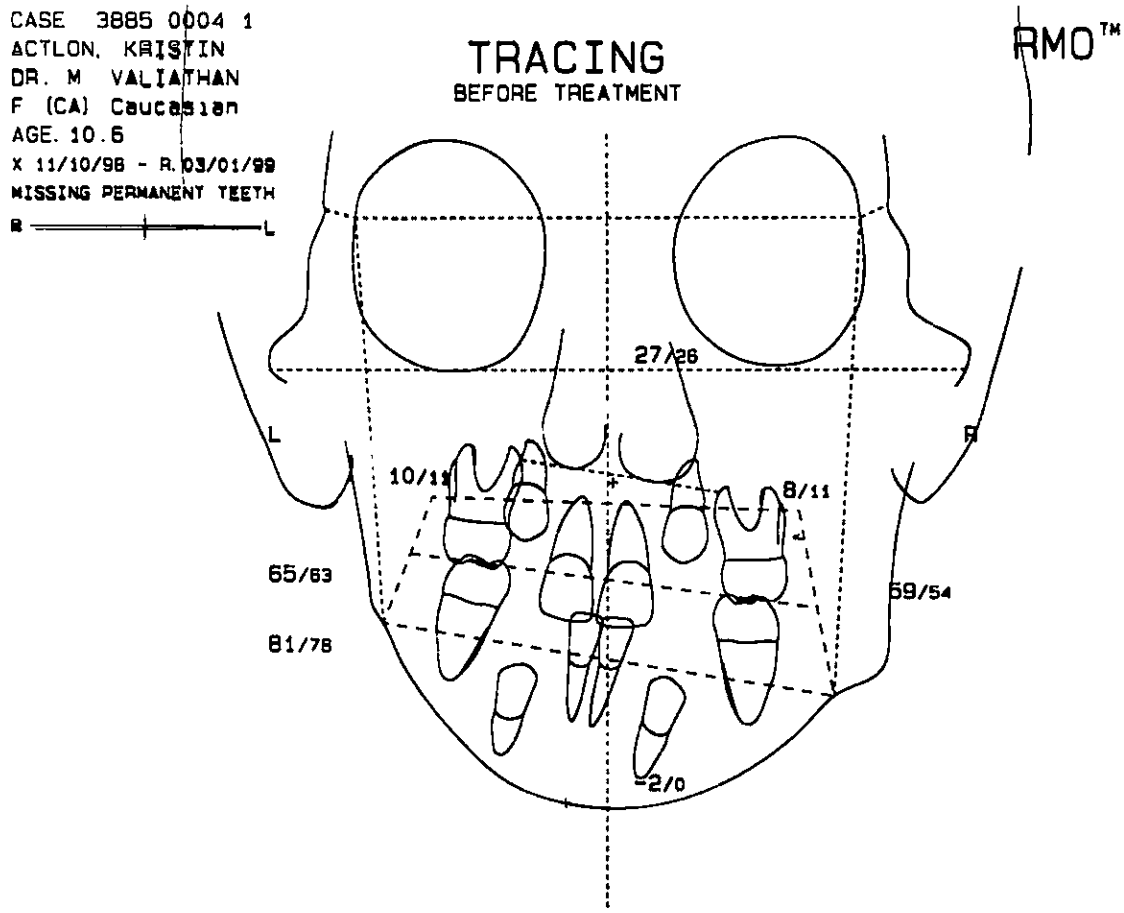


SIGNIFICANT CONSIDERATIONS	
CONDITION	REASON
Skeletal Class II Adenoid blockage of the airway?	Short Anterior Cranial Base Most probably

FACIAL PATTERN: MILD VERTICAL						
# FACTORS	MEASURED VALUE		NORM		CLINICAL DEVIATION	
Interincisal Angle	127.3	dg	130.0	dg	-0.4	
Convexity	4.6	mm	2.6	mm	1.0	*
Lower Facial Height	46.4	dg	45.0	dg	0.3	
A6 Molar Position to PTV	11.6	mm	13.6	mm	-0.7	
Bi to A-Po Plane	3.0	mm	1.0	mm	0.9	
Bi Inclination to A-Po	21.7	dg	22.0	dg	-0.1	
Facial Depth	87.3	dg	87.1	dg	0.1	
Facial Axis	81.7	dg	90.0	dg	-2.4	**
Maxillary Depth	92.0	dg	90.0	dg	0.7	
Mandibular Plane to FH	30.3	dg	25.5	dg	1.1	*
Mandibular Arc	21.4	dg	26.9	dg	-1.4	*

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Figure 1 A. Sample tracing of lateral cephalogram (ID 17) by RMDS employing 29 landmarks with measurements



MEASURED VALUE/NORM

SIGNIFICANT CONSIDERATIONS	
CONDITION	REASON
Midline Asymmetry Positional Max-Mand asymmetry	due to skel asymmetry-mandible

FACIAL PATTERN: MILD VERTICAL			
# FACTORS	MEASURED VALUE	NORM	CLINICAL DEVIATION
Intermolar Width (B6-B6)	59.0 mm	54.0 mm	2.5 **
Denture Midline	-1.7 mm	0.0 mm	-1.1 *
Max-Mand Width Left	-10.2 mm	-10.6 mm	0.4
Max-Mand Width Right	-8.0 mm	-10.5 mm	1.9 *
Denture to Jaw Midlines	1.7 mm	0.0 mm	1.1 *
Nasal Width	27.3 mm	26.1 mm	0.6
Maxillary Width (J-J)	64.8 mm	60.6 mm	1.1 *
Mandibular Width (AG-GA)	80.7 mm	77.7 mm	1.5 *

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Figure 1 B. Sample frontal cephalogram (ID 17) tracing by RMDS employing 28 landmarks and measurements

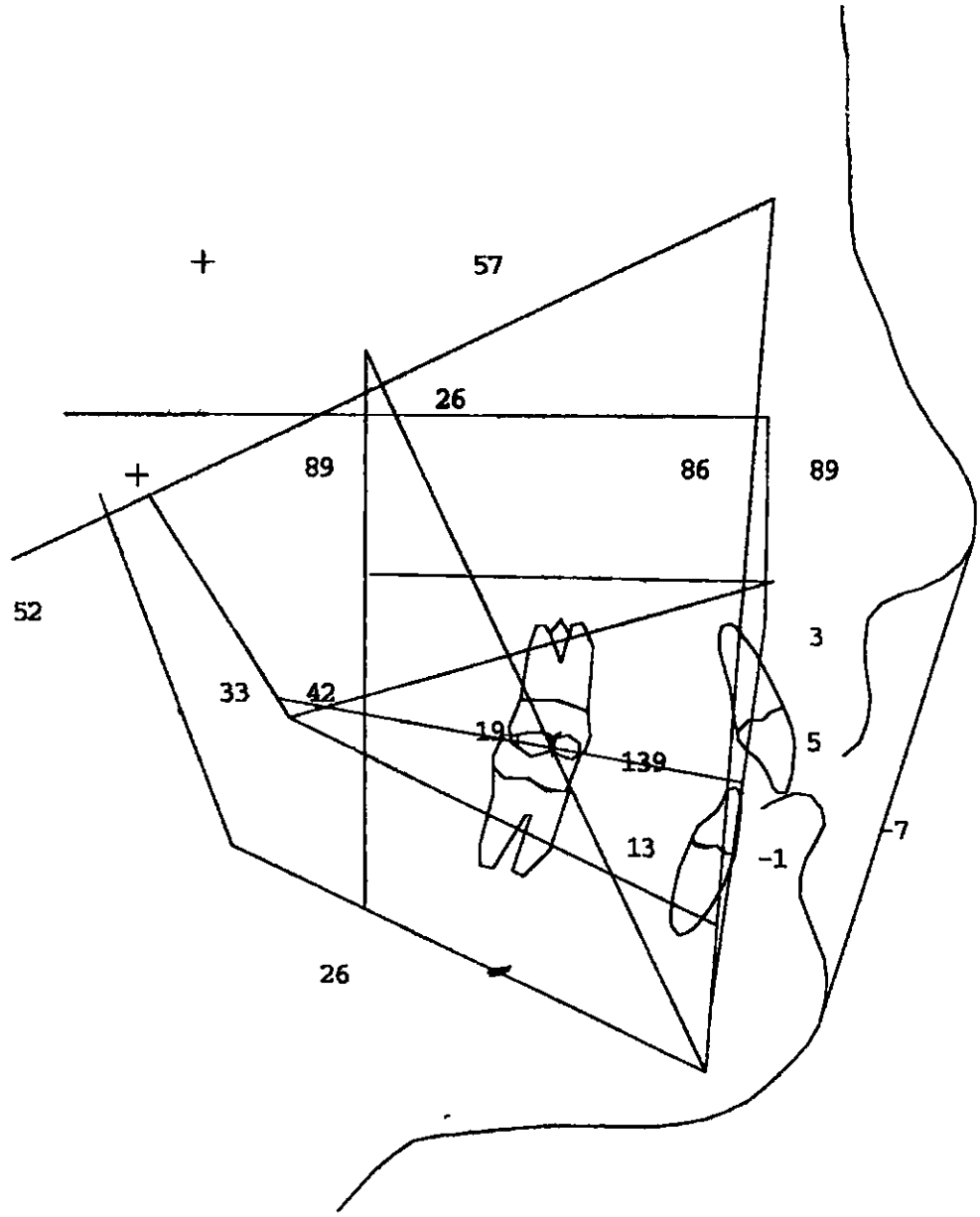


Figure 2 A. Sample lateral Cephalogram tracing (ID 4) by Quick Ceph® using 29 landmarks

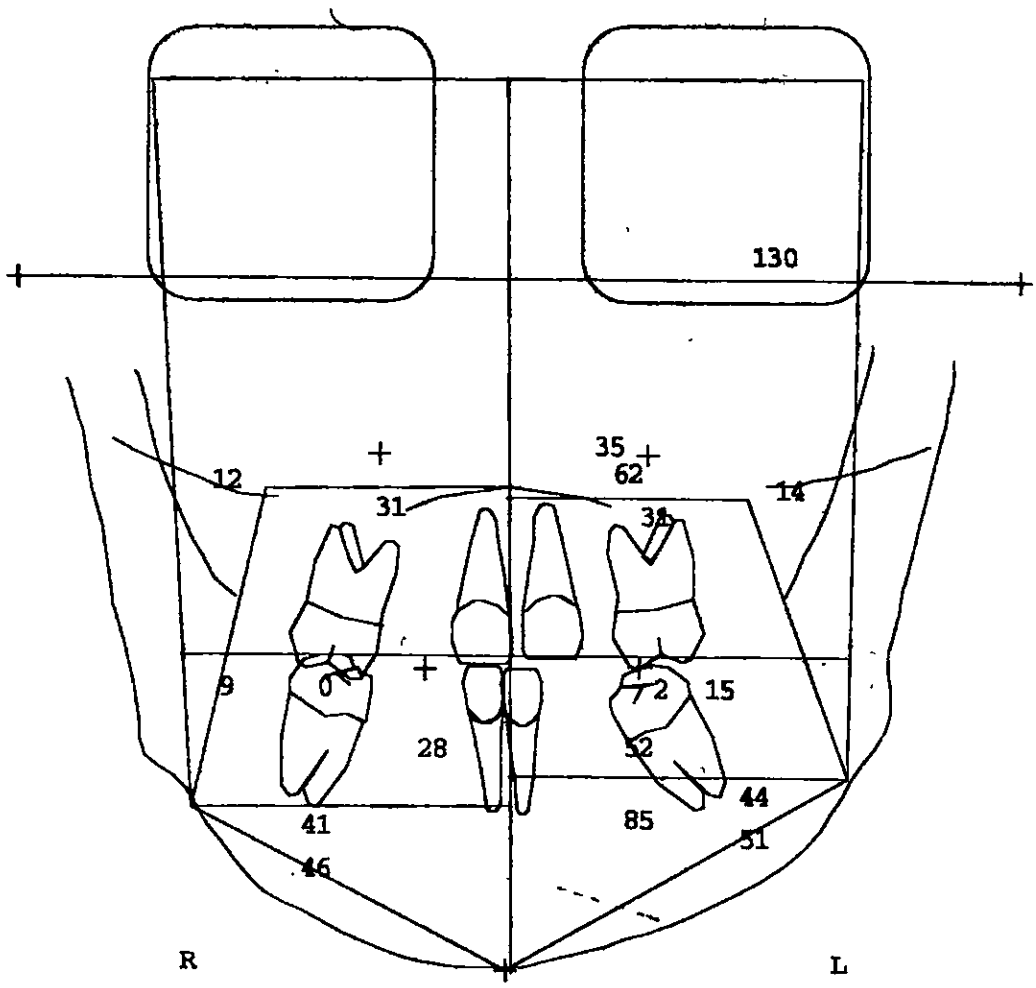


Figure 2 B. Sample frontal cephalogram tracing by Quick Ceph® using 30 landmarks

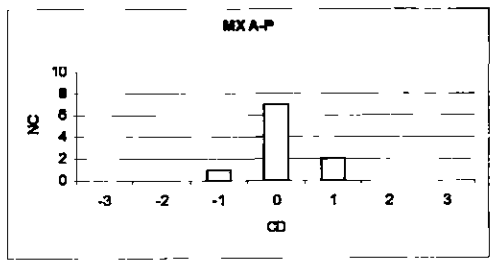


Figure 3 A

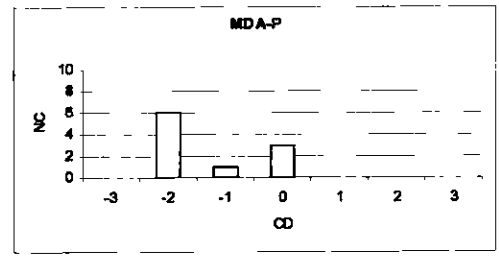


Figure 3 B

Id # 5 Operation: BSSO Mandibular advancement

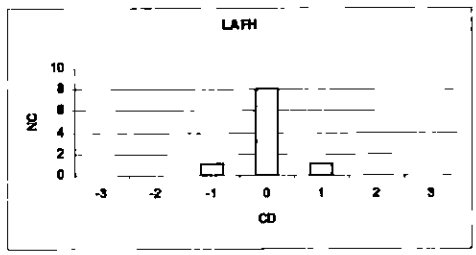


Figure 3 C

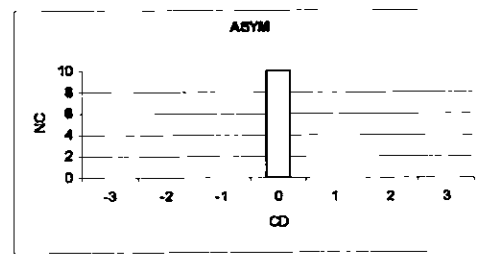


Figure 3 D

Figure 3. Charts above are samples to demonstrate the distribution of clinician opinion for four variables (ID # 5). The number of clinicians is denoted by the Y-axis and the number of clinical deviations is denoted by the X-axis. 3 a indicates maxillary antero-posterior (A-P) position (ideal), while 3 b demonstrates mandibular A-P position. Lower anterior facial height (3 c) and Asymmetries (3 d) appear normal

RESULTS

Variance among Clinicians

Descriptive analyses were done for each variable in each case and the mode, means and standard deviations calculated (Appendix 4). The standard deviations for each variable in the fifteen cases were averaged to estimate the variance for the particular variable. Table 2 and Table 3 lists the variance for each variable in descending order. Table 2 consists of the five variables for which information (Occlusion, Overjet, Profile, Maxillary and Mandibular midlines) was collected on a three-point ordinal scale. Table 3 contains the other nine variables that had seven choices in the questionnaire.

