THE VALIDATION OF A CEPHALOMETRIC INDEX FOR ORTHODONTIC TREATMENT NEED

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

Department of Orthodontics
School of Dentistry
CASE WESTERN RESERVE UNIVERSITY

August 16, 1996

CASE WESTERN RESERVE UNIVERSITY

SCHOOL OF DENTISTRY

GRADUATE STUDIES

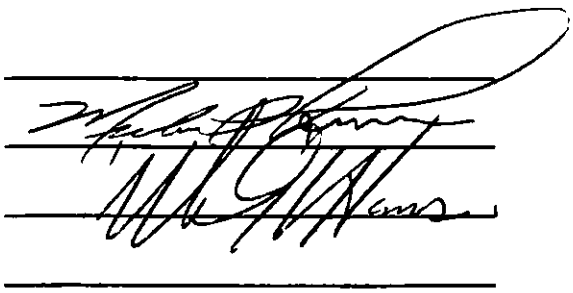
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ABSTRACT

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The purpose of this study was to evaluate the validity of a cephalometric index for determining orthodontic treatment need with statistical tests for sensitivity and specificity. The control group or "treatment not needed group" consisted of sixty-two lateral cephalograms of twelve year olds with equal proportions of males and females. The specificity of the cephalometric index (the number of subjects in the control group correctly identified) by the cephalometric index was 46.7%. The experimental group or "treatment needed group" consisted of thirty lateral cephalograms of twelve year olds, with equal proportions of males and females. The sensitivity of the cephalometric index (the number of subject correctly identified in the experimental group) was 73.3%.A large range of normal variation in cephalometric values resulted

in low scores for specificity. This demonstrated the difficulty in distinguishing an orthodontic treatment needed group from a no treatment group based on cephalometric values alone. The current limitations of the cephalometric index were discussed and methods to improve the applicability of the cephalometric index to determine orthodontic treatment need suggested.

ACKNOWLEDGEMENTS

Dr. Suchitra Nelson, my thesis advisor, her constant support and direction made this thesis possible.

Dr. Mark Hans, an invaluable thesis committee member and chairman of the department of orthodontics, has provided me with an exceptional education for which I will always be grateful.

Dr. Micheal Powers, his willingness to participate as a thesis committe member was crucial in the completion of this project.

Drs. S. Neuger, S. Simpson, S, Papandreas,whose time and effort was necessary in the validation of the cephalograms.

Dennis Nagy, a hard working dental student, his dedication and friendship will always be cherished.

Drs. S. Baek, A. Bazzucchi, D. Harmon, and W. Najem, my classmates, their support and most of all their friendship have made the last two years the most educational and enjoyable years of my life.

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INTRODUCTION

Orthodontic treatment need is routinely determined by a clinicians subjective opinion of the functional, health, and esthetic implications of the malocclusion. A current study by Richmond (1994) studied the variation in dentist's perception of orthodontic treatment need. In this study seventy-four dentists were asked to assess 320 dental casts in relation to the esthetic and dental health need. The results of this study revealed that the panel was equally divided on what constituted a dental health component requiring orthodontic treatment. The authors suggested that until an objective evaluation of orthodontic treatment need is developed and accepted by the profession, the ambiguity surrounding the need for orthodontic treatment will continue.

The lack of objectivity in determining orthodontic treatment need has resulted in a renewed interest in occlusal indices. Although, occlusal indices such as the Index of Orthodontic Treatment Need(Brook and Shaw 1989), have already been accepted in Europe (Miotti 1995), such is not the case in North America due to the several

limitations of occlusal indices. A major limitation to occlusal indices is that they are only a reflection of how well teeth line up on plaster dental models. Orthodontic diagnosis and treatment planning is based on dental, skeletal and soft tissue relationships. Occlusal indices can be used only to evaluate one of these factors, that is dental relationships. In order to evaluate skeletal and soft tissue relationships, orthodontists are dependent on cephalometric and photographic analysis'.

Thus, in response to the limitations of occlusal indices as a determinator of orthodontic treatment need, Dhingra (1995) developed a cephalometric index with the intention of being able to discriminate subjects with and without cephalometric indications for orthodontic treatment. The discriminant function equation which was created, correctly identified 98.7 % of the individuals with cephalometric indications for treatment and 100% of the individuals with no cephalometric indications for treatment when tested on the same sample from which the equation was derived. However, in order for any index to be valid and useful it must not only be able to discriminate subjects in the sample from which it was created, it must also be applicable to other populations.

The purpose of the present study was to evaluate the

validity of the cephalometric index in determining orthodontic treatment need using statistical tests for sensitivity and specificity. The control group or treatment not needed group consisted of sixty-two lateral cephalograms and the experimental group or treatment needed group consisted of thirty lateral cephalograms, the average age of both samples was twelve years of age and consisted of equal proportions of males and females.