Comparison of RMDS and Quick Ceph™ to the Mode

The assessments of RMDS and Quick Ceph™ were compared to the mode for each variable. Table 4 describes the agreement observed for each variable across all fifteen cases.

Comparison of RMDS and Quick Ceph™ to the Mode ±1 Clinical Deviation

The assessments of RMDS and Quick Ceph™ that lay within a clinical standard deviation of the mode were calculated. The frequency of agreement for the fourteen variables is displayed in Table 5.

Comparison of RMDS and Quick Ceph™ to the Mean ± 1 Clinical Deviation

The frequency of agreement between the computer evaluations and the clinicians mean ± 1 standard deviation were calculated. The results of this comparison are displayed in Table 6.

Observed Agreement for Each Clinician with the Mode, Mode ± 1, and Mean ± 1

The frequency of agreement for each clinician, for each variable, was calculated employing the three evaluations described earlier. The opinion of the respective clinician was matched against the mode, the mode ± 1, and the mean ± 1 standard deviation. Tables 7-10 displays the agreement for the four variables chosen to characterize the surgery patients underwent.

Table 2.--Variance of variables on which information was collected on a three point scale.

Occlusion	0.2
Overjet	0.3
Profile	0.3
Maxillary midline	0.4
Mandibular midline	0.4

Table 3.--Variance of the nine variables where data was collected on a seven point ordinal scale.

Overbite	0.6
Maxillary width	0.7
Mandibular dentition	0.8
Maxillary dentition	0.8
Mandibular width	0.8
Asymmetry	0.9
Lower anterior FH	1.0
Mandibular A-P	1.1
Maxillary A-P	1.1

Table 4.--Frequency of agreement for each variable in fifteen cases with the mode as assessed by the software programs.

Variable	RMDS	Variable	QC
OJET	12 (80.4%)	PRO	15 (100%)
PRO	11 (73.7%)	OCCL	14 (93.8%)
OCCL	10 (67.0%)	OJET	14 (93 8%)
ASYM	8 (53.6%)	MX ML	13 (87.1%)
OBITE	8 (53.6%)	MD ML	12 (80.4%)
MX ML	8 (53.6%)	ASYM	11 (73.7%)
LAFH	7 (46.9%)	OBITE	10 (67.0%)
MD ML	7 (46.9%)	MX W	8 (53.6%)
MX A-P	5 (33.5%)	MD A-P	7 (46.9%)
MX D	5 (33.5%)	MD D	7 (46.9%)
MX W	4 (26.8%)	MX D	6 (40.2%)
MD D	3 (20.1%)	MD W	6 (40.2%)
MD W	3 (20.1%)	LAFH	5 (33.5%)
MD A-P	2 (13.4%)	MX A-P	4 (26.8%)
Total	93 (44.3%)		132 (62.8%)

Total number of assessments made were 210.

Table 5.--Frequency of agreement between computer software programs and the mode ± 1 for each variable in fifteen cases.

Variable	RMDS	Variable	QC
MX ML	15 (100%)	OCCL	15 (100%)
OCCL	15 (100%)	OJET	15 (100%)
PRO	15 (100%)	PRO	15 (100%)
ASYM	14 (93.8%)	MX W	15 (100%)
OBITE	14 (93.8%)	MX ML	15 (100%)
OJET	14 (93.8%)	MD ML	15 (100%)
MX D	13 (87.1%)	MD A-P	14 (93.8%)
MD ML	12 (80.4%)	MX A-P	13 (87.1%)
LAFH	11 (73.7%)	ASYM	13 (87.1%)
MX A-P	10 (67.0%)	OBITE	13 (87.1%)
MX W	9 (60.3%)	MX D	12 (80.4%)
MD D	8 (53.6%)	MD D	12 (80.4%)
MD A-P	7 (46.9%)	LAFH	10 (67.0%)
MD W	7 (46 9%)	MD W	9 (60.3%)
Total	164 (78.0%)		186 (88.6%)

The total number of assessments made were 210.

Table 6.--Frequency of agreement between RMDS and Quick Ceph™ with the mean + 1 standard deviation for each variable in fifteen cases.

Variable	RMDS	Variable	QC
ASY	12 (80.4%)	PROF	15 (100%)
OJET	12 (80.4%)	OCCL	14 (93.8%)
PROF	11 (73.7%)	OJET	14 (93.8%)
LAFH	10 (67.0%)	MD A-P	13 (87.1%)
OCCL	10 (67.0%)	MX ML	13 (87.1%)
OBITE	9 (60.3%)	OBITE	12 (80.4%)
MX ML	8 (53.6%)	MD ML	12 (80.4%)
MX A-P	7 (46.9%)	MX A-P	10 (67.0%)
MX D	7 (46.9%)	ASY	10 (67.0%)
MD ML	7 (46.9%)	LAFH	9 (60.3%)
MD A-P	6 (40.2%)	MX W	9 (60.3%)
MX W	5 (33.5%)	MD D	8 (53.6%)
MD D	4 (26.8%)	MX D	7 (46.9%)
MD W	4 (26.8%)	MD W	7 (46.9%)
Total	112 (53.4%)		153(72.9%)

Total number of assessments made was 210.

Table 7.--Agreement demonstrated by individual clinicians on maxillary antero-posterior position, with the mode, mode ± 1 clinical deviation and the mean ± 1 standard deviation for fifteen assessments.

Clinician	Mode	Mode ± 1	Mean ± 1
1	8	15	13
2	8	14	12
3	5	13	11
4	9	14	14
5	9	13	12
6	13	15	15
7	12	13	13
8	9	10	10
9	9	12	10
10	6	9	6

Table 8.--Agreement demonstrated by individual clinicians on mandibular antero-posterior position, with the mode, mode ± 1 clinical deviation and the mean ±1 standard deviation for fifteen cases.

Clinician	Mode	Mode ± 1	Mean ± 1
1	10	12	11
2	9	12	12
3	7	13	10
4	12	15	14
5	9	14	13
6	12	15	14
7	11	13	12
8	9	11	11
9	10	13	11
10	8	10	10

Table 9.--Agreement demonstrated by individual clinicians on lower anterior facial height, with the mode, mode ± 1 clinical deviation and the mean ± 1 standard deviation.

Clinician	Mode	Mode ± 1	Mean ± 1
1	7	13	11
2	11	14	12
3	10	13	11
4	6	9	7
5	11	13	13
6	9	12	10
7	9	12	11
8	10	12	11
9	8	11	9
10	9	11	11

Assessments for the fifteen cases are represented above.

Table 10.--Agreement demonstrated by individual clinicians in asymmetry, with the mode, mode ± 1 clinical deviation and the mean ± 1 standard deviation.

Clinician	Mode	Mode ± 1	Mean ± 1
1	9	13	11
2	12	15	15
3	11	12	12
4	10	13	12
5	12	14	14
6	9	11	10
7	8	13	11
8	11	12	11
9	10	11	11
10	11	12	12

Assessment among the fifteen cases is represented below

DISCUSSION

Questionnaire

The preparation of the questionnaire, which formed the basis of the study, was based on the "problem oriented approach to treatment" advocated by Ackerman and Proffit (1969). The authors of the publication displayed, by means of a Vinn diagram, the five major characteristics of malocclusion, and a modern method to classify malocclusion. Unlike several earlier classification systems, the newer approach recognizes traits of a malocclusion in the antero-posterior dimension, vertical plane and transverse axis. Additionally, consideration is given to the soft tissue profile. The questionnaire obtained information on the five major characteristics of malocclusion by asking fourteen questions. The questions were further subdivided into seven categories. However, five variables could not be categorized as the computers do not generate the required information. These five had only three categories. Numerical values were assigned to the responses based on the category chosen for the variable, which depended on the severity of the condition. The categorization of responses was done to quantitate the responses and thereby lend itself for comparison.

Variance among Clinicians

The fifteen completed questionnaires from ten clinicians each were qualitative in nature. The categorical data were assigned numerical values on an ordinal scale on either side of zero (considered ideal). The results were described using means, standard deviations and frequencies (Appendix 4). To estimate the variance among clinicians we used the standard deviations of each variable across the fifteen cases. The value obtained by averaging the standard deviations for each variable provided an estimate for the variance of variables.

It is worth noting that the five characteristics of malocclusion that were not answered on a seven-point scale and rather on a three-point scale demonstrated the least variation. The finding was not suprising as by reducing the categories there would more likely be agreement amongst the clinicians. The finding may alternately be described in the following manner. It is routine practice during pre surgical orthodontics to remove the dental compensations nature has made for a skeletal discrepancy. Removal of the dental compensations most often clearly answers the five variables in question. Perhaps both factors contributed to the good level of agreement observed for the five variables.

It was of interest to note that the four variables considered to be most often employed in determining the type of surgery to be performed demonstrated the greatest variation. The variation among clinicians in

assessing maxillary and mandibular position in the antero-posterior dimension as well as the poor agreement observed in relation to the lower anterior facial height may be in part due to the lack of rigid guidelines. Although independent analysis exists of ideal maxillary and mandibular length, the spatial position of these craniofacial bones may be contributing to the disagreement among clinicians. Maxillary and mandibular widths demonstrated less variation than the four skeletal variables used to characterize the surgeries performed. It may be attributed, in part, to these variables being more often normal than not as indicated by the surgical procedures performed. Silling et al. 1979, Baumrind et al. 1984, and Han et al. 1991 attributed the variation amongst clinicians to educational background, clinical experience in surgical orthodontics and treatment objectives

Comparison of the Mode with Computer Generated Data

The mode is indicative of the maximum number of clinicians in agreement for each assessment. Employing the mode eliminated variations observed between clinicians. The overall agreement between the computer programs and clinicians assessments may not be considered high. Quick Ceph™ agreed (62.8%) with the mode with greater frequency than RMDS (44.3%). The overall poor agreement maybe explained in part by the random error inherent in cephalometrics. It is well established that error in landmark identification cannot be ignored as it significantly alters linear measurements although angular measurements are affected to a lesser extent (Bergin et al.

1978). RMDS and Quick Ceph™ utilized linear and angular measurements to complete the questionnaires. The results should not be compared to the findings of el Mangoury et al. (1987), that determined skeletal landmarks and their measurements were more reliable than dental landmarks and associated measurements. The present study was not designed to determine reliability of landmarks or the measurements obtained from them.

The fact that the magnitude of error varies from landmark to landmark (Baumrind 1971 b) may be a possible explanation to the varied levels of agreement among the different variables. Both computer programs demonstrated similar variation patterns to the clinicians i.e. the computers tended to agree with greater frequency for the variables in which clinicians showed less variation.

It is also important to consider the possibility, however small, of possible systematic errors in the location of landmarks. An analytic bias would affect the assessment and performance of RMDS adversely. A senior technical analyst with eight years experience, evaluating all cases minimized such measurement biases. The employee of RMDS had undergone six months of calibration in identifying landmarks, completing tracing and the procedure of digitization. Although the operator was not blinded for the current project it should not have affected our results. It would be unfair not to mention the possibility of clinicians having made incorrect assessments, especially in their assessment of frontal cephalograms. Frontal cephalograms are not routinely

prescribed and examined by orthodontists in practice environments (Atchison et al. 1991). The use of ten clinicians and employing the mode should minimize errors caused by random errors amongst the clinicians.

Another consideration would be the standards that RMDS software employs which were created from a sample of two thousand treated cases (Ricketts 1972). No mention was made in the publication as to whether the cases were treated to the ideal values as publicized by various other cephalometric analyses. It is therefore conceivable that the clinicians evaluated the cases, as how severe the case may be from "ideal" based on analyses of their choice. RMDS used a different set of standards, arguably, closer to outcomes that may be anticipated from orthodontic therapy. Quick Ceph™ on the other hand utilizes standards established from the "ideal" population.

Agreement Between the Computer Program and the Mode ± 1 Clinical Deviation

It is important to note that collapsing the sub categories was not undertaken to in an effort to increase interclinician agreement but rather to establish whether the assessment of RMDS and Quick Ceph™ was within a clinical deviation of the mode.

The overall agreement between RMDS, Quick Ceph™ and the mode ± 1 went up to 78% (164/210). A similar trend of increase in agreement was observed among the skeletal and dental variables assessed. However, it is important to note that in contrast to being evaluated against the mode, where

there was a 1/7 chance of random agreement, now the number had gone up to 3/7. The finding indicate that RMDS and Quick Ceph™ were within a clinical deviation of the Gold Standard with much greater frequency. Although the finding is not suprising, it does pose the question whether the clinicians historic perspective of "ideal" has undergone change. Research (Turley and Auger 1994, Nguyen and Turley 1998) has demonstrated that the classical icons of "ideal" facial attractiveness no longer represent present concepts of facial beauty. Have skeletal and dental "ideals" followed suit?

Agreement between the Computer Programs to the Mean ± 1 Standard Deviation

The purpose of using the standard deviation to evaluate agreement between the computer programs and clinicians was purely to redue the chance agreement that occurs when we use the mode ± 1. Unless, the standard deviation was one or more, the chance of random agreement could be minimized. Agreement between the computer programs and mean ± 1 was higher for all variables than when compared to the mode. However, the percent agreement was lower than when the computer generated data was compared to the mode ± 1.

In all three assessments carried out, Quick Ceph™ demonstrated much better agreement with the clinicians than RMDS. The findings may be explained by the observer who identified the landmarks for Quick Ceph™ being an orthodontist in training with a strong background in cephalometrics. This would decrease the possibility of systematic error in digitization.

Additionally, as the operator for the study was the principal investigator for the study, greater attention may have been paid to the important step of digitization. The operator could not be blinded for the study, but all radiographs were coded and digitized randomly.

CONCLUSIONS

Limitations in the present study design restrict our ability to derive valid conclusions. The ability of clinicians to reproduce their respective results when evaluating the same cases was not tested. Similarly, intra computer program reliability; or the ability of the computer programs to reproduce their results when evaluating the same cases, was not examined. Future studies could test the intra clinician variance by comparing evaluations of the clinicians for the same cases made at different times. The ability of the operators of the computer programs to reproduce the same results at different times should also be evaluated. The Kappa statistic (Landis and Koch, 1975) may be employed to test interoperator reliability where categorical data is involved. However, the program is DOS based and limited in its application. In the absence of these two reproducibility tests, the accuracy of the data collected in the present study remains uncharacterized.

Based on the results of the present study certain trends were observed. Neither computer software programs demonstrated a high frequency of agreement among the skeletal variables assessed, with the mode derived from the clinician data. Of the two computers programs tested, Quick Ceph™ agreed more often with the clinicians than RMDS.

Quick Ceph™ and RMDS tended to agree with the mode obtained from the clinician data when examined for dental variables. Quick Ceph™ tended to agree with the clinicians with greater frequency than RMDS in all assessments except lower anterior facial height. The trend based on the present study indicates Quick Ceph™ relates better with the clinician opinion than RMDS.

Ricketts (1972) has strongly recommended the use of a service organization such as RMDS to assist in the process of diagnosis and thereafter deriving a treatment plan. Based on the finding of the present study, such practice should be adopted with a healthy measure of caution.