LITERATURE REVIEW

The Need For Orthodontic Treatment

The need for orthodontic treatment is routinely determined by a dentist's subjective opinion of several different variables. Malocclusions create problems in three general circumstances:

> (1) problems of greater susceptibility to trauma or disease, including periodontal disease and tooth decay;
>
> (2) problems with oral function, including temporomandibular joint disturbances, and problems with mastication, swallowing, or speech;
>
> (3) psychosocial problems related to impaired dentofacial esthetics (Proffit 1993).

Malocclusion and it's Relationship to Injury and Oral Disease

It seems oblivious that malocclusions would have an impact on the ability for people to effectively remove plaque from their teeth and therefore create a greater susceptibility for dental caries. Adler (1956) classified malocclusions in accordance with Angle and reported higher DMF scores in individuals with malocclusion than those with normal occlusion. These findings are in conflict with

those of Katz (1978) who found no correlation between various occlusal indices and DMFS scores. Helm and Peterson (1989a) suggested that these contradictory findings are due to the multifactorial etiology of dental caries, it was further suggested that cross sectional samples of children may not be well suited for these studies because dental caries may not manifest itself until adult life. Helm, therefore conducted a longitudinal study from childhood to adulthood to determine the longterm adverse effects of malocclusion on the risk for dental caries. Malocclusions were recorded in 1965 for 176 adolescents, and then re-examined twenty years later. DMFS scores were compared to group without malocclusion at both examinations. The results of this study suggest no relationship between malocclusion traits and caries prevalence, and hence increased risk of caries should not be considered as a indication for orthodontic treatment.

The ability to remove plaque from the teeth also influences the health of the periodontium. Numerous studies have examined the relationship between malocclusion and periodontal disease. A number of studies have reported increased prevalence of periodontal disease in the presence of malocclusion. Poulton and Aaronson (1961) found a significant relationship between lower incisor crowding

and periodontal status when evaluated by the periodontal index of Russell. Buckley (1972) also reported a relationship between lower incisor crowding and periodontal disease.

In more recent studies, there does not appear to be a very significant relationship between malocclusion and periodontal disease. Sadowsky and Begole (1981) compared ninety-six patients who had received comprehensive orthodontics during adolescence to 103 adults who were similar with regard to race, sex, age, socioeconomic status, dental awareness and oral hygiene status but had malocclusions that had not been orthodontically treated. The results suggested no significant difference between the two groups. In other words there was no evidence of a beneficial effect of orthodontic treatment on future periodontal health. A twenty year follow up study by Helm and Peterson (1989b) assessed whether certain traits of malocclusion result in an increased risk of periodontal disease. The presence of increased overjet, crossbite and crowding in the maxilla were associated with more periodontal pocketing than the control group. No significant differences were found in the mandible. Although the hypothesis that malocclusion may increase the risk of periodontal disease was confirmed it was suggested

that these situations call for special efforts of oral hygiene education rather than orthodontic therapy. Polson and Heil (1980) suggest only a small link between malocclusion and periodontal disease, emphasizing the presence of plaque as the major cause of periodontal disease. This review suggests that the occlusal relationships have little effect on the development of periodontal disease but will significantly affect it's progress once the disease process has been started.

Certain malocclusions can increase the susceptibility to certain types of dental trauma and therefore, a reduction in the likelihood of injury may be an indication for orthodontic treatment (Proffit 1993). Protruding maxillary incisors, as found in class I division I malocclusions, are at a increased risk for injury. O'Mullane (1989) concluded there is a one in three chance that a child with an untreated class II malocclusion will experience significant trauma to the upper incisors, resulting in fracture of the tooth and/or devitalization to the pulp. Profitt (1993) suggests in cases with extreme overbite, in which the lower incisors contact the palate, can cause significant tissue damage and may eventually result in loss of the upper incisors.

Malocclusion and it's Relation to Oral Function

Compromises in oral function, including mastication, speech and swallowing may be linked to severe malocclusions (Proffit 1993). Patients with severe malocclusions often have difficulty with chewing and may learn to avoid certain foods they can not manage. These same patients indicate an improvement in chewing ability after treatment and consider this improvement to be one of main reasons for seeking treatment (Ostler and Kiyak 1991). Difficulty in speech may be another indication for orthodontic treatment. Laine et al., (1985) suggested that a correct /s/ sound is more difficult to produce in cases of increased overjet or decreased overbite. Other articulatory disorders associated with malocclusion include difficulty in producing /t/ and /d/ sounds with maxillary incisors located lingually and distortion of /f/ and /v/ sounds in skeletal class III patients (Proffit 1993).

The relationship between occlusal factors and temporomandibular disorders is very controversial. Certain authors consider occlusal interferences to be very important in the etiology of TMD (Ramfjord and Ash 1971). However, more recent studies downplay the importance of occlusion in the development of TMD and suggest TMD to be more multifactorial in nature (Greene and Marbach 1982).

Egermark and Thilander (1992) reexamined a group a of adolescents with respect to signs and symptoms of TMD and evaluated differences between those who had received orthodontic treatment and those that had not. In this study those subjects that had received orthodontic treatment had a lower prevalence of TMD symptoms than those who had not received orthodontic treatment. The authors suggest decreasing symptoms of TMD may be a indication for orthodontics in some cases, however, they also emphasize the multifactorial nature of TMD and the importance of thorough diagnosis and strict treatment planning. Due to weak link between TMD and occlusion, prevention of TMD in itself does not indicate a need for orthodontics, however, in certain cases of existing TMD, orthodontics may play a therapeutic role (Proffit 1993).

Malocclusion and it's Relation to Psychosocial Problems

Orthodontic treatment is not only indicated for physiologic implications of malocclusion but also for esthetic considerations as well. The primary motivation for patients seeking orthodontic care are for psychosocial factors rather than clinical occlusal status (Albino et al.,1981). Although it is possible to objectively study the relationship between occlusal morphology and physiologic conditions, it is inherently much more

difficult to measure the relationship between occlusal morphology and social functioning (Jenny et al.,1980). It is well documented that facial appearance can influence teachers opinions of school children in regard to their intelligence, how well they will progress in school and how popular they will be among their peers (Clifford and Walster 1973; Saliva et al.,1977). In order to determine whether the social attractiveness of a child would be influenced by his or her dentofacial appearance, Shaw (1981) obtained portraits of an attractive boy and girl and an unattractive boy and girl and modified them so each would have five different dentofacial arrangements. The five different dentofacial arrangements were normal incisors, missing lateral incisor, severely crowded incisor and unilateral cleft lip. Each photograph was viewed by forty-two adults and by forty-two children and their impressions were recorded with a visual analogue scale. The results indicate that children with a normal dental appearance are judged to be better looking, more desirable as friends, more intelligent, and less likely to behave aggressively, than children portraying dentofacial anomalies.

It is very clear that severe malocclusions can be a social handicap that can have deleterious effects on an

individual's whole adaptation to life (Macgregor 1979). Kilpelainen et al., (1993) report that malalignment of teeth and increased overjet to be significant predictors of parent reports that their is child being teased. A psychosocial study of the effects of malocclusion studied longitudinally by Helm et al.,(1985) concluded malocclusion may adversely affect body image and self concept, not only at adolescence but also in adulthood. Other studies report on the importance of a good dental appearance during dating and searching for top ranked employment opportunities (Linn 1966; Samuels and Proshek 1973).

In summary, the need for orthodontic treatment is determined by evaluating the increased risks for disease and trauma due to the malocclusion, the functional implications of the malocclusion, and the psychosocial effects of the malocclusion. All three of these variables play an important role in determining the need for orthodontic treatment, however, it is important to understand that one person's acceptable malocclusion may be another persons problem, and thus similar malocclusions may indicate a need for orthodontic treatment in one person but not for another (Proffit and Ackerman 1994).

Occlusal Indices

The use of indices is not new in dentistry, indices can provide an objective alternative to what normally is determined by subjective clinical judgement. Indices such as DMF scores, plaque indices and periodontal indices have been valuable in determining the prevalence of caries and periodontal conditions, as well as determining the effectiveness of various treatment regimens (Klein et al., 1938; Russell 1956; Greene and Vermillion 1960).

The ability to develop an objective measure for orthodontic treatment need has been very difficult for several reasons. Orthodontic treatment is indicated in patients for two unrelated variables; esthetics and function. The difference between normal occlusion and malocclusion falls somewhere in the continuum between normal variation and deviation (Foster and Menezes 1976). Despite the inherent difficulties in objectively measuring orthodontic treatment need, occlusal indices have been developed for diagnostic classification, epidemiological data collection, determining treatment priority, and assessment of treatment outcomes (Shaw et al.,1991). Occlusal indices are descriptions or measurements taken either directly from observation of a patient's dentition or from plaster dental models.

The original and most famous occlusal index is Angle's molar classification. Angle (1899) classified occlusions based on the position of the buccal cusp of the maxillary first molar and it's relation to the buccal groove of the lower first molar. Angle's classification of occlusion is purely descriptive and is of little value in determining treatment need.

The next group of indices were developed mainly for epidemiological purposes. Bjork et al., (1964) and Baume and Marechaux (1974) developed complicated classifications which could record every trait in a malocclusion and allow estimation of the prevalence of malocclusion, or it's traits, to be made from the population. These indices were to be used for programming and evaluation of dental health services, as well as tools for distinguishing between environmental and genetic factors in the etiology of malocclusion.