When enlisting the services of a service organization for future studies, it would be beneficial to eliminate a measurement bias by requesting multiple operator data of properly calibrated operators. Stringent calibration procedures should be adhered to for all operators of the computer programs.

The results of the present study suggest that Rocky Mountain Diagnostic Services and Quick Ceph™, the two computerized cephalometrics programs tested, may be limited in its application in the field of orthognathic surgery. The results tend to indicate that computerized cephalometrics may at best serve as an adjunct to the routine diagnostic aids used by clinicians, and at worst, could be misleading to the naïve clinician.

APPENDIX 1

Patient consent form for investigational studies

TITLE OF PROJECT: The use of cephalometrics in planning orthognathic surgical procedures

Purpose of Study: I am an individual who is to undergo orthognathic surgical procedures. I understand that as part of my diagnostic records, and to facilitate my treatment plan, I will be radiographed using the Broadbent-Bolton cephalometer available in the Bolton Brush Growth Study Center. The technique will yield a lateral and a frontal view cephalometric radiograph for subsequent analyses. These two dimensional x-ray images will be repeated after my surgery as part of my post treatment records.

The pre surgical x-rays will be analyzed by five experienced orthodontists and two softwares programs. A list of "problems" or deviations in specific regions of my face, from the "norm", will be listed. The lists will be compared to each other.

Brief description of study procedures: To produce the bi-orthogonal radiographs, I will be seated in the Broadbent Bolton cephalometer for 5-8 minutes. These are standard clinical x-ray images being produced and there are no known risks from the procedure.

Risks and Benefits: As mentioned, there is no known risk associated with the production of these standard x-ray images. I expect no adverse reaction to any portion of the procedure and the surgical/orthodontic care I receive will be

first rate. The benefits of my image to the scientific community cannot be calculated, however I do know that it could be extremely useful to the craniofacial patient community.

Alternatives: Participation in the present study is purely voluntary. There will be no form of compensation besides contributing to the posterity of craniofacial research.

Confidentiality: At no time will my identity be revealed to patients, practitioners, or research scientists affiliated with or using the study data. My complete anonymity will be maintained.

Date _____

Patient signature _____

Principal investigator _____

Witness _____

APPENDIX 2

Questionnaire

Please complete the following questionnaire by entering the appropriate code. Your cooperation in greatly appreciated. Please note, mild is considered less than one standard deviation above or below the norm, moderate as at least one deviation above or below the norm and severe as at least two standard deviations above or below the norm. In case of queries please contact Dr. Manish Valiathan at 216-368 3249 or 216-231 0487. Thank you.

Serial number: **Clinician:**
Software: **Date:**

ANTERIO – POSTERIOR: SKELETAL

MAXILLA

- ❑ Normal
- ❑ Mildly Hypoplastic
- ❑ Moderately Hypoplastic
- ❑ Severely Hypoplastic
- ❑ Mildly Hyperplastic
- ❑ Moderately Hyperplastic
- ❑ Severely Hyperplastic

MANDIBLE

- ❑ Normal
- ❑ Mildly Retrognathic
- ❑ Moderately Retrognathic
- ❑ Severely Retrognathic
- ❑ Mildly Prognathic
- ❑ Moderately Prognathic
- ❑ Severely Prognathic

ANTERIOR - POSTERIOR: DENTAL

- ❑ Class I
- ❑ Class II
- ❑ Class III

ANTERIOR OCCLUSION

- ❑ Normal Overjet
- ❑ Anterior cross bite
- ❑ Increased Overjet
- ❑ Decreased Overjet (Class II div.)

MAXILLARY TEETH

- ❑ Normal
- ❑ Mildly Retroclined
- ❑ Moderately Retroclined
- ❑ Severely Retroclined
- ❑ Mildly Proclined
- ❑ Moderately Proclined
- ❑ Severely Proclined

MANDIBULAR TEETH

- ❑ Normal
- ❑ Mildly Retroclined
- ❑ Moderately Retroclined
- ❑ Severely Retroclined
- ❑ Mildly Proclined
- ❑ Moderately Proclined
- ❑ Severely Proclined

VERTICAL: SKELETAL

LOWER ANTERIOR FACIAL HEIGHT

- ❑ Proportional
- ❑ Mildly Short
- ❑ Moderately Short
- ❑ Severely short
- ❑ Mildly Long
- ❑ Moderately Long
- ❑ Severely Long

VERTICAL: DENTAL

- ❑ Normal (25% – 50 %)
- ❑ Mild Open bite
- ❑ Moderate open bite
- ❑ Severe Open bite
- ❑ Mild Deep bite
- ❑ Moderate Deep bite
- ❑ Severe Deep bite

TRANSVERSE

MAXILLA

- ❑ Normal maxilla
- ❑ Mildly Narrow maxilla
- ❑ Moderately Narrow maxilla
- ❑ Severely Narrow maxilla
- ❑ Mildly Wide maxilla
- ❑ Moderately Wide maxilla
- ❑ Severely Wide maxilla

MANDIBLE

- ❑ Normal mandible
- ❑ Mildly narrow mandible
- ❑ Moderately narrow mandible
- ❑ Severely narrow mandible

- ❑ Mildly wide mandible
- ❑ Moderately wide mandible
- ❑ Severely wide mandible

ASYMETRY

- ❑ Normal
- ❑ Right side Mildly longer
- ❑ Right side Moderately longer
- ❑ Right side Severely longer
- ❑ Left side mildly longer
- ❑ Left side moderately longer
- ❑ Left side severely longer

UPPER MIDLINE

- ❑ On
- ❑ Off Pts right
- ❑ Off Pts left

LOWER MIDLINE

- ❑ Centered on Mandible
- ❑ Off Pts right
- ❑ Off Pts left

PROFILE

- ❑ Convex
- ❑ Concave
- ❑ Straight

OTHER

DIAGNOSIS

APPENDIX 3

Raw data from clinicians and computer programs

Table 11

ID 1	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	2	0	0	-2	2	0	0	-3	3	0	-1	-1	-1
QC	-1	2	1	1	1	-2	1	1	-1	3	0	0	0	-1
CL 1	-1	1	1	1	1	0	0	1	0	0	0	0	1	-1
CL 2	-2	0	1	1	1	0	0	1	-1	0	1	0	0	-1
CL 3	-2	0	1	0	2	0	0	1	-1	0	2	0	1	-1
CL 4	-2	0	0	1	2	0	-2	1	-1	1	-2	0	1	-1
CL 5	-3	2	1	1	3	-1	2	1	1	1	0	-1	1	-1
CL 6	-2	0	1	1	1	0	0	1	0	0	1	0	1	-1
CL 7	-1	0	1	1	1	0	-1	0	1	0	1	-1	0	-1
CL 8	0	1	1	1	0	0	1	1	0	0	-1	0	0	-1
CL 9	-3	0	1	1	2	0	0	1	0	0	1	1	1	-1
CL 10	-2	0	1	1	0	0	0	0	0	0	0	0	0	-1
ID 2	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	0	0	0	3	3	2	3	0	3	-2	1	1	-1
QC	-3	0	1	0	3	2	2	3	0	2	0	0	0	0
CL 1	-1	0	0	1	3	0	0	3	0	0	0	0	0	0
CL 2	-1	1	0	1	1	1	2	2	0	2	0	0	0	0
CL 3	-2	1	0	1	2	1	2	3	-1	0	0	0	0	-1
CL 4	-1	1	0	0	2	0	0	2	0	1	0	0	0	0
CL 5	-1	3	0	1	-3	0	3	3	1	3	0	0	0	0
CL 6	-2	1	1	1	2	0	0	3	0	1	0	0	0	0
CL 7	-2	0	0	0	2	0	0	2	0	0	0	0	0	0
CL 8	-1	1	0	0	2	0	0	2	0	0	0	0	0	-1
CL 9	-3	1	-1	1	1	0	3	3	-1	2	0	-1	0	0
CL 10	-3	0	1	1	2	0	1	2	0	0	0	1	0	1
ID 3	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	2	0	-1	-2	3	0	0	-2	-3	0	0	1	-1
QC	-3	0	1	-1	0	3	0	1	-3	-3	0	1	-1	-1
CL 1	-2	2	1	-1	0	1	0	1	-3	3	0	0	1	-1
CL 2	-2	0	1	-1	0	2	-1	1	-1	0	0	0	0	-1
CL 3	-3	2	1	-1	0	2	0	0	-1	0	-1	1	-1	-1
CL 4	-3	0	1	-1	2	2	-2	0	-2	0	0	1	-1	-1
CL 5	-3	3	1	-1	2	2	-1	-2	-2	-2	0	-1	-1	-1
CL 6	-3	0	1	-1	0	1	-1	1	-2	0	0	1	-1	-1
CL 7	-3	1	1	-1	0	3	-1	0	0	0	0	1	-1	-1
CL 8	-2	0	1	-1	0	1	0	1	-2	0	0	1	-1	-1
CL 9	-3	0	1	-1	1	3	0	1	-2	2	0	0	-1	-1
CL 10	-3	1	1	-1	0	1	-1	1	-2	0	-1	1	-1	-1

Table 11 Contd

ID 4	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	0	-1	-1	2	0	1	1	2	-2	1	0	1	0	0
QC	1	0	-1	2	2	0	1	1	0	1	0	0	1	-1
CL 1	1	0	-1	2	1	1	0	1	0	0	-1	0	1	1
CL 2	1	-1	-1	2	-1	1	0	1	1	0	1	0	1	1
CL 3	2	-2	-1	2	-1	2	1	1	0	1	-1	0	1	1
CL 4	1	0	-1	2	-1	0	0	1	-2	0	-1	0	1	0
CL 5	0	0	-1	2	-2	1	3	2	0	0	-1	0	1	1
CL 6	0	-1	-1	2	0	0	0	1	-2	0	2	0	1	0
CL 7	0	0	-1	2	0	1	0	1	0	2	1	0	1	0
CL 8	0	-2	-1	2	0	0	0	1	-2	1	0	0	0	0
CL 9	2	0	-1	2	0	0	2	2	0	1	1	0	1	0
CL 10	0	-2	-1	2	0	0	1	2	-2	0	1	0	1	0
ID 5	**MX**	**MD**	**OCC**	**OJ**	**MX D**	**MD D**	**LFH**	**OB**	**MXW**	**MDW**	**ASY**	**MXL**	**MDL**	**PRO**
RMDS	1	0	-1	2	-1	1	0	1	0	0	-1	0	-1	1
QC	0	-1	-1	2	1	-1	0	1	0	0	0	0	0	1
CL 1	1	0	-1	2	0	0	0	0	0	0	0	0	1	1
CL 2	0	-2	-1	2	0	0	0	1	0	0	0	0	0	1
CL 3	0	-2	-1	2	-1	0	0	1	0	0	0	-1	0	1
CL 4	0	-2	-1	2	-1	0	0	0	0	0	0	0	1	1
CL 5	0	-2	-1	2	2	0	1	2	0	-1	0	0	1	0
CL 6	0	-1	-1	2	0	0	0	1	0	0	0	0	0	1
CL 7	0	0	-1	2	0	0	0	0	0	0	0	0	1	0
CL 8	0	-2	-1	2	0	0	-1	1	0	0	0	0	0	0
CL 9	1	0	-1	2	0	0	0	1	0	0	0	0	1	0
CL 10	-1	-2	-1	2	0	-1	0	1	0	0	0	0	1	-1
ID 6	**MX**	**MD**	**OCC**	**OJ**	**MX D**	**MD D**	**LFH**	**OB**	**MXW**	**MDW**	**ASY**	**MXL**	**MDL**	**PRO**
RMDS	-3	0	0	-1	-3	3	-2	1	-3	-3	0	1	1	-1
QC	-1	2	1	-1	0	2	1	0	-1	1	0	-1	0	-1
CL 1	-3	2	1	-1	2	1	0	0	-2	3	-1	-1	0	-1
CL 2	-1	2	1	-1	2	2	0	0	-1	1	-1	-1	0	-1
CL 3	-2	3	1	-1	2	3	0	0	-1	-1	-3	-1	0	-1
CL 4	-2	1	1	-1	2	2	-1	0	-2	1	-1	0	1	-1
CL 5	-3	3	1	-1	3	3	1	-1	0	0	0	-1	0	-1
CL 6	-2	2	1	-1	2	1	-1	-2	-2	0	1	-1	1	1
CL 7	-3	0	1	-1	3	3	0	0	0	3	0	-1	0	-1
CL 8	0	2	1	-1	1	0	1	0	-1	0	0	0	0	-1
CL 9	-3	2	1	-1	3	2	0	0	0	2	1	0	1	0
CL 10	-3	1	1	-1	2	2	-2	0	-2	1	1	-1	0	-1

Table 11 Contd

ID 7	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	0	0	-1	-3	3	2	3	0	0	-2	0	0	-1
QC	-3	-3	-1	-1	0	3	1	2	-3	2	0	0	0	-1
CL 1	-3	1	0	-1	-2	1	0	1	-2	0	0	0	0	-1
CL 2	-2	2	-1	-1	0	1	1	2	-2	0	-1	1	0	0
CL 3	-3	2	1	-1	2	1	-1	1	-2	-1	-2	1	1	-1
CL 4	-3	-1	0	-1	1	0	-1	1	-2	0	0	1	0	-1
CL 5	-3	1	1	-1	2	1	3	2	0	0	1	0	0	-1
CL 6	-3	-2	1	-1	0	1	-1	1	-2	0	0	1	-1	-1
CL 7	-3	1	1	-1	1	2	1	1	0	0	0	1	0	-1
CL 8	-3	0	1	-1	0	0	2	2	-2	0	0	0	0	-1
CL 9	-3	0	0	-1	0	0	2	2	-2	0	0	1	0	-1
CL 10	-3	-1	1	-1	1	0	2	2	-3	0	0	0	0	-1
ID 8	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	0	1	-1	-3	3	3	1	-3	-3	0	-1	-1	-1
QC	-2	2	1	-1	-1	2	3	1	-2	1	0	-1	-1	-1
CL 1	-3	1	1	-1	0	0	1	0	-2	0	0	0	0	-1
CL 2	0	2	1	-1	0	1	2	1	-1	0	0	0	0	-1
CL 3	-2	2	1	-1	0	1	3	0	-2	-1	-1	-1	-1	-1
CL 4	-1	2	1	-1	0	-1	2	0	-2	-2	0	0	0	-1
CL 5	-3	3	1	-1	0	1	3	1	-2	-2	0	0	0	-1
CL 6	-3	2	1	-1	0	1	3	0	-2	0	0	0	0	-1
CL 7	-3	3	1	-1	0	3	2	0	-1	0	0	0	0	-1
CL 8	-2	3	1	-1	0	0	3	1	-2	0	0	0	0	-1
CL 9	-2	1	1	-1	1	-1	3	1	0	1	0	0	1	0
CL 10	-3	2	1	-1	0	-1	3	1	-3	0	0	0	0	-1
ID 9	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-1	0	1	-1	1	3	3	3	-2	3	-2	-1	-1	-1
QC	-2	-1	1	-1	2	3	3	3	-3	3	0	0	0	-1
CL 1	-1	1	1	-1	1	2	0	1	-1	0	0	0	0	-1
CL 2	-1	1	1	-1	1	1	-1	2	-2	0	0	0	0	0
CL 3	-2	1	1	-1	2	2	3	2	-2	-1	0	1	0	-1
CL 4	-2	0	1	-1	2	2	-2	2	-2	1	0	0	0	-1
CL 5	-2	3	1	-1	3	3	3	2	-1	2	0	0	0	-1
CL 6	0	2	1	-1	2	2	2	2	-2	0	1	0	0	-1
CL 7	-2	3	1	-1	2	3	-1	2	0	0	0	0	0	0
CL 8	-2	0	1	-1	2	1	2	2	-2	0	0	0	0	-1
CL 9	-3	2	1	-1	2	1	3	2	0	1	0	0	1	-1
CL 10	-3	2	1	-1	2	2	2	2	-2	0	1	0	1	-1