Although the previous indices were effective in describing the prevalence of malocclusion, they did not attempt to define treatment need. The next series of occlusal indices were developed with intention of categorizing malocclusion into various groups according to the level of treatment need. These indices include the Handicapping Labiolingual Deviation Index (Draker 1960),

the Treatment Priority Index (Grainger 1967), Handicapping Malocclusion Assessment Record (Salzmann 1968), Occlusal Index (Summers 1971), and the Index of Treatment Need (Brook and Shaw 1989).

The Handicapping Labiolingual Deviation (HLD) was developed in response to public health programs covering orthodontics which demanded a more objective measure alternative to subjective clinical opinion in determining orthodontic treatment need. From a public health view point Draker (1960) suggested that evidence of a demonstrable handicap was more valuable than the descriptive term malocclusion. Furthermore, Draker suggested that the HLD could yield a cut off point which can be adjusted to correspond to budget changes without abandoning the objectivity of measurements. Weightings of nine conditions were determined by trial and error. The scores were tabulated and a score of greater than thirteen constituted a physical handicap. The intention was to measure the presence or absence, and the degree, of the handicap caused by the components of the index, and not to diagnose malocclusion.

The Treatment Priority Index (TPI) was developed by Grainger (1967) in connection with the Burlington Orthodontic Research Project at the University of Toronto.

The TPI was originally used to assess the effects of preventive orthodontic treatment on the prevalence and severity of malocclusion in children. It was later recognized that the same method could be useful for population surveys of the epidemiologic type and as screening device in public health programs. Scores on the TPI range from 0 to 10, with 0 representing ideal occlusion and 10 representing severe malocclusion. A total score is derived from component scores, vertical overbite or openbite, overjet of upper and lower incisors, posterior crossbite, tooth displacement, and buccal segment relationships. Weights for these components are determined from multiple regression analysis and are related to the degree of malalignment.

The Handicapping Malocclusion Assessment Record (HMAR) was developed by Salzmann (1968) in response to a recommendation by the American Dental Association's Council on Dental Health. The purpose of the HMAR is to provide means for establishing priority for treatment of handicapping malocclusion in children according to the severity as reflected in a score obtained from the index. The index is designed to identify any occlusal condition that interferes with oral health or general well being, rather than for identification of specific occlusal traits.

The total score is derived from subscores reflecting intra and interarch deviations within the anterior and posterior segments of the maxilla and mandible. Intra-arch deviations reflect the number of teeth which are missing, crowded, rotated, or spaced. Interarch deviations reflect overjet, overbite, crossbite and buccal relationships in the posterior segments. Weights were assigned to specific deviations based on clinical experience of the contribution of the various conditions to problems of dental function, health and appearance.

The Occlusal Index (OI) developed by Summers (1971) is based upon the Treatment Priority Index. Nine characteristics are evaluated from dental models which include: tooth displacement, molar relation, overbite, overjet, posterior crossbite, posterior open bite, midline relations, congenitally missing permanent maxillary incisors and dental age. The scores for various characteristics are weighted differently at different age groups. Prior to the eruption of the canines and premolars the mixed dentition analysis as described by Moyers (1963) is used to assess any future crowding. This crowding is then scored in same way as if tooth displacement had already occurred. Grewe and Hagan (1972) compared the HMAR, the TPI. and the OI in regard to precision, examiner

variability, and bias. None of the indices showed a significant difference in precision or examiner variability, however, the occlusal index was suggested to be the index of choice because it demonstrated the least amount of bias. The occlusal index was also one of the first indices used not only to assess treatment need but also used to assess orthodontic treatment outcome (Pickering and Vig 1975).

Although the HLDI, TPI, HMAR, and OI have all added objectivity to the determination of orthodontic treatment need, their scores are mostly made on subjective clinical assessment of the adverse effects of malocclusion traits on oral health, function and facial appearance. The Index of Orthodontic Treatment Need (IOTN) developed by Brook and Shaw (1989) appears to have achieved a higher level of objectivity and seems to have been accepted by the profession in Europe (Miotti 1995). The index of orthodontic treatment need ranks malocclusion based on both a dental health component and a esthetic component, with the intention of identifying those individuals who would most likely benefit from orthodontic treatment. The dental health component is comprised of three main categories which include, no need, borderline need, and need for orthodontic treatment. The esthetic component is a visual

scale with a score being given for general attractiveness rather than specific deviations. Brook and Shaw (1989) emphasize that the main benefit of orthodontic treatment may be improved esthetics and social psychological well being and therefore they must be considered in the construction of a treatment priority index.

The most recent occlusal indices developed have been used to evaluate orthodontic treatment outcome as opposed to orthodontic treatment need. Although these indices do not measure treatment need directly, they are important in treatment decisions because they can identify cases which are likely to benefit from orthodontic treatment, as well as, treatment modalities which are most predictable. The Peer Assessment Rating (PAR) Index was developed by Richmond (1992) which measures the percent change between pre and post treatment dental casts. Scores for alignment of the dentition, buccal segment relationship, overjet, overbite, and midline discrepancy are summed to calculate an overall severity of the malocclusion severity. Recently, Tahir et al.,(1995) have developed "The Ideal Tooth Relationship Index" which uses the ideal position of tooth cusps as an alternative method to evaluate treatment outcome.

The continued search for objectivity in orthodontics

has resulted in a renewed interest in occlusal indices (Richmond 1992). Although, occlusal indices have been somewhat effective in measuring orthodontic treatment need and outcome, there still remains several shortcomings. The importance of esthetics and psychological benefits from orthodontic treatments has already been reviewed. Carlos (1970) suggested occlusal indices had good reliability but he questioned their validity because of the difficulty in measuring the social handicap associated with malocclusions. Similar statements by other authors suggest that malocclusion indices fail in their ability to measure the effect of the malocclusion on the social and psychological well being of the individual (Moorres et al., 1971; Helm 1977).

Occlusal indices reflect primarily dental relationships. Orthodontic diagnosis and treatment planning is based on dental, skeletal and soft tissue relationships. Therefore, in order to thoroughly determine treatment need in terms of dental, skeletal and soft tissue relationship the clinician is also dependent on photographic and cephalometric analyses.

Cephalometric Analyses

The cephalometer was first developed by Broadbent in 1931 at Western Reserve University in Cleveland, Ohio.

Since it's inception, cephalometrics has been an invaluable tool in terms of diagnosis and treatment planning in orthodontics (Broadbent 1931). Over the last sixty years, numerous cephalometric analyses have been developed by various people, based on diagnostic criteria important to that particular individual. In the following section the most important and popular cephalometric analysis' will be reviewed.

The first valuable cephalometric analysis for diagnosis in orthodontics was developed by Downs (1948; 1952). Downs' analysis is based on normal angular measurements derived from twenty-five individuals believed to have excellent facial proportions and occlusion. Downs believed that individuals vary in facial type and pattern but those possessing optimum oral health, functional balance and esthetics have common profile characteristics. Skeletal patterns were mostly described in terms of facial convexity and dental patterns were described in reference to the inclination of the lower incisors. Down's measurements use the Frankfort Horizontal plane as a reference line.

Vohries and Adams (1951) constructed a graphic representation of Down's values which was a polgonic portrayal of the skeletal and dental patterns of the face.

The vertical line represents Down's mean values, the left and right lines represent the maximal and minimal values which were believed to be the limit of the normal range. Down's values are organized such that measurements which fall on the left of the polygon indicate a class II pattern and values to the right represent a class III pattern.

Tweed (1946; 1954; 1969) developed the diagnostic triangle for cephalometric analysis. Using the reference line Frankfort-Horizontal, the following angles were measured; Frankfort mandibular plane angle (FMA), Frankfort mandibular incisor angle(FMIA) and incisor mandibular plane angle(IMPA). From a sample of forty-five individuals, it was determined that a minimum FMIA of 65° was necessary to achieve excellent facial balance and occlusion.

The angular measurements sella nasion A-point (SNA), sella nasion B-point (SNB) and A-point nasion B-point (ANB) were developed by Reidel(1952; 1957) and are still used in many analysis' today. The relationship of the maxilla and the mandible are related to the cranial base as well as each to other.

The angles SNA, SNB and ANB are also a component of the Steiner analysis. The Steiner analysis (1953; 1959; 1960) is often considered the first modern cephalometric analysis for two reasons. First it displayed measurements

in a way that emphasized not only individual measurements but also their inter-relationships. Second it offered specific guidelines for use of cephalometrics in treatment planning. The measurements for the Steiner analysis are represented graphically as "Steiner sticks". Interestingly, it is rumored that Steiner's standards are based on one Hollywood actress. Dr. Steiner must of had a good eye, because recalculation of his original values based on larger samples produced only small changes (Proffit 1993).

The Sassouni analysis (1955) was the first cephalometric analysis to include vertical as well as horizontal relationships. Sassouni believed that the inclination of the anterior cranial base, the Frankfort-Horizontal plane, the palatal plane, occlusal plane and mandibular plane all converged to a single point in well proportioned faces. If the planes converged close to the face then this was typically a long face with a predisposition to an open bite. If the planes converged far behind the face then this was typically a short face with a predisposition to a deep bite. Planes with unusual inclination so that they missed the general area of intersection were easily identified as important factors in the vertical relationships of the face. The

anterior-posterior dimension of the face and the dentition were related by a series of arcs drawn at certain points on the horizontal planes. The arcial analysis described by Sassouni is no longer used but the concept of horizontal planes is still widely used in assessing the vertical relationships of the face and occlusion.