Table 11 Contd

ID 10	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	-3	0	-1	0	-3	3	3	-1	3	-2	1	1	-1
QC	-3	-1	-1	-1	1	3	3	3	-3	3	0	0	-1	-1
CL 1	-2	0	1	-1	1	-1	2	2	-2	0	1	0	-1	-1
CL 2	-2	1	1	-1	1	-1	1	3	-1	1	-1	0	0	-1
CL 3	-2	1	1	-1	0	0	2	3	-2	1	-2	-1	1	-1
CL 4	-3	0	1	-1	1	-1	0	2	-1	0	1	0	-1	-1
CL 5	-3	3	1	-1	3	-1	3	2	-2	1	-2	0	-1	-1
CL 6	-2	2	1	-1	2	0	2	3	-2	2	-1	0	-1	-1
CL 7	-3	0	1	-1	2	0	0	3	0	1	-3	0	-1	0
CL 8	-3	2	1	-1	1	-1	3	3	-2	0	0	1	0	-1
CL 9	-3	0	1	-1	1	-1	2	2	-1	0	-1	0	-1	0
CL 10	-3	0	1	-1	3	-1	3	3	-2	0	-1	1	0	-1
ID 11	**MX**	**MD**	**OCC**	**OJ**	**MX D**	**MD D**	**LFH**	**OB**	**MXW**	**MDW**	**ASY**	**MXL**	**MDL**	**PRO**
RMDS	-1	-2	0	0	-1	-1	3	0	-3	3	0	0	0	0
QC	-1	-3	-1	2	3	1	3	0	-1	3	0	0	0	1
CL 1	0	-1	0	2	-1	0	2	0	0	0	0	0	0	1
CL 2	0	-1	-1	2	-1	0	2	-1	-1	0	0	0	0	0
CL 3	1	-2	-1	2	-2	2	2	-1	-1	0	2	0	0	1
CL 4	0	-2	0	2	-2	0	1	-2	0	0	0	0	0	1
CL 5	-3	-3	-1	0	-2	-2	3	0	0	2	0	0	0	1
CL 6	1	-2	-1	2	-1	1	2	-1	0	0	0	0	0	1
CL 7	0	-3	0	0	0	1	3	0	0	0	0	0	0	1
CL 8	0	-1	0	2	0	0	3	1	0	0	-1	0	0	1
CL 9	0	-3	1	2	-1	1	3	-1	0	0	0	0	0	1
CL 10	-2	-3	-1	2	0	0	2	0	0	0	1	0	0	1
ID 12	**MX**	**MD**	**OCC**	**OJ**	**MX D**	**MD D**	**LFH**	**OB**	**MXW**	**MDW**	**ASY**	**MXL**	**MDL**	**PRO**
RMDS	2	2	0	0	-2	2	0	0	-3	0	2	1	1	0
QC	1	-1	0	0	0	0	1	0	-2	0	0	-1	-1	-1
CL 1	0	-1	0	0	0	0	0	0	-1	1	2	-1	-1	1
CL 2	0	0	0	0	0	0	0	0	-1	0	1	1	-1	0
CL 3	0	-1	0	0	0	1	0	-1	-2	-1	2	0	-1	1
CL 4	0	-1	0	0	-1	1	0	0	0	1	1	0	-1	0
CL 5	0	0	0	0	1	1	1	0	-1	2	2	-1	-1	0
CL 6	0	0	0	2	0	0	0	-1	-2	2	2	0	-1	0
CL 7	0	0	0	0	0	0	0	0	0	1	0	0	-1	0
CL 8	0	0	0	0	0	0	0	0	0	2	3	-1	1	0
CL 9	0	0	0	0	0	1	1	0	0	1	1	0	-1	1
CL 10	-1	-2	0	2	0	0	0	0	-1	1	0	0	1	1

Table 11 Contd

ID 13	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-2	0	-1	2	0	3	-2	-3	0	0	0	0	0	1
QC	1	-2	-1	2	2	0	0	-1	0	3	0	0	0	1
CL 1	-1	-3	-1	2	-1	0	-2	-1	0	0	0	0	0	1
CL 2	-1	-2	-1	2	0	0	-2	-2	0	0	0	0	0	1
CL 3	1	-3	-1	2	-1	1	-2	-2	0	0	-2	1	1	1
CL 4	-1	-2	-1	2	-1	0	-2	-2	0	1	0	0	0	1
CL 6	0	-2	-1	2	0	0	-2	-3	0	0	0	0	0	1
CL 7	0	-3	-1	2	0	1	-1	-3	0	0	0	0	0	0
CL 8	0	-2	-1	2	0	0	0	-2	0	0	0	0	0	1
CL 9	0	-1	-1	2	0	0	0	-2	0	0	1	0	0	1
CL 10	-2	-3	-1	2	0	0	-2	0	0	0	0	0	0	1
ID 14	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	0	-2	0	2	3	-3	0	-2	-2	3	-1	0	0	1
QC	1	-2	1	2	-3	0	1	0	0	3	0	-1	1	1
CL 1	-1	-3	-1	2	1	1	-1	-2	0	2	0	0	0	1
CL 2	0	-2	-1	2	0	0	0	0	0	2	0	0	0	1
CL 3	2	-2	-1	2	0	2	1	-2	0	0	-2	1	1	1
CL 4	0	-2	-1	2	1	0	-1	-2	-1	2	0	0	0	1
CL 5	0	0	-1	2	2	2	2	0	0	3	0	0	0	1
CL 6	0	-3	-1	2	1	1	-2	-2	0	2	1	0	0	1
CL 7	3	0	-1	2	1	2	2	-2	0	2	2	0	0	1
CL 8	2	-2	-1	2	1	0	-2	-2	-1	0	0	1	0	1
CL 9	0	-3	-1	2	0	1	0	0	-1	1	1	0	-1	1
CL 10	-2	-3	-1	2	1	1	1	0	-1	0	2	0	0	1
ID 15	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	3	0	1	2	1	1	3	-2	-3	-3	-2	1	1	1
QC	1	0	1	0	2	0	3	-1	-1	0	0	0	0	1
CL 1	1	-1	1	2	0	0	0	-1	0	0	-1	0	1	1
CL 2	2	-1	0	2	1	1	1	-1	0	0	0	0	0	1
CL 3	2	-1	0	2	1	2	2	-2	-2	-1	-2	-1	-1	1
CL 4	2	-2	0	2	0	2	1	-2	0	0	0	0	0	1
CL 5	0	0	0	0	2	3	3	0	0	0	0	0	0	1
CL 6	1	-2	-1	2	0	0	0	-2	-1	1	0	1	-1	1
CL 7	2	0	1	0	2	3	2	-2	2	1	3	0	-1	1
CL 8	0	-2	1	2	2	-1	-2	-3	0	0	0	0	0	1
CL 9	2	-2	0	2	0	2	2	-1	0	0	0	1	-1	1
CL 10	1	-2	-1	2	1	0	1	-1	0	-1	2	0	0	1

Table 11 Contd

ID 16	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	-3	0	0	2	-1	3	2	3	-3	-2	0	1	0	-1
QC	-3	-1	1	2	3	1	2	3	-3	0	0	1	1	0
CL 1	-2	-2	0	2	2	1	0	2	-2	2	2	-1	0	0
CL 2	0	1	0	2	1	0	0	2	-2	0	0	-1	0	0
CL 3	-1	-1	0	2	1	1	2	3	-1	0	0	-1	0	-1
CL 4	-1	0	0	2	1	0	0	2	-2	0	0	-1	0	0
CL 5	-1	0	0	2	1	0	2	2	-2	0	2	-1	0	0
CL 6	-2	0	1	2	2	0	1	3	-2	0	0	-1	0	-1
CL 7	0	0	0	2	1	1	0	2	0	0	2	-1	0	0
CL 8	0	0	0	0	0	0	2	2	-1	0	0	0	0	0
CL 9	-3	-3	0	1	1	0	2	3	-1	0	1	-1	0	-1
CL 10	-2	-2	-1	2	1	0	0	2	-2	0	0	-1	0	-1
ID 17	**MX**	**MD**	**OCC**	**OJ**	**MX D**	**MD D**	**LFH**	**OB**	**MXW**	**MDW**	**ASY**	**MXL**	**MDL**	**PRO**
RMDS	1	0	0	0	1	0	0	0	1	2	-2	-1	-1	0
QC	0	0	0	0	1	1	0	0	-1	2	-2	-1	-1	1
CL 1	0	0	0	0	0	0	0	0	0	0	-2	1	1	1
CL 2	0	-1	0	0	0	0	0	0	0	0	-3	-1	1	1
CL 3	0	-1	-1	0	0	0	1	-1	-1	-1	-3	1	1	1
CL 4	0	-2	-1	2	-1	0	0	0	0	0	-2	1	1	1
CL 5	0	-1	0	0	1	0	1	0	-2	-2	-2	1	1	0
CL 6	0	0	0	2	0	0	0	-1	-1	1	-2	1	-1	0
CL 7	0	0	0	0	1	0	0	0	0	2	-3	1	-1	0
CL 8	0	0	0	0	0	0	0	0	0	0	-2	0	-1	1
CL 9	0	-1	-1	2	1	2	0	0	0	0	-2	1	1	1
CL 10	-1	-2	-1	2	1	0	0	0	0	0	-2	1	1	1
ID 18	**MX**	**MD**	**OCC**	**OJ**	**MX D**	**MD D**	**LFH**	**OB**	**MXW**	**MDW**	**ASY**	**MXL**	**MDL**	**PRO**
RMDS	1	0	0	2	3	2	-3	0	0	2	0	-1	-1	1
QC	-1	-2	-1	2	3	1	-2	0	-1	0	0	0	0	1
CL 1	-3	-3	-1	2	3	3	-3	-2	0	0	0	0	0	1
CL 2	1	-2	-1	2	2	2	-2	-2	0	0	0	0	0	1
CL 3	1	-2	-1	2	2	2	-2	-1	0	0	-1	-1	-1	1
CL 4	-1	-2	-1	2	2	2	-1	-2	0	0	0	0	0	1
CL 5	-1	-1	-1	2	3	2	-2	-2	0	0	0	0	0	1
CL 6	0	-1	-1	2	2	2	-2	-1	0	0	0	0	0	1
CL 7	0	-1	0	2	2	3	-2	-2	0	0	0	-1	0	1
CL 8	2	0	-1	2	2	0	-1	-1	0	0	0	0	0	0
CL 9	0	-1	-1	2	2	2	-3	0	0	0	0	-1	0	1
CL 10	-3	-3	-1	2	3	2	-3	0	0	0	0	-1	0	1

Table 11

ID 19	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	3	0	-1	2	1	0	0	1	-2	0	1	0	0	1
QC	0	-2	-1	2	1	0	0	1	2	0	0	0	0	1
CL 1	-1	-2	-1	2	1	0	1	0	0	0	0	0	-1	1
CL 2	1	0	-1	2	1	0	0	1	-1	0	1	0	-1	1
CL 3	0	-2	-1	2	0	0	1	0	-1	-1	0	0	-1	1
CL 4	0	-2	-1	2	0	0	-1	0	-1	2	0	0	-1	1
CL 5	-3	0	-1	2	2	-1	0	2	-2	0	0	0	0	1
CL 6	0	-3	-1	2	1	0	-1	0	0	0	0	0	-1	1
CL 7	2	0	-1	2	1	0	1	0	0	0	2	0	-1	1
CL 8	3	-1	-1	2	1	0	0	2	0	0	-2	0	-1	1
CL 9	0	-2	-1	2	0	0	0	1	0	0	1	0	-1	1
CL 10	-2	-3	-1	2	1	0	0	1	-2	0	1	0	-1	1
ID 20	MX	MD	OCC	OJ	MX D	MD D	LFH	OB	MXW	MDW	ASY	MXL	MDL	PRO
RMDS	2	-1	0	2	3	2	3	3	-2	2	0	0	-1	1
QC	1	-1	1	2	3	2	3	3	-1	3	0	0	0	1
CL 1	0	0	0	2	2	0	1	3	-1	1	0	0	0	1
CL 2	0	-2	0	2	2	1	2	3	-1	0	0	0	0	1
CL 3	2	2	0	2	2	1	3	3	0	0	-1	0	-1	1
CL 4	0	-2	0	2	3	2	2	3	-1	-1	0	0	0	1
CL 5	-1	-2	-1	2	3	2	3	3	-2	-2	0	0	0	1
CL 6	0	-3	-1	2	2	2	2	3	-1	0	0	0	0	1
CL 7	0	-3	0	2	3	2	3	3	2	3	0	0	0	1
CL 8	0	0	-1	2	1	0	3	3	0	0	0	0	0	1
CL 9	2	2	-1	2	3	3	3	3	-1	1	0	0	0	1
CL 10	-2	-2	-1	2	3	1	2	3	-3	0	-2	0	0	1

APPENDIX 4

Descriptive statistics of clinician data

Table 12

ID 1	Lefort														
MX	*A-P*	*MD*	*A-P*	*OCCL*		*OJ*		*MX D*	*A-P*	*MD D*	*A-P*	*LFH*		*OB*	
Mean	-1.8	Mean	0.4	Mean	0.9	Mean	0.9	Mean	1.3	Mean	-0 1	Mean	0.0	Mean	0.8
SE	0.3	SE	0 2	SE	0.1	SE	0.1	SE	0.3	SE	0.1	SE	0.3	SE	0.1
Median	-2.0	Median	0.0	Median	1.0	Median	1 0	Median	1.0	Median	0.0	Median	0 0	Median	1.0
Mode	-2.0	Mode	0.0	Mode	1.0	Mode	1.0	Mode	1.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.9	SD	0.7	SD	0.3	SD	0 3	SD	0.9	SD	0.3	SD	1 1	SD	0.4
SV	0.8	SV	0.5	SV	0.1	SV	0 1	SV	0.9	SV	0.1	SV	1 1	SV	0.2
Range	3 0	Range	2.0	Range	1.0	Range	1.0	Range	3.0	Range	1.0	Range	4 0	Range	1.0
Minimum	-3.0	Minimum	0.0	Minimum	0.0	Minimum	0.0	Minimum	0.0	Minimum	-1.0	Minimum	-2.0	Minimum	0.0
Maximum	0.0	Maximum	2.0	Maximum	1.0	Maximum	1.0	Maximum	3.0	Maximum	0.0	Maximum	2.0	Maximum	1.0
Sum	-18.0	Sum	4.0	Sum	9.0	Sum	9.0	Sum	13.0	Sum	-1.0	Sum	0.0	Sum	8.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10 0	Count	10.0	Count	10.0	Count	10.0
ID 2	**Lefort**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-1.7	Mean	0.9	Mean	0.1	Mean	0.7	Mean	1.4	Mean	0.2	Mean	1 1	Mean	2.5
SE	0.3	SE	0.3	SE	0.2	SE	0.2	SE	0.5	SE	0.1	SE	0 4	SE	0.2
Median	-1.5	Median	1.0	Median	0.0	Median	1.0	Median	2.0	Median	0.0	Median	0.5	Median	2.5
Mode	-1.0	Mode	1.0	Mode	0.0	Mode	1 0	Mode	2.0	Mode	0.0	Mode	0 0	Mode	3.0
SD	0.8	SD	0.9	SD	0.6	SD	0 5	SD	1.6	SD	0.4	SD	1.3	SD	0.5
SV	0.7	SV	0.8	SV	0.3	SV	0.2	SV	2.7	SV	0.2	SV	1.7	SV	0.3
Range	2 0	Range	3.0	Range	2.0	Range	1 0	Range	6.0	Range	1.0	Range	3.0	Range	1.0
Minimum	-3.0	Minimum	0.0	Minimum	-1 0	Minimum	0 0	Minimum	-3.0	Minimum	0.0	Minimum	0.0	Minimum	2.0
Maximum	-1.0	Maximum	3.0	Maximum	1.0	Maximum	1.0	Maximum	3.0	Maximum	1.0	Maximum	3.0	Maximum	3.0
Sum	-17.0	Sum	9.0	Sum	1.0	Sum	7.0	Sum	14.0	Sum	2.0	Sum	11 0	Sum	25.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