Burstone (1958; 1959; 1967) recognized that previous cephalometric analyses were only concerned with skeletal and dental relationships and that little attention was being made to soft tissue relationships. Using the lateral cephalograms of thirty-two acceptable faces, Burstone developed a number of measurements of normal soft tissue relationships. These measurements included lip length, lip line, nose length and lip protrusion. Soft tissue analysis became an important component to cephalometric data.

Ricketts (1960; 1961) studied one thousand consecutive cases and suggested five measurements which were indicators of facial depth, facial height, and profile contour. Ricketts' analysis not only described a patient's initial condition but was also capable of measuring the amount of change expected from normal growth and treatment. The term visual treatment objective (VTO) was coined to describe the effects from growth and treatment. VTO's play an important role in establishing treatment objectives and mechanics.

In 1968, Ricketts using the esthetic-plane (a plane from the tip of the nose to soft tissue pogonion) formulated the law of lip relationships. This law states that in caucasian individuals the lips are contained within the esthetic plane with the upper lip slightly posterior to the lower lip.

Ricketts (1981) revised his original descriptive analysis to present an eleven factor summary analysis. The eleven factor summary analysis has four objectives as follows; (1) location of the chin space, (2) location of the maxilla through the convexity of the face, (3) location of the denture in face, (4) evaluation of the profile. The reference lines for this analysis are Frankfort-Horizontal, nasion-basion, and pterygoid vertical. The major weakness of the Ricketts' analysis is that the normative data are derived from an unspecified sample, and thus caution must be used when measurements are significantly different from the norms (Proffit 1993).

The Harvold analysis (1974) is derived from data in the Burlington Growth Study. In this analysis, standards for the unit length of the maxilla and the mandible are given and the difference between these numbers is an indication of the size discrepancy between the jaws. Harvold's analysis also takes into account the vertical

dimension of the face and the effect it has on the anterior-posterior position of the chin. The Harvold standards are not influenced by the position of the teeth.

The Wits analysis (Jacobson 1975) in contrast to the Harvold analysis takes into account the vertical and horizontal position of the teeth. The Wits analysis is an alternative method to the use of ANB in determining the anterior-posterior relationships of the jaws. In this analysis, perpendicular projections from A-Point and B-point are marked on the functional occlusal plane. If the anterior-posterior position of the jaws is normal then the projections from A-point and B-point will intersect the occlusal plane at nearly the same point. In Class II skeletal patterns A-point will be ahead of B-point and the reverse will be true in class III skeletal patterns. The Wits analysis is greatly influenced by the position of the teeth which may camouflage skeletal relationships. The most recent cephalometric analysis was proposed by McNamara (1984) at the University of Michigan. This analysis combines parts from both Ricketts' and Harvold's analysis in an effort to relate teeth to teeth, teeth to jaws, each jaw to the other, and the jaws to the cranial base. In this analysis, Frankfort-Horizontal and the basion-nasion planes are used as reference lines. The anterior posterior

position of the maxilla is evaluated relative to nasion perpendicular to Frankfort. The size of anterior-posterior discrepancy is evaluated by comparison of effective mandibular and maxillary unit length, as in the Harvold analysis. The position of the mandible is evaluated using lower anterior face height. The position of the maxillary teeth are evaluated relative to the maxilla by Point A perpendicular to Frankfort and the position of the lower incisor is evaluated relative to the A-Pogonion line. The strengths of this analysis is the projection of the anterior-posterior discrepancy relative to a true vertical line and the well defined samples (Bolton, Burlington, and Ann Arbor) from which the normative data are based (Proffit 1993).

In conclusion, it is clear cephalometric analysis has evolved into an integral part of orthodontic diagnosis and treatment planning. Cephalometrics has become invaluable in evaluating the dental, skeletal and soft tissue relationships often not available from clinical examination or model analysis. However, with the large number of different cephalometric analyses' each with different measurements, placing diagnostic value on individual variables can be very confusing. It would be very beneficial if all these cephalometric analyses could be

consolidated using only the cephalometric measurements which are known to be of diagnostic importance. Diagnostically important measurements would be those measurements which could account for the maximum variation in the craniofacial complex.

The Development of the Cephalometric Index

Factor analysis is a statistical technique which reduces a large number of correlated variables into a smaller number of uncorrelated sets or factors. With this technique, it can be demonstrated that a large portion of the variation in a given sample is included in a subset of principal factors. Factor analysis has been applied to cephalometrics to describe the variation in the craniofacial complex (Brown et al., 1965; Solow 1966). These studies showed factor analysis could be used to describe mathematical relationships between cephalometric variables. These relationships were intended to be a guide to the biologic influences underlying the observed dependent and independent variation in the original variables. More recent studies have used factor analysis to study craniofacial growth by attempting to identify growth patterns in different cephalometric variables (Cleall and Chebib 1976; Cleall and Begole 1979; Buschang et al.,1982; Ohtsuki et al.,1982).

Previous studies using factor analysis applied to cephalometric research have not fully determined the variables that most thoroughly describe the variation in the craniofacial region. To completely study the variation in the craniofacial region it would be more beneficial to study the craniofacial complex as a whole. Individual cephalometric analysis only account for part of the variation in the craniofacial region and often contain redundant measurements. Spillas (1993) used ten popular cephalometric analysis' and factor analysis to reduce the number of cephalometric variables necessary to account for maximum variation in the craniofacial complex. In this study, one hundred and fifty radiographs taken from fifteen males and fifteen females at ages 6,9,12,15, and 18 comprised the sample. These records were provided by the Bolton Brush Growth Center, Cleveland, Ohio and consisted of the sample used to produce the "Bolton Standard" templates. Each cephalogram was traced utilizing one hundred and thirty-four measurements taken from ten popular cephalometric analysis'. Factor analysis performed on these measurements generated fourteen factors which accounted for 84.3 % of the total variance in the craniofacial complex.

Dhingra (1995) verified Spillas' statistical technique using a 150 pretreatment lateral cephalograms

from the orthodontic clinic at Case Western Reserve University. Dhingra also extracted fourteen factors which accounted for nearly the same variation as reported by Spillas. In the second part of Dhingra's study, a reduced number of cephalometric variables were chosen from the fourteen variables by a group of five experienced orthodontists practicing in the Cleveland area. Nineteen variables were selected by the five orthodontists based on diagnostic importance. A cephalometric index was constructed by comparing these nineteen variables in an orthodontic treatment needed group to an orthodontic treatment not needed group via discriminant analysis. Discriminant analysis between the two groups was done using both a forced entry method and a stepwise procedure. In Dhingra's sample of twelve year olds, the stepwise method used seven variables (palatal plane, upper lip length, posterior face height, SNB, lower lip to E plane, mandibular prognathism and upper 1-FH) and correctly classified 96.7% for each the treatment needed group and the treatment not needed group. Using the forced entry method 96.7% of the treatment needed group and 100% of the treatment not needed group were correctly classified. These findings demonstrate the feasibility of using a cephalometric index to correctly identify subjects with and

without orthodontic treatment need. The cephalometric index of orthodontic treatment need may serve as a valuable adjunct to already existing occlusal indices. However, before too much merit is placed on the cephalometric index of orthodontic treatment need, it first needs to be validated on a different sample.

STATEMENT OF THESIS

The long-term objective of this study is to facilitate the development of a cephalometric index to be used in conjunction with occlusal and facial analyses in evaluating orthodontic treatment need, orthodontic treatment severity or priority and orthodontic treatment outcome. Specifically, this study will determine the validity of the cephalometric index developed to predict orthodontic treatment need via statistical tests for sensitivity and specificity.

MATERIALS AND METHODS

Study Population

Control Group

The control group or treatment not needed group consisted of sixty-two lateral cephalograms of Caucasian subjects taken from the Burlington Growth Study, in Toronto, Ontario, Canada. The subjects in the control sample consist of untreated individuals with class I molar and skeletal relationships, and represent average vertical growth patterns as determined by the standards used in the Burlington Growth Study (Popovich and Thompson 1977). The average age of the control sample at the time of the lateral cephalogram was twelve years of age and consisted of equal proportions of males and females. Twelve years of age was the age Dhingra(1995) used in constructing the cephalometric index and was based on the average age of exfoliation of second deciduous mandibular molars and closure of the leeway space. Twelve years of age is also typical of the starting age of many orthodontic patients. Verification of no cephalometric indication for orthodontictreatment was confirmed by three experienced

practicing orthodontists on faculty in the Department of Orthodontics at Case Western Reserve University, if any one of the three orthodontists indicated there was a cephalometric indication for orthodontic treatment in a particular individual, that subject was eliminated from the sample.

Experimental Group

The experimental group, or treatment needed group consisted of thirty pretreatment lateral cephalograms of Caucasian subjects taken from the orthodontic clinic at Case Western Reserve University. All the subjects in the experimental group were currently undergoing or had completed orthodontic treatment. The average age of the control sample at the time of the lateral cephalogram was twelve years of age and consisted of equal proportions of males and females. Verification of a cephalometric indication for orthodontic treatment was confirmed by three experienced practicing orthodontists on faculty in the Department of Orthodontics at Case Western Reserve University, if any one of the three orthodontists indicated there was no cephalometric indication for orthodontic treatment in a particular individual, that subject was eliminated from the sample.