Table 12 contd

ID 1	Lefort										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.1	Mean	0.2	Mean	0.3	Mean	-0.1	Mean	0.6	Mean	-1.0
SE	0.2	SE	0.1	SE	0.4	SE	0.2	SE	0.2	SE	0.0
Median	0.0	Median	0.0	Median	0.5	Median	0.0	Median	1.0	Median	-1.0
Mode	0.0	Mode	0.0	Mode	1 0	Mode	0.0	Mode	1.0	Mode	-1.0
SD	0.7	SD	0 4	SD	1.2	SD	0.6	SD	0.5	SD	0.0
SV	0 5	SV	0 2	SV	1.3	SV	0.3	SV	0.3	SV	0 0
Range	2.0	Range	1.0	Range	4.0	Range	2.0	Range	1.0	Range	0 0
Minimum	-1 0	Minimum	0.0	Minimum	-2.0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0
Maximum	1.0	Maximum	1.0	Maximum	2.0	Maximum	1.0	Maximum	1.0	Maximum	-1.0
Sum	-1.0	Sum	2.0	Sum	3.0	Sum	-1.0	Sum	6.0	Sum	-10.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 2	**Lefort**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.1	Mean	0.9	Mean	0.0	Mean	0.0	Mean	0 0	Mean	-0.1
SE	0.2	SE	0.3	SE	0.0	SE	0.1	SE	0.0	SE	0.2
Median	0.0	Median	0.5	Median	0.0	Median	0.0	Median	0.0	Median	0.0
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0
SD	0.6	SD	1.1	SD	0.0	SD	0.5	SD	0.0	SD	0.6
SV	0.3	SV	1.2	SV	0.0	SV	0 2	SV	0.0	SV	0.3
Range	2 0	Range	3.0	Range	0.0	Range	2.0	Range	0.0	Range	2.0
Minimum	-1.0	Minimum	0.0	Minimum	0 0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0
Maximum	1.0	Maximum	3.0	Maximum	0.0	Maximum	1 0	Maximum	0.0	Maximum	1.0
Sum	-1.0	Sum	9.0	Sum	0.0	Sum	0.0	Sum	0.0	Sum	-1.0
Count	10 0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 3	Lefort	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-2.7	Mean	0.9	Mean	1.0	Mean	-1.0	Mean	0.5	Mean	1.8	Mean	-0.7	Mean	0 4
SE	0.2	SE	0.3	SE	0.0	SE	0.0	SE	0.3	SE	0.2	SE	0.2	SE	0.3
Median	-3.0	Median	0.5	Median	1.0	Median	-1.0	Median	0.0	Median	2.0	Median	-1.0	Median	1.0
Mode	-3.0	Mode	0.0	Mode	1.0	Mode	-1.0	Mode	0.0	Mode	1.0	Mode	-1.0	Mode	1 0
SD	0.5	SD	1.1	SD	0.0	SD	0.0	SD	0.8	SD	0.8	SD	0.7	SD	1.0
SV	0.2	SV	1.2	SV	0.0	SV	0 0	SV	0 7	SV	0.6	SV	0.5	SV	0.9
Range	1.0	Range	3.0	Range	0.0	Range	0.0	Range	2 0	Range	2.0	Range	2.0	Range	3 0
Minimum	-3.0	Minimum	0.0	Minimum	1.0	Minimum	-1.0	Minimum	0.0	Minimum	1.0	Minimum	-2.0	Minimum	-2.0
Maximum	-2.0	Maximum	3.0	Maximum	1.0	Maximum	-1 0	Maximum	2.0	Maximum	3.0	Maximum	0.0	Maximum	1.0
Sum	-27.0	Sum	9.0	Sum	10.0	Sum	-10.0	Sum	5.0	Sum	18.0	Sum	-7.0	Sum	4.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 4	**Lefort**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	0.7	Mean	-0.8	Mean	-1.0	Mean	2.0	Mean	-0.4	Mean	0.6	Mean	0.7	Mean	1.3
SE	0.3	SE	0.3	SE	0.0	SE	0.0	SE	0.3	SE	0.2	SE	0.3	SE	0.2
Median	0.5	Median	-0.5	Median	-1.0	Median	2.0	Median	0.0	Median	0.5	Median	0.0	Median	1.0
Mode	0.0	Mode	0.0	Mode	-1.0	Mode	2.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.8	SD	0.9	SD	0.0	SD	0.0	SD	0.8	SD	0.7	SD	1.1	SD	0 5
SV	0.7	SV	0.8	SV	0.0	SV	0.0	SV	0.7	SV	0 5	SV	1 1	SV	0.2
Range	2 0	Range	2.0	Range	0.0	Range	0.0	Range	3.0	Range	2.0	Range	3 0	Range	1.0
Minimum	0 0	Minimum	-2.0	Minimum	-1.0	Minimum	2 0	Minimum	-2.0	Minimum	0.0	Minimum	0.0	Minimum	1.0
Maximum	2 0	Maximum	0.0	Maximum	-1.0	Maximum	2.0	Maximum	1.0	Maximum	2 0	Maximum	3.0	Maximum	2.0
Sum	7.0	Sum	-8.0	Sum	-10.0	Sum	20.0	Sum	-4.0	Sum	6.0	Sum	7.0	Sum	13 0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 3	Lefort		Table 12 contd								
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1 7	Mean	0.3	Mean	-0.2	Mean	0.5	Mean	-0 7	Mean	-1.0
SE	0.3	SE	0.4	SE	0 1	SE	0 2	SE	0.2	SE	0.0
Median	-2.0	Median	0.0	Median	0 0	Median	1.0	Median	-1.0	Median	-1.0
Mode	-2 0	Mode	0 0	Mode	0.0	Mode	1.0	Mode	-1.0	Mode	-1.0
SD	0 8	SD	1.3	SD	0.4	SD	0.7	SD	0.7	SD	0.0
SV	0 7	SV	1.8	SV	0.2	SV	0.5	SV	0.5	SV	0.0
Range	3.0	Range	5 0	Range	1.0	Range	2.0	Range	2.0	Range	0.0
Minimum	-3 0	Minimum	-2.0	Minimum	-1.0	Minimum	-1.0	Minimum	-1.0	Minimum	-1.0
Maximum	0.0	Maximum	3.0	Maximum	0.0	Maximum	1.0	Maximum	1 0	Maximum	-1.0
Sum	-17.0	Sum	3 0	Sum	-2.0	Sum	5.0	Sum	-7.0	Sum	-10.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 4	**Lefort**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.7	Mean	0.5	Mean	0.2	Mean	0.0	Mean	0.9	Mean	0.4
SE	0.4	SE	0.2	SE	0.4	SE	0.0	SE	0 1	SE	0.2
Median	0.0	Median	0.0	Median	0.5	Median	0 0	Median	1.0	Median	0.0
Mode	0.0	Mode	0.0	Mode	-1 0	Mode	0.0	Mode	1.0	Mode	0.0
SD	1.2	SD	0.7	SD	1.1	SD	0.0	SD	0 3	SD	0.5
SV	1.3	SV	0.5	SV	1.3	SV	0.0	SV	0.1	SV	0.3
Range	3.0	Range	2.0	Range	3.0	Range	0.0	Range	1.0	Range	1.0
Minimum	-2.0	Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	0 0	Minimum	0.0
Maximum	1.0	Maximum	2.0	Maximum	2.0	Maximum	0.0	Maximum	1.0	Maximum	1.0
Sum	-7.0	Sum	5.0	Sum	2 0	Sum	0.0	Sum	9.0	Sum	4.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 5	BSSO	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	0.1	Mean	-1.3	Mean	-1 0	Mean	2.0	Mean	0.0	Mean	-0.1	Mean	0 0	Mean	0.8
SE	0.2	SE	0.3	SE	0.0	SE	0.0	SE	0.3	SE	0 1	SE	0.1	SE	0.2
Median	0.0	Median	-2.0	Median	-1.0	Median	2.0	Median	0 0	Median	0.0	Median	0.0	Median	1.0
Mode	0.0	Mode	-2.0	Mode	-1.0	Mode	2.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.6	SD	0.9	SD	0.0	SD	0.0	SD	0.8	SD	0.3	SD	0.5	SD	0.6
SV	0.3	SV	0.9	SV	0.0	SV	0.0	SV	0.7	SV	0.1	SV	0.2	SV	0.4
Range	2.0	Range	2.0	Range	0.0	Range	0 0	Range	3.0	Range	1.0	Range	2.0	Range	2 0
Minimum	-1.0	Minimum	-2.0	Minimum	-1.0	Minimum	2.0	Minimum	-1.0	Minimum	-1 0	Minimum	-1.0	Minimum	0 0
Maximum	1.0	Maximum	0.0	Maximum	-1.0	Maximum	2.0	Maximum	2.0	Maximum	0.0	Maximum	1.0	Maximum	2.0
Sum	1.0	Sum	-13.0	Sum	-10.0	Sum	20.0	Sum	0.0	Sum	-1.0	Sum	0.0	Sum	8.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 6	**Lef,BS,GP**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-2.2	Mean	1 8	Mean	1.0	Mean	-1.0	Mean	2.2	Mean	1.9	Mean	-0.2	Mean	-0.3
SE	0.3	SE	0.3	SE	0.0	SE	0.0	SE	0.2	SE	0.3	SE	0.3	SE	0.2
Median	-2.5	Median	2.0	Median	1 0	Median	-1.0	Median	2.0	Median	2 0	Median	0.0	Median	0.0
Mode	-3.0	Mode	2.0	Mode	1.0	Mode	-1.0	Mode	2.0	Mode	2 0	Mode	0.0	Mode	0 0
SD	1.0	SD	0.9	SD	0.0	SD	0.0	SD	0.6	SD	1.0	SD	0.9	SD	0.7
SV	1 1	SV	0.8	SV	0 0	SV	0.0	SV	0.4	SV	1.0	SV	0.8	SV	0.5
Range	3.0	Range	3 0	Range	0.0	Range	0.0	Range	2.0	Range	3.0	Range	3.0	Range	2.0
Minimum	-3.0	Minimum	0.0	Minimum	1.0	Minimum	-1.0	Minimum	1.0	Minimum	0.0	Minimum	-2.0	Minimum	-2.0
Maximum	0.0	Maximum	3.0	Maximum	1.0	Maximum	-1.0	Maximum	3.0	Maximum	3.0	Maximum	1.0	Maximum	0.0
Sum	-22.0	Sum	18.0	Sum	10.0	Sum	-10.0	Sum	22.0	Sum	19.0	Sum	-2.0	Sum	-3.0
Count	10.0	Count	10 0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 5	BSSO		Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	0.0	Mean	-0.1	Mean	0.0	Mean	-0.1	Mean	0.6	Mean	0 4
SE	0.0	SE	0 1	SE	0.0	SE	0 1	SE	0.2	SE	0.2
Median	0.0	Median	0 0	Median	0.0	Median	0.0	Median	1.0	Median	0.5
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0 0	Mode	1.0	Mode	1.0
SD	0.0	SD	0.3	SD	0.0	SD	0.3	SD	0 5	SD	0.7
SV	0.0	SV	0.1	SV	0.0	SV	0.1	SV	0.3	SV	0.5
Range	0.0	Range	1.0	Range	0.0	Range	1.0	Range	1.0	Range	2.0
Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0
Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	1.0	Maximum	1.0
Sum	0.0	Sum	-1.0	Sum	0.0	Sum	-1.0	Sum	6.0	Sum	4.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
	Lef,BS,GP										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1 1	Mean	1.0	Mean	-0 3	Mean	-0.7	Mean	0.3	Mean	-0.7
SE	0.3	SE	0.4	SE	0.4	SE	0 2	SE	0 2	SE	0.2
Median	-1.0	Median	1.0	Median	0.0	Median	-1.0	Median	0.0	Median	-1.0
Mode	-2.0	Mode	1.0	Mode	-1.0	Mode	-1.0	Mode	0.0	Mode	-1 0
SD	0.9	SD	1.3	SD	1.3	SD	0.5	SD	0.5	SD	0 7
SV	0.8	SV	1.8	SV	1.6	SV	0.2	SV	0.2	SV	0.5
Range	2 0	Range	4 0	Range	4.0	Range	1 0	Range	1.0	Range	2.0
Minimum	-2.0	Minimum	-1 0	Minimum	-3.0	Minimum	-1.0	Minimum	0 0	Minimum	-1 0
Maximum	0.0	Maximum	3.0	Maximum	1.0	Maximum	0.0	Maximum	1.0	Maximum	1.0
Sum	-11.0	Sum	10.0	Sum	-3.0	Sum	-7.0	Sum	3.0	Sum	-7.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 7	Lefort	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-2.9	Mean	0 3	Mean	0.5	Mean	-1.0	Mean	0.5	Mean	0.7	Mean	0.8	Mean	1.5
SE	0.1	SE	0.4	SE	0.2	SE	0.0	SE	0.4	SE	0.2	SE	0.5	SE	0.2
Median	-3.0	Median	0.5	Median	1 0	Median	-1.0	Median	0.5	Median	1 0	Median	1.0	Median	1.5
Mode	-3.0	Mode	1.0	Mode	1.0	Mode	-1.0	Mode	0.0	Mode	1.0	Mode	-1.0	Mode	1 0
SD	0.3	SD	1.3	SD	0.7	SD	0.0	SD	1.2	SD	0.7	SD	1.5	SD	0.5
SV	0.1	SV	1 8	SV	0.5	SV	0.0	SV	1 4	SV	0.5	SV	2.2	SV	0.3
Range	1.0	Range	4.0	Range	2.0	Range	0.0	Range	4.0	Range	2.0	Range	4.0	Range	1.0
Minimum	-3.0	Minimum	-2.0	Minimum	-1.0	Minimum	-1 0	Minimum	-2.0	Minimum	0.0	Minimum	-1.0	Minimum	1.0
Maximum	-2.0	Maximum	2.0	Maximum	1.0	Maximum	-1.0	Maximum	2.0	Maximum	2.0	Maximum	3.0	Maximum	2.0
Sum	-29.0	Sum	3.0	Sum	5.0	Sum	-10.0	Sum	5.0	Sum	7.0	Sum	8.0	Sum	15.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 8	**Lef,BS,GP**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-2.2	Mean	2.1	Mean	1.0	Mean	-1.0	Mean	0.1	Mean	0.4	Mean	2.5	Mean	0.5
SE	0.3	SE	0.2	SE	0.0	SE	0.0	SE	0.1	SE	0.4	SE	0.2	SE	0.2
Median	-2.5	Median	2.0	Median	1.0	Median	-1.0	Median	0.0	Median	0.5	Median	3.0	Median	0.5
Mode	-3.0	Mode	2.0	Mode	1.0	Mode	-1.0	Mode	0.0	Mode	1.0	Mode	3.0	Mode	0.0
SD	1.0	SD	0.7	SD	0.0	SD	0 0	SD	0.3	SD	1 3	SD	0.7	SD	0.5
SV	1.1	SV	0.5	SV	0.0	SV	0.0	SV	0.1	SV	1.6	SV	0.5	SV	0.3
Range	3.0	Range	2.0	Range	0.0	Range	0.0	Range	1.0	Range	4.0	Range	2.0	Range	1.0
Minimum	-3.0	Minimum	1.0	Minimum	1.0	Minimum	-1.0	Minimum	0 0	Minimum	-1.0	Minimum	1.0	Minimum	0.0
Maximum	0.0	Maximum	3.0	Maximum	1.0	Maximum	-1.0	Maximum	1 0	Maximum	3.0	Maximum	3 0	Maximum	1.0
Sum	-22.0	Sum	21.0	Sum	10.0	Sum	-10.0	Sum	1.0	Sum	4 0	Sum	25.0	Sum	5.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 7	Lefort		Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1.7	Mean	-0.1	Mean	-0.2	Mean	0.6	Mean	0.0	Mean	-0.9
SE	0.3	SE	0.1	SE	0 2	SE	0.2	SE	0.1	SE	0.1
Median	-2.0	Median	0.0	Median	0.0	Median	1.0	Median	0.0	Median	-1.0
Mode	-2.0	Mode	0.0	Mode	0.0	Mode	1.0	Mode	0.0	Mode	-1.0
SD	0.9	SD	0.3	SD	0.8	SD	0.5	SD	0.5	SD	0.3
SV	0.9	SV	0.1	SV	0.6	SV	0.3	SV	0.2	SV	0.1
Range	3.0	Range	1.0	Range	3.0	Range	1.0	Range	2.0	Range	1.0
Minimum	-3.0	Minimum	-1.0	Minimum	-2.0	Minimum	0.0	Minimum	-1.0	Minimum	-1.0
Maximum	0.0	Maximum	0.0	Maximum	1.0	Maximum	1.0	Maximum	1.0	Maximum	0.0
Sum	-17.0	Sum	-1.0	Sum	-2.0	Sum	6.0	Sum	0.0	Sum	-9.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10 0
ID 8	**Lef,BS,GP**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1.7	Mean	-0.4	Mean	-0.1	Mean	-0.1	Mean	0.0	Mean	-0.9
SE	0.3	SE	0.3	SE	0 1	SE	0.1	SE	0.1	SE	0.1
Median	-2.0	Median	0.0	Median	0 0	Median	0.0	Median	0.0	Median	-1.0
Mode	-2.0	Mode	0 0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	-1.0
SD	0.8	SD	1.0	SD	0.3	SD	0.3	SD	0.5	SD	0.3
SV	0.7	SV	0.9	SV	0.1	SV	0.1	SV	0.2	SV	0.1
Range	3.0	Range	3.0	Range	1.0	Range	1.0	Range	2 0	Range	1.0
Minimum	-3 0	Minimum	-2.0	Minimum	-1.0	Minimum	-1.0	Minimum	-1.0	Minimum	-1.0
Maximum	0.0	Maximum	1.0	Maximum	0.0	Maximum	0.0	Maximum	1.0	Maximum	0.0
Sum	-17.0	Sum	-4.0	Sum	-1.0	Sum	-1.0	Sum	0.0	Sum	-9.0
Count	10.0	Count	10 0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 9	Lef,BS,GP			Table 12 contd											
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-1.8	Mean	1.5	Mean	1.0	Mean	-1 0	Mean	1.9	Mean	1.9	Mean	1.1	Mean	1.9
SE	0.3	SE	0 3	SE	0.0	SE	0.0	SE	0.2	SE	0.2	SE	0.6	SE	0.1
Median	-2.0	Median	1.5	Median	1.0	Median	-1.0	Median	2.0	Median	2.0	Median	2.0	Median	2.0
Mode	-2 0	Mode	1 0	Mode	1.0	Mode	-1 0	Mode	2.0	Mode	2.0	Mode	3.0	Mode	2 0
SD	0.9	SD	1.1	SD	0.0	SD	0.0	SD	0.6	SD	0.7	SD	1.9	SD	0.3
SV	0.8	SV	1 2	SV	0.0	SV	0 0	SV	0.3	SV	0.5	SV	3.7	SV	0.1
Range	3.0	Range	3.0	Range	0.0	Range	0.0	Range	2.0	Range	2.0	Range	5.0	Range	1.0
Minimum	-3 0	Minimum	0.0	Minimum	1.0	Minimum	-1.0	Minimum	1.0	Minimum	1 0	Minimum	-2.0	Minimum	1.0
Maximum	0.0	Maximum	3.0	Maximum	1.0	Maximum	-1.0	Maximum	3.0	Maximum	3.0	Maximum	3.0	Maximum	2.0
Sum	-18.0	Sum	15.0	Sum	10.0	Sum	-10.0	Sum	19.0	Sum	19.0	Sum	11.0	Sum	19.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 10	**Lef, GP**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-2.6	Mean	0.9	Mean	1.0	Mean	-1.0	Mean	1.5	Mean	-0.7	Mean	1.8	Mean	2.6
SE	0.2	SE	0 3	SE	0.0	SE	0.0	SE	0.3	SE	0.2	SE	0.4	SE	0.2
Median	-3.0	Median	0.5	Median	1.0	Median	-1.0	Median	1.0	Median	-1.0	Median	2.0	Median	3.0
Mode	-3.0	Mode	0.0	Mode	1.0	Mode	-1.0	Mode	1.0	Mode	-1.0	Mode	2.0	Mode	3.0
SD	0.5	SD	1.1	SD	0.0	SD	0.0	SD	1.0	SD	0.5	SD	1.1	SD	0.5
SV	0.3	SV	1.2	SV	0.0	SV	0.0	SV	0.9	SV	0 2	SV	1.3	SV	0.3
Range	1.0	Range	3.0	Range	0.0	Range	0.0	Range	3.0	Range	1.0	Range	3.0	Range	1.0
Minimum	-3 0	Minimum	0.0	Minimum	1.0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	2.0
Maximum	-2.0	Maximum	3.0	Maximum	1.0	Maximum	-1.0	Maximum	3.0	Maximum	0.0	Maximum	3.0	Maximum	3.0
Sum	-26.0	Sum	9.0	Sum	10.0	Sum	-10 0	Sum	15.0	Sum	-7.0	Sum	18.0	Sum	26.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 9	Lef,BS,GP			Table 12 contd							
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1.4	Mean	0.3	Mean	0.2	Mean	0.1	Mean	0.2	Mean	-0.8
SE	0.3	SE	0.3	SE	0.1	SE	0 1	SE	0.1	SE	0.1
Median	-2 0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	-1.0
Mode	-2.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0 0	Mode	-1.0
SD	0.8	SD	0.8	SD	0.4	SD	0.3	SD	0.4	SD	0.4
SV	0.7	SV	0.7	SV	0.2	SV	0.1	SV	0.2	SV	0 2
Range	2.0	Range	3.0	Range	1.0	Range	1.0	Range	1.0	Range	1.0
Minimum	-2.0	Minimum	-1.0	Minimum	0.0	Minimum	0.0	Minimum	0.0	Minimum	-1.0
Maximum	0.0	Maximum	2.0	Maximum	1.0	Maximum	1.0	Maximum	1.0	Maximum	0.0
Sum	-14.0	Sum	3.0	Sum	2.0	Sum	1.0	Sum	2.0	Sum	-8.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 10	**Lef, GP**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1.5	Mean	0.6	Mean	-0.9	Mean	0.1	Mean	-0.5	Mean	-0.8
SE	0.2	SE	0.2	SE	0.4	SE	0.2	SE	0.2	SE	0.1
Median	-2.0	Median	0.5	Median	-1.0	Median	0.0	Median	-1.0	Median	-1.0
Mode	-2.0	Mode	0.0	Mode	-1.0	Mode	0.0	Mode	-1.0	Mode	-1.0
SD	0.7	SD	0.7	SD	1.3	SD	0.6	SD	0.7	SD	0.4
SV	0.5	SV	0.5	SV	1 7	SV	0.3	SV	0 5	SV	0.2
Range	2.0	Range	2.0	Range	4.0	Range	2.0	Range	2.0	Range	1.0
Minimum	-2.0	Minimum	0.0	Minimum	-3.0	Minimum	-1.0	Minimum	-1.0	Minimum	-1.0
Maximum	0.0	Maximum	2.0	Maximum	1.0	Maximum	1.0	Maximum	1.0	Maximum	0.0
Sum	-15.0	Sum	6.0	Sum	-9.0	Sum	1.0	Sum	-5.0	Sum	-8.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 11	Lefort	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-0.3	Mean	-2 1	Mean	-0.4	Mean	1.6	Mean	-1.0	Mean	0.3	Mean	2.3	Mean	-0.5
SE	0 4	SE	0.3	SE	0.2	SE	0.3	SE	0.3	SE	0.3	SE	0.2	SE	0.3
Median	0.0	Median	-2.0	Median	-0.5	Median	2.0	Median	-1.0	Median	0.0	Median	2.0	Median	-0.5
Mode	0.0	Mode	-3.0	Mode	-1.0	Mode	2 0	Mode	-1.0	Mode	0.0	Mode	2.0	Mode	0.0
SD	1.3	SD	0.9	SD	0.7	SD	0.8	SD	0.8	SD	1.1	SD	0.7	SD	0.8
SV	1.6	SV	0.8	SV	0.5	SV	0.7	SV	0.7	SV	1.1	SV	0.5	SV	0.7
Range	4.0	Range	2 0	Range	2.0	Range	2.0	Range	2.0	Range	4.0	Range	2.0	Range	3.0
Minimum	-3.0	Minimum	-3 0	Minimum	-1.0	Minimum	0.0	Minimum	-2.0	Minimum	-2.0	Minimum	1.0	Minimum	-2.0
Maximum	1.0	Maximum	-1.0	Maximum	1.0	Maximum	2.0	Maximum	0.0	Maximum	2.0	Maximum	3.0	Maximum	1.0
Sum	-3.0	Sum	-21 0	Sum	-4.0	Sum	16.0	Sum	-10.0	Sum	3.0	Sum	23.0	Sum	-5.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 12	**Lef,GP**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-0.1	Mean	-0.5	Mean	0.0	Mean	0 4	Mean	0.0	Mean	0.4	Mean	0.2	Mean	-0.2
SE	0 1	SE	0.2	SE	0.0	SE	0.3	SE	0.1	SE	0.2	SE	0.1	SE	0.1
Median	0 0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0
Mode	0 0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0
SD	0.3	SD	0.7	SD	0.0	SD	0.8	SD	0.5	SD	0.5	SD	0.4	SD	0.4
SV	0.1	SV	0.5	SV	0.0	SV	0.7	SV	0.2	SV	0.3	SV	0.2	SV	0.2
Range	1.0	Range	2.0	Range	0.0	Range	2.0	Range	2.0	Range	1.0	Range	1.0	Range	1.0
Minimum	-1.0	Minimum	-2.0	Minimum	0.0	Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	0.0	Minimum	-1.0
Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	2.0	Maximum	1.0	Maximum	1.0	Maximum	1.0	Maximum	0.0
Sum	-1.0	Sum	-5.0	Sum	0.0	Sum	4.0	Sum	0.0	Sum	4.0	Sum	2.0	Sum	-2.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 11	Lefort	Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.2	Mean	0.2	Mean	0.2	Mean	0.0	Mean	0.0	Mean	0.9
SE	0.1	SE	0.2	SE	0.2	SE	0.0	SE	0.0	SE	0.1
Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	1.0
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.4	SD	0.6	SD	0 8	SD	0 0	SD	0.0	SD	0.3
SV	0.2	SV	0.4	SV	0.6	SV	0.0	SV	0.0	SV	0.1
Range	1.0	Range	2.0	Range	3.0	Range	0.0	Range	0.0	Range	1.0
Minimum	-1.0	Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	0.0	Minimum	0 0
Maximum	0.0	Maximum	2.0	Maximum	2.0	Maximum	0.0	Maximum	0.0	Maximum	1.0
Sum	-2.0	Sum	2.0	Sum	2 0	Sum	0.0	Sum	0.0	Sum	9.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 12	**Lef,GP**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.8	Mean	1.0	Mean	1.4	Mean	-0.2	Mean	-0.6	Mean	0.4
SE	0.2	SE	0.3	SE	0.3	SE	0.2	SE	0.3	SE	0.2
Median	-1.0	Median	1.0	Median	1.5	Median	0.0	Median	-1.0	Median	0.0
Mode	-1.0	Mode	1.0	Mode	2.0	Mode	0.0	Mode	-1.0	Mode	0.0
SD	0.8	SD	0.9	SD	1.0	SD	0.6	SD	0.8	SD	0.5
SV	0.6	SV	0.9	SV	0 9	SV	0.4	SV	0.7	SV	0.3
Range	2.0	Range	3.0	Range	3.0	Range	2.0	Range	2.0	Range	1.0
Minimum	-2.0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0	Minimum	-1.0	Minimum	0.0
Maximum	0.0	Maximum	2.0	Maximum	3.0	Maximum	1.0	Maximum	1.0	Maximum	1.0
Sum	-8.0	Sum	10.0	Sum	14.0	Sum	-2 0	Sum	-6.0	Sum	4.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 13	BSSO	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-0.4	Mean	-2.3	Mean	-1 0	Mean	2.0	Mean	-0.3	Mean	0.2	Mean	-1.4	Mean	-1.9
SE	0.3	SE	0.2	SE	0.0	SE	0.0	SE	0.2	SE	0.1	SE	0.3	SE	0.3
Median	0.0	Median	-2.0	Median	-1.0	Median	2.0	Median	0.0	Median	0.0	Median	-2.0	Median	-2.0
Mode	0.0	Mode	-3.0	Mode	-1.0	Mode	2.0	Mode	0.0	Mode	0.0	Mode	-2 0	Mode	-2.0
SD	0.9	SD	0.7	SD	0.0	SD	0.0	SD	0.5	SD	0.4	SD	0.9	SD	0 9
SV	0.8	SV	0 5	SV	0.0	SV	0.0	SV	0.3	SV	0.2	SV	0.8	SV	0.9
Range	3.0	Range	2 0	Range	0.0	Range	0.0	Range	1.0	Range	1.0	Range	2.0	Range	3.0
Minimum	-2.0	Minimum	-3.0	Minimum	-1.0	Minimum	2 0	Minimum	-1.0	Minimum	0.0	Minimum	-2.0	Minimum	-3.0
Maximum	1.0	Maximum	-1.0	Maximum	-1.0	Maximum	2.0	Maximum	0.0	Maximum	1.0	Maximum	0 0	Maximum	0.0
Sum	-4.0	Sum	-21.0	Sum	-9.0	Sum	18.0	Sum	-3.0	Sum	2.0	Sum	-13.0	Sum	-17.0
Count	9.0	Count	9.0	Count	9.0	Count	9.0	Count	9.0	Count	9.0	Count	9.0	Count	9.0
ID 14	**Lef,BS**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	0.4	Mean	-2.0	Mean	-1.0	Mean	2.0	Mean	0.8	Mean	1.0	Mean	0.0	Mean	-1.2
SE	0.5	SE	0.4	SE	0.0	SE	0.0	SE	0.2	SE	0.3	SE	0.5	SE	0.3
Median	0.0	Median	-2.0	Median	-1.0	Median	2.0	Median	1.0	Median	1.0	Median	0.0	Median	-2.0
Mode	0.0	Mode	-3.0	Mode	-1.0	Mode	2.0	Mode	1.0	Mode	1.0	Mode	-1.0	Mode	-2.0
SD	1.5	SD	1.2	SD	0.0	SD	0.0	SD	0 6	SD	0.8	SD	1.5	SD	1.0
SV	2.3	SV	1.3	SV	0.0	SV	0.0	SV	0.4	SV	0.7	SV	2.2	SV	1.1
Range	5.0	Range	3.0	Range	0.0	Range	0.0	Range	2.0	Range	2.0	Range	4.0	Range	2.0
Minimum	-2.0	Minimum	-3.0	Minimum	-1.0	Minimum	2.0	Minimum	0.0	Minimum	0.0	Minimum	-2.0	Minimum	-2.0
Maximum	3.0	Maximum	0.0	Maximum	-1.0	Maximum	2.0	Maximum	2.0	Maximum	2 0	Maximum	2.0	Maximum	0.0
Sum	4.0	Sum	-20.0	Sum	-10.0	Sum	20.0	Sum	8 0	Sum	10.0	Sum	0.0	Sum	-12 0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 13	BSSO	Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	0.0	Mean	0 1	Mean	-0.1	Mean	0.1	Mean	0.1	Mean	0.9
SE	0.0	SE	0.1	SE	0.3	SE	0 1	SE	0.1	SE	0.1
Median	0.0	Median	0.0	Median	0.0	Median	0 0	Median	0.0	Median	1.0
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.0	SD	0.3	SD	0.8	SD	0.3	SD	0 3	SD	0.3
SV	0.0	SV	0.1	SV	0.6	SV	0.1	SV	0.1	SV	0 1
Range	0.0	Range	1.0	Range	3 0	Range	1.0	Range	1.0	Range	1.0
Minimum	0.0	Minimum	0.0	Minimum	-2.0	Minimum	0.0	Minimum	0.0	Minimum	0.0
Maximum	0.0	Maximum	1.0	Maximum	1.0	Maximum	1.0	Maximum	1.0	Maximum	1.0
Sum	0.0	Sum	1.0	Sum	-1.0	Sum	1.0	Sum	1.0	Sum	8.0
Count	9.0	Count	9.0	Count	9.0	Count	9.0	Count	9.0	Count	9.0
ID 14	**Lef,BS**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.4	Mean	1.4	Mean	0.4	Mean	0.2	Mean	0.0	Mean	1.0
SE	0.2	SE	0.3	SE	0.4	SE	0.1	SE	0.1	SE	0.0
Median	0.0	Median	2 0	Median	0 0	Median	0.0	Median	0.0	Median	1.0
Mode	0.0	Mode	2.0	Mode	0 0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.5	SD	1.1	SD	1.2	SD	0.4	SD	0 5	SD	0.0
SV	0.3	SV	1.2	SV	1.4	SV	0.2	SV	0.2	SV	0.0
Range	1.0	Range	3.0	Range	4.0	Range	1.0	Range	2.0	Range	0.0
Minimum	-1.0	Minimum	0.0	Minimum	-2.0	Minimum	0 0	Minimum	-1.0	Minimum	1.0
Maximum	0 0	Maximum	3.0	Maximum	2.0	Maximum	1 0	Maximum	1 0	Maximum	1.0
Sum	-4.0	Sum	14.0	Sum	4.0	Sum	2.0	Sum	0 0	Sum	10.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10 0

ID 15	Lef,BS,GP					Table 12 contd									
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	1.3	Mean	-1 3	Mean	0.1	Mean	1.6	Mean	0 9	Mean	1.2	Mean	1.0	Mean	-1 5
SE	0.3	SE	0.3	SE	0.2	SE	0.3	SE	0.3	SE	0.4	SE	0.4	SE	0.3
Median	1 5	Median	-1.5	Median	0.0	Median	2.0	Median	1.0	Median	1 5	Median	1 0	Median	-1.5
Mode	2.0	Mode	-2.0	Mode	0.0	Mode	2.0	Mode	0 0	Mode	0.0	Mode	1 0	Mode	-1.0
SD	0.8	SD	0.8	SD	0.7	SD	0.8	SD	0.9	SD	1.4	SD	1 4	SD	0.8
SV	0.7	SV	0.7	SV	0.5	SV	0.7	SV	0 8	SV	2.0	SV	2 0	SV	0.7
Range	2.0	Range	2 0	Range	2.0	Range	2.0	Range	2.0	Range	4.0	Range	5 0	Range	3.0
Minimum	0.0	Minimum	-2.0	Minimum	-1.0	Minimum	0 0	Minimum	0 0	Minimum	-1.0	Minimum	-2.0	Minimum	-3.0
Maximum	2.0	Maximum	0.0	Maximum	1.0	Maximum	2 0	Maximum	2.0	Maximum	3.0	Maximum	3.0	Maximum	0.0
Sum	13.0	Sum	-13.0	Sum	1.0	Sum	16.0	Sum	9.0	Sum	12.0	Sum	10 0	Sum	-15.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 16	**Lefort**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-1.2	Mean	-0.7	Mean	0.0	Mean	1.7	Mean	1.1	Mean	0.3	Mean	0.9	Mean	2.3
SE	0.3	SE	0.4	SE	0 1	SE	0.2	SE	0.2	SE	0.2	SE	0.3	SE	0.2
Median	-1.0	Median	0.0	Median	0.0	Median	2.0	Median	1.0	Median	0.0	Median	0.5	Median	2.0
Mode	-2.0	Mode	0.0	Mode	0.0	Mode	2.0	Mode	1.0	Mode	0.0	Mode	0.0	Mode	2.0
SD	1.0	SD	1.3	SD	0.5	SD	0.7	SD	0.6	SD	0.5	SD	1.0	SD	0.5
SV	1.1	SV	1.6	SV	0.2	SV	0.5	SV	0 3	SV	0.2	SV	1.0	SV	0.2
Range	3.0	Range	4.0	Range	2.0	Range	2.0	Range	2.0	Range	1.0	Range	2.0	Range	1.0
Minimum	-3.0	Minimum	-3.0	Minimum	-1.0	Minimum	0.0	Minimum	0.0	Minimum	0.0	Minimum	0.0	Minimum	2.0
Maximum	0.0	Maximum	1.0	Maximum	1.0	Maximum	2.0	Maximum	2.0	Maximum	1.0	Maximum	2.0	Maximum	3.0
Sum	-12 0	Sum	-7.0	Sum	0.0	Sum	17.0	Sum	11.0	Sum	3.0	Sum	9.0	Sum	23 0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10 0	Count	10.0

ID 15	Lef,BS,GP	Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.1	Mean	0.0	Mean	0 2	Mean	0.1	Mean	-0.3	Mean	1.0
SE	0.3	SE	0.2	SE	0.4	SE	0.2	SE	0.2	SE	0.0
Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	1 0
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	1.0	SD	0.7	SD	1 4	SD	0.6	SD	0.7	SD	0 0
SV	1.0	SV	0.4	SV	2.0	SV	0.3	SV	0.5	SV	0.0
Range	4.0	Range	2.0	Range	5.0	Range	2.0	Range	2.0	Range	0.0
Minimum	-2 0	Minimum	-1.0	Minimum	-2.0	Minimum	-1.0	Minimum	-1.0	Minimum	1.0
Maximum	2.0	Maximum	1.0	Maximum	3.0	Maximum	1.0	Maximum	1.0	Maximum	1.0
Sum	-1.0	Sum	0.0	Sum	2.0	Sum	1.0	Sum	-3.0	Sum	10.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 16	**Lefort**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-1.5	Mean	0.2	Mean	0.7	Mean	-0 9	Mean	0.0	Mean	-0.4
SE	0.2	SE	0.2	SE	0.3	SE	0.1	SE	0.0	SE	0.2
Median	-2.0	Median	0.0	Median	0.0	Median	-1.0	Median	0 0	Median	0.0
Mode	-2.0	Mode	0.0	Mode	0.0	Mode	-1.0	Mode	0 0	Mode	0.0
SD	0.7	SD	0.6	SD	0.9	SD	0.3	SD	0.0	SD	0.5
SV	0.5	SV	0.4	SV	0.9	SV	0.1	SV	0 0	SV	0.3
Range	2.0	Range	2.0	Range	2.0	Range	1.0	Range	0.0	Range	1.0
Minimum	-2.0	Minimum	0.0	Minimum	0.0	Minimum	-1 0	Minimum	0.0	Minimum	-1.0
Maximum	0 0	Maximum	2.0	Maximum	2.0	Maximum	0.0	Maximum	0.0	Maximum	0.0
Sum	-15.0	Sum	2.0	Sum	7.0	Sum	-9.0	Sum	0.0	Sum	-4.0
Count	10.0	Count	10.0	Count	10 0	Count	10.0	Count	10.0	Count	10.0

ID 17	VRO	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-0.1	Mean	-0 8	Mean	-0.4	Mean	0.8	Mean	0 3	Mean	0.2	Mean	0.2	Mean	-0 2
SE	0.1	SE	0.2	SE	0.2	SE	0.3	SE	0.2	SE	0.2	SE	0.1	SE	0.1
Median	0.0	Median	-1.0	Median	0.0	Median	0.0	Median	0.0	Median	0 0	Median	0.0	Median	0.0
Mode	0 0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0
SD	0.3	SD	0.8	SD	0.5	SD	1.0	SD	0.7	SD	0.6	SD	0.4	SD	0.4
SV	0.1	SV	0.6	SV	0.3	SV	1.1	SV	0.5	SV	0.4	SV	0.2	SV	0.2
Range	1.0	Range	2.0	Range	1.0	Range	2.0	Range	2.0	Range	2.0	Range	1.0	Range	1.0
Minimum	-1.0	Minimum	-2.0	Minimum	-1.0	Minimum	0.0	Minimum	-1.0	Minimum	0.0	Minimum	0.0	Minimum	-1.0
Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	2.0	Maximum	1.0	Maximum	2.0	Maximum	1.0	Maximum	0.0
Sum	-1.0	Sum	-8.0	Sum	-4.0	Sum	8.0	Sum	3.0	Sum	2.0	Sum	2.0	Sum	-2.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 18	**BSSO**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	-0.4	Mean	-1.6	Mean	-0.9	Mean	2.0	Mean	2.3	Mean	2.0	Mean	-2.1	Mean	-1.3
SE	0.5	SE	0.3	SE	0 1	SE	0.0	SE	0 2	SE	0.3	SE	0.2	SE	0.3
Median	0.0	Median	-1.5	Median	-1.0	Median	2.0	Median	2.0	Median	2.0	Median	-2.0	Median	-1.5
Mode	0.0	Mode	-1.0	Mode	-1.0	Mode	2.0	Mode	2.0	Mode	2.0	Mode	-2.0	Mode	-2.0
SD	1.6	SD	1.0	SD	0 3	SD	0.0	SD	0 5	SD	0.8	SD	0.7	SD	0 8
SV	2.7	SV	0.9	SV	0.1	SV	0.0	SV	0.2	SV	0.7	SV	0.5	SV	0.7
Range	5.0	Range	3.0	Range	1.0	Range	0.0	Range	1.0	Range	3.0	Range	2.0	Range	2 0
Minimum	-3.0	Minimum	-3.0	Minimum	-1.0	Minimum	2.0	Minimum	2.0	Minimum	0.0	Minimum	-3.0	Minimum	-2.0
Maximum	2.0	Maximum	0.0	Maximum	0.0	Maximum	2.0	Maximum	3.0	Maximum	3.0	Maximum	-1.0	Maximum	0.0
Sum	-4.0	Sum	-16.0	Sum	-9.0	Sum	20.0	Sum	23.0	Sum	20.0	Sum	-21.0	Sum	-13.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 17	VRO	Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.4	Mean	0.0	Mean	-2.3	Mean	0.7	Mean	0.4	Mean	0.7
SE	0.2	SE	0.3	SE	0.2	SE	0.2	SE	0.3	SE	0.2
Median	0.0	Median	0.0	Median	-2.0	Median	1.0	Median	1.0	Median	1.0
Mode	0.0	Mode	0.0	Mode	-2.0	Mode	1.0	Mode	1.0	Mode	1.0
SD	0.7	SD	1.1	SD	0.5	SD	0.7	SD	1.0	SD	0.5
SV	0.5	SV	1.1	SV	0.2	SV	0.5	SV	0.9	SV	0.2
Range	2.0	Range	4.0	Range	1.0	Range	2.0	Range	2.0	Range	1.0
Minimum	-2.0	Minimum	-2.0	Minimum	-3.0	Minimum	-1.0	Minimum	-1.0	Minimum	0.0
Maximum	0.0	Maximum	2.0	Maximum	-2.0	Maximum	1.0	Maximum	1.0	Maximum	1.0
Sum	-4.0	Sum	0.0	Sum	-23.0	Sum	7.0	Sum	4.0	Sum	7.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 18	**BSSO**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	0.0	Mean	0.0	Mean	-0.1	Mean	-0.4	Mean	-0.1	Mean	0.9
SE	0.0	SE	0.0	SE	0.1	SE	0.2	SE	0.1	SE	0.1
Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	1.0
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	0.0	SD	0.0	SD	0.3	SD	0.5	SD	0.3	SD	0.3
SV	0.0	SV	0.0	SV	0.1	SV	0.3	SV	0.1	SV	0.1
Range	0.0	Range	0.0	Range	1.0	Range	1.0	Range	1.0	Range	1.0
Minimum	0.0	Minimum	0.0	Minimum	-1.0	Minimum	-1.0	Minimum	-1.0	Minimum	0.0
Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	1.0
Sum	0.0	Sum	0.0	Sum	-1.0	Sum	-4.0	Sum	-1.0	Sum	9.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 19	BSSO	Table 12 contd													
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	0.0	Mean	-1.5	Mean	-1.0	Mean	2.0	Mean	0.8	Mean	-0.1	Mean	0.1	Mean	0.7
SE	0.6	SE	0.4	SE	0.0	SE	0.0	SE	0.2	SE	0.1	SE	0.2	SE	0.3
Median	0.0	Median	-2.0	Median	-1.0	Median	2.0	Median	1.0	Median	0.0	Median	0.0	Median	0.5
Mode	0.0	Mode	-2.0	Mode	-1.0	Mode	2.0	Mode	1.0	Mode	0.0	Mode	0 0	Mode	0.0
SD	1.8	SD	1.2	SD	0.0	SD	0.0	SD	0.6	SD	0.3	SD	0.7	SD	0.8
SV	3.1	SV	1.4	SV	0.0	SV	0.0	SV	0 4	SV	0.1	SV	0 5	SV	0.7
Range	6.0	Range	3.0	Range	0.0	Range	0.0	Range	2.0	Range	1.0	Range	2.0	Range	2.0
Minimum	-3.0	Minimum	-3.0	Minimum	-1.0	Minimum	2.0	Minimum	0.0	Minimum	-1.0	Minimum	-1 0	Minimum	0.0
Maximum	3.0	Maximum	0.0	Maximum	-1.0	Maximum	2.0	Maximum	2.0	Maximum	0.0	Maximum	1.0	Maximum	2.0
Sum	0.0	Sum	-15.0	Sum	-10.0	Sum	20.0	Sum	8.0	Sum	-1.0	Sum	1.0	Sum	7.0
Count	10.0	Count	10 0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 20	**Lefort**														
MX		*MD*		*OCCL*		*OJ*		*MX D*		*MD D*		*LFH*		*OB*	
Mean	0.1	Mean	-1.0	Mean	-0.5	Mean	2 0	Mean	2.4	Mean	1.4	Mean	2.4	Mean	3.0
SE	0.4	SE	0.6	SE	0.2	SE	0.0	SE	0 2	SE	0.3	SE	0.2	SE	0.0
Median	0.0	Median	-2.0	Median	-0.5	Median	2.0	Median	2.5	Median	1.5	Median	2.5	Median	3.0
Mode	0.0	Mode	-2.0	Mode	0.0	Mode	2.0	Mode	3.0	Mode	2.0	Mode	3.0	Mode	3.0
SD	1.2	SD	1.9	SD	0.5	SD	0.0	SD	0 7	SD	1.0	SD	0.7	SD	0.0
SV	1.4	SV	3.6	SV	0.3	SV	0 0	SV	0.5	SV	0.9	SV	0.5	SV	0.0
Range	4.0	Range	5.0	Range	1.0	Range	0.0	Range	2 0	Range	3.0	Range	2.0	Range	0.0
Minimum	-2.0	Minimum	-3.0	Minimum	-1.0	Minimum	2.0	Minimum	1.0	Minimum	0.0	Minimum	1.0	Minimum	3.0
Maximum	2.0	Maximum	2 0	Maximum	0.0	Maximum	2.0	Maximum	3.0	Maximum	3.0	Maximum	3.0	Maximum	3.0
Sum	1.0	Sum	-10.0	Sum	-5.0	Sum	20.0	Sum	24.0	Sum	14.0	Sum	24.0	Sum	30.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

ID 19	BSSO	Table 12 contd									
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.7	Mean	0.1	Mean	0.3	Mean	0.0	Mean	-0.9	Mean	1.0
SE	0.3	SE	0.2	SE	0 3	SE	0.0	SE	0.1	SE	0.0
Median	-0.5	Median	0.0	Median	0.0	Median	0 0	Median	-1.0	Median	1.0
Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	-1.0	Mode	1.0
SD	0.8	SD	0.7	SD	1.1	SD	0 0	SD	0.3	SD	0.0
SV	0.7	SV	0.5	SV	1.1	SV	0.0	SV	0.1	SV	0.0
Range	2.0	Range	3.0	Range	4.0	Range	0.0	Range	1.0	Range	0.0
Minimum	-2.0	Minimum	-1.0	Minimum	-2.0	Minimum	0.0	Minimum	-1.0	Minimum	1.0
Maximum	0.0	Maximum	2.0	Maximum	2.0	Maximum	0.0	Maximum	0.0	Maximum	1.0
Sum	-7.0	Sum	1.0	Sum	3.0	Sum	0.0	Sum	-9.0	Sum	10.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0
ID 20	**Lefort**										
MXW		*MDW*		*ASYM*		*MXL*		*MDL*		*PRO*	
Mean	-0.8	Mean	0.2	Mean	-0.3	Mean	0.0	Mean	-0.1	Mean	1.0
SE	0.4	SE	0.4	SE	0.2	SE	0.0	SE	0.1	SE	0.0
Median	-1.0	Median	0.0	Median	0.0	Median	0.0	Median	0.0	Median	1.0
Mode	-1.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	0.0	Mode	1.0
SD	1.3	SD	1.3	SD	0.7	SD	0.0	SD	0.3	SD	0.0
SV	1.7	SV	1.7	SV	0.5	SV	0.0	SV	0.1	SV	0.0
Range	5.0	Range	5.0	Range	2.0	Range	0.0	Range	1.0	Range	0.0
Minimum	-3.0	Minimum	-2.0	Minimum	-2.0	Minimum	0.0	Minimum	-1.0	Minimum	1.0
Maximum	2.0	Maximum	3 0	Maximum	0.0	Maximum	0.0	Maximum	0.0	Maximum	1.0
Sum	-8.0	Sum	2.0	Sum	-3.0	Sum	0.0	Sum	-1.0	Sum	10.0
Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0	Count	10.0

BIBLIOGRAPHY

Ackerman JL, Profitt WR. 1969. The characteristics of malocclusion: A modern approach to classification and diagnosis. Am J Orthod 56: 443-454

Adams JW. 1940. Correction of error in cephalometric roentgenograms. Angle Orthod 10: 3-13

Angle EH. 1899. Classification of malocclusion. Dental Cosmos 41; 248-264, 350-357

Angle EH. 1907. Treatment of Malocclusion of the Teeth. 7th edition. Philadelphia. S.S. White Dental Manufacturing Co.

Atchison KA. 1986. Radiographic examinations of orthodontic educators and practitioners. J Dent Educ 50: 651-5

Atchison KA, Luke LS, White SC. 1991. Contribution of pretreatment radiographs to orthodontists' decision making. Oral Surg Oral Med Oral Pathol 71: 238-245

Baumrind S, Frantz R. 1971 a. The reliability of head film measurements. 1. Landmark identification. Am J Orthod 60: 111-127

Baumrind S, Frantz R. 1971 b. The reliability of head film measurements. 2. Conventional angular and linear measurements. Am J Orthod 60: 505-517

Baumrind S, Miller DM. 1980. Computer aided head film analysis: The University of California San Francisco Method. Am J Orthod Dentofacial Othodp 7: 41-65

Baumrind S, Korn EL, West EE. 1984. Prediction of mandibular rotation: An empirical test of clinical performance. Am J Orthod. 86: 371-385

Bergin R, Hallenberg J, Malmgren O. 1978. Computerized cephalometrics. Acta Odontol Scand 36, 349-357

Bhatia SN, Sowray JH. 1984. A Computer aided design for orthognathic surgery. Br J Oral Maxillofac Surg 22: 237-53

Bjork A and Solow B. 1962. Measurements on radiographs. J Dent Res 41: 672-683

Blair VP. 1909. Underdeveloped jaw with limited excursion. JAMA 17: 178-183

Broadbent BH. 1931. A new x-ray technique and its application to orthodontia. Angle Orthod 1:45-66

Brodie AG. 1949. Cephalometric roentgenology: history, technique and uses. J Oral Surg 185-198

Burstone CJ. 1959. Integumental contour and extension patterns. Angle Orthod 29: 93-104

Burstone CJ. 1967. Lip posture and its significance in treatment planning. Am J Orthod 53:262-284

Burstone CJ, et al. 1978. Cephalometrics for orthognathic surgery. J Oral Surg 36: 269-277

Cleall JF, Chebib FS. 1971. Coordinate analysis applied to orthodontic studies. Angle Orthod 64: 214-218

Cleall JF, Chebib FS. 1976. On line computer system for the analysis of cephalometric radiographs. Angle Orthod 46: 305-311

Cohen AM. 1984. Uncertainty in orthodontics. Br J Orthod 11: 44-48

Cutting C, Grayson B, Bookstein F, Fellingham L, McCarthy JG. 1986. Computer-aided planning and evaluation of facial and orthognathic surgery. Clin Plastic Surg 13: 449-462

Delaire J, Schendel SA, Tuasne JF. 1981. An architectural and structural craniofacial analysis: A new lateral cephalometric analysis. Oral Surg Oral Med Oral Path 52: 226-238

Donatsky O, Hillerup S, Jacobsen PU. 1992. Computerized cephalometric orthognathic surgical simulation, prediction, and postoperative evaluation of precision. Int J Oral Maxillofac Surg 21: 199-203

Donatsky O, Jorgensen BJ, Holmqvist ML, Hillerup S. 1997. Computerized cephalometric orthognathic surgical precision and stability in relation to maxillary superior repositioning combined with mandibular advancement or setback. J Oral Maxillofac Surg 55: 1071-1079

Downs WB. 1948. Variations in facial relationships: Their significance in treatment and prognosis. Am J Orthod 34: 812-840

Ellis E, Gallo WJ. 1986. Relapse following mandibular advancement with dental plus skeletal maxillomandibular fixation. J Oral Maxillofac Surg 44: 509-515

Goldstein A. 1947. Appraisal of results of surgical correction of class III malocclusions. Angle Orthod 17: 59-91

Hambleton RS. 1964. Soft tissue covering of the skeletal face as related to orthodontic problems. Am J Orthod 50:405-420

Han UK, Vig KWL, Weintraub JA, Vig PS, Kowalski CJ. 1991. Consistency of orthodontic treatment decisions relative to diagnostic records. Am J of Orthod Dentofac Orthop. 100: 212-219

Harradine NWT, Birnie DJ. 1985. Computerized prediction of results of orthognathic surgery. J Maxillofac Surg 13: 245-249

Hiranaka DK, Kelly JP. 1987. Stability of simultaneous orthognathic surgery on the maxilla and mandible. A computer assisted study. Int J Adult Orthod Orthogn Surg 2: 193-213

Holdaway R. 1956. Changes in relationship of point A and point B during orthodontic treatment. Am J Orthod 42: 176-193

Jacobson A. 1975. The "Wits" appraisal of jaw disharmony. Am J Orthod 67: 125-138

Jacobson A. 1990. Planning for orthognathic surgery – art or science? Int J of Adult Orthod And Orthogn Surg 5: 4; 217-224

Konchak PA, Koehler JA. 1985. A Pascal computer program for digitizing lateral cephalometric radiographs. Am J Orthod Dentofacial Orthop 3: 197-200

Landis JR, Koch GG. 1975. The measurement of observer agreement for categorical data. Biometrics 33: 159-174

Lines PA, Steinhauser EW. 1974. Diagnosis and treatment planning in surgical orthodontic therapy. Am J Orthod 66: 378-397

Macri V, Wenzel A. 1993. Reliability of landmark recording on film and digital lateral cephalograms. Eur J Orthod 15: 137-148

Major PW, Johnson DE, Hesse KL, Glover KE. 1994. Landmark identification error in posterior anterior cephalometrics. Angle Orthod 6: 447-454

el Mangoury NH, Shaheen SI, Mostafa YA. 1987. Landmark identification in computerized posteroanterior cephalometrics. Am J Orthod and Dentofacial Orthodp 91: 57-61

McNamara JA, Jr. 1983. A method of cephalometric analysis. In clinical alteration of the growing face, Monograph 12, Craniofacial Growth Series, Ann Arbor, University of Michigan, Center for Human Growth and Development

McNeill WR, Proffit WR, White RP. 1972. Cephalometric prediction for orthognathic surgery. Angle Orthod 42: 154-164

Mitgard J, Bjork G, Linder-Aronson S. 1974. Reproducibility of cephalometric landmarks and errors of measurement of cephalometric cranial distances. Angle Orthod 44: 56-62

Moloney F, Worthington P. 1981. The origin of the LeFort I maxillary osteotomy. Cheever's Operation. J Oral Surg 39: 731-734

Morris Al . 1975. Handicapping Orthodontic Conditions. Washington DC National Academy of Sciences

Nguyen DD, Turley PK. 1998. Changes in the caucasian male profile as depicted in fashion magazines during the twentieth century. Am J Orthod Dentofacial orthod 114: 208-17

Nimkaran Y, Miles PG. 1995. Reliability of computerized cephalometrics. Int J Adult Orthod Orthogna Surg 10: 43-52

Poulton DR., Taylor RC, Ware WH. 1963. Cephalometric x-ray evaluation of vertical osteotomy correction of mandibular prognathism. Oral Surg Oral Med Oral Path 16: 807-820

Proffit WR, Phillips C, Turvey TA. 1987. Stability following superior repositioning of the maxilla by Le Fort I osteotomy. Am J Orthod Orthop 92: 151-161

Proffit WR, White RP. 1990. Surgical Orthodontic Treatment. St. Louis, Missouri. Mosby-Year Book

Richardson A. 1966. An investigation into the reproducibility of points, planes and lines used in cephalometric analyses. Am J Orthod 52: 637-651

Riedel RA. 1950. Esthetics and its relation to orthodontic therapy. Angle Orthod 20: 168-178

Riedel RA. 1957. An analysis of dentofacial relationships. Am J Orthod 43:103-119

Ricketts RM. 1957. Planning treatment on the basis of the facial pattern and an estimate of its growth. Angle Orthod 27: 14-37

Ricketts RM. 1972. Computerized cephalometrics. Am J Orthod 61:1; 1-28

Ricketts RM. 1981. Perspectives in the clinical application of cephalometrics. Angle Orthod 51: 115-150

Robinson SW. 1971. Soft tissue profile change produced by reduction of mandibular prognathism. Angle Orthodontist 41: 227-235

Salzmann JA. 1964. Limitations of roentgenographic cephalometrics. Am J Orthod 169-188

Silling G, Rauch MA, Pentel L, Garfinkel L, Halberstadt G. 1979. The significance of cephalometrics in treatment planning. Eur J Orthod 49: 4; 259-262

Steiner CC. 1960. The use of cephalometrics as an aid to planning and assessing orthodontic treatment. Am J Orthod 46: 721-735

Stoner MM. 1955. Photometric analysis of the facial profile. Am J Orthod 41: 453

Sassouni VA. 1969. A classification of skeletal facial types. Am J Orthod 55: 109-123

Turley PK, Auger TA. 1994. Esthetic soft-tissue profile changes during the 1900's. J Dent Res (IADR Abstracts). 73: 2128

Tweed CH. 1954. The Frankfurt – mandibular incisor angle (FMIA) in orthodontic diagnosis, treatment planning and prognosis. Angle Orthod 24: 121-169

Vogel CJ. 1967. Correction of frontal dimensions from head x-rays. Angle Orthod 37: 1-8

Walker GF. 1972. A new approach to the analysis of craniofacial morphology and growth. Am J Orthod 61: 3; 221-230

Walters H, Walters D. 1986. Computerized planning of maxillo-facial osteotomies: The program and its clinical applications. Brit J Oral Maxillofac Surg 24: 178-189

Welch TB. 1989. Stability in the correction of dentofacial deformities. A comprehensive review. J Oral Maxillofac Surg 47: 1142-9

Winstanly RP. 1968. Subcondylar osteotomy of the mandible and the intraoral approach. Br J Oral Surg 6: 134-136

Wylie GA, Fish LC, Epker BN. 1987. Cephalometrics: A comparison of five analyses currently used in the diagnosis of dentofacial deformities. Int J Adult Orthod Orthogn Surg 2: 15-36

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