Data Collection

Lateral radiographs were traced on 0.03 inch matte acetate paper with a 0.5 mm HB lead pencil. Each tracing was digitized with a X-Y coordinate digitizer, an IBM computer and the software Dentofacial Planner™ (Dentofacial Software Incorporated, P.O Box 950, Station A, Toronto, Canada, M5W IG5). Each digitized tracing consisted of 152 recognized cephalometric landmarks as depicted in Appendix A. The digitized coordinates were used to calculate the nineteen measurements which compose the cephalometric index equation (with the exception of two of the nineteen measurements, A-point to nasion perpendicular and mandibular prognathism, which were measured manually because of inconsistencies in computerized measurements). A description of the nineteen measurements can be found in Appendix B.

The cephalometric index equation as determined by (Dhingra 1995) is as follows:

Cephalometric Index Score=
.158(A point to N-perp)-.2(facial convexity)
+.63(lower 1 to APo)+.189(lower1 to mand
plane)-.057(lower lip to E plane)+.052(mand
length)+.363(mand plane angle)-.192(mand
prognathism) +.012(mental labial sulcus)-
.013(nasal labial angle)-.035(occlusal plane)-
.428(palataplane)+.175(posterior
face height)+.045(saddle angle)-.132(SNA)
+.32(SNB) +.157(UFH:LFH)+.142(upper lip
length)+.182(upper1 to FH) -81.29

Cephalometric index scores above zero suggest a cephalometric indication for orthodontic treatment while cephalometric index scores below zero suggest no cephalometric indication for orthodontic treatment. Cephalometric index scores were calculated for both the control and experimental groups.

Errors made in landmark identification and for digitizing method were estimated by retracing and redigitizing 10% of the cephalometric radiographs. Selection of radiographs was randomly done. All of the 152 landmarks were redigitized by the same investigator and the nineteen measurements were then compared to those taken from the original tracings. Intra-class correlation coefficients were computed for reliability.

Data Analysis

The validity of an diagnostic test indicates how close the test scores corresponds to some objective gold standard. Validity is usually evaluated by calculating for sensitivity and specificity. Sensitivity is defined as the number of individuals positively identified by a diagnostic test,who are true positives, divided by the total number of individuals positive for the disease state. Specificity is defined as the number of individuals negatively identified by a diagnostic test, who are true negatives, divided by

the total number of individuals negative for the disease state (Krammer 1988).

Validity of the cephalometric index will be evaluated by calculating for sensitivity and specificity. In this study sensitivity will be defined as the number of individuals from the treatment needed group identified by the cephalometric index to need treatment divided by the total number in the treatment needed group. Specificity will be defined as the number of individuals from the no treatment needed group identified by the cephalometric index not to need treatment divided by the total number of individuals in the no treatment needed group. To evaluate how the sensitivity and specificity change at different cut off values for the index, a receiver operating charecteristic curve will be constructed using cut off values between -1 and 1.

RESULTS

The control group consisted of sixty-two lateral cephalograms determined not to have any cephalometric indications for orthodontic treatment. The experimental group consisted of thirty lateral cephalograms determined to have cephalometric indications for orthodontic treatment. The means and standard deviations of the nineteen measurements used in the cephalometric index for the control and experimental group is depicted in Table 1.

Validity of the Cephalometric Index

Control Group

Cephalometric index scores were calculated using the discriminant function as derived by Dhingra. The specificity of the cephalometric index was 46.7%. The number of cases with scores less than zero indicating no need for orthodontic treatment was 29. The number of scores above zero representing misclassifications in the control group was 33. A distribution of the cephalometric scores for the control group is depicted in Figure 1.

Table 1.— Mean and Standard Deviation of Variables used in Cephalometric Index For the Control and Experimental Groups.

Variable*	Control Group		Experimental Group	
	Mean	S.D	Mean	S.D
APTNPERP	-02.45	03.22	-02.08	04.01
FACLCNVX	085.73	02.45	084.54	03.96
LOWR1APO	-02.41	02.01	-02.42	02.54
LOWR1MPL	092.88	05.32	091.17	07.92
LOWRLIPE	001.72	02.58	-01.22	03.13
MANDLGTH	112.69	04.67	111.76	05.95
MANPLAGL	028.34	03.17	031.09	04.52
MANPROG	-06.69	05.92	-08.09	07.91
MLSULCUS	004.77	01.14	006.04	01.64
NASLBANG	130.97	10.62	128.60	15.75
OCCLPLAN	010.58	02.87	011.07	03.86
PALPLANE	001.45	03.16	-01.20	03.35
POSFACHT	072.58	04.35	072.62	04.56
SADANGLE	125.13	04.71	122.36	05.76
SNA	080.43	03.20	081.08	03.71
SNB	077.81	02.51	076.61	03.98
UFH:LFH	083.26	06.59	076.70	06.59
UPLIPLGTH	019.93	02.94	020.66	02.02
UPPER1FH	107.60	05.62	109.24	07.39

*Definition of variables are located in appendix B.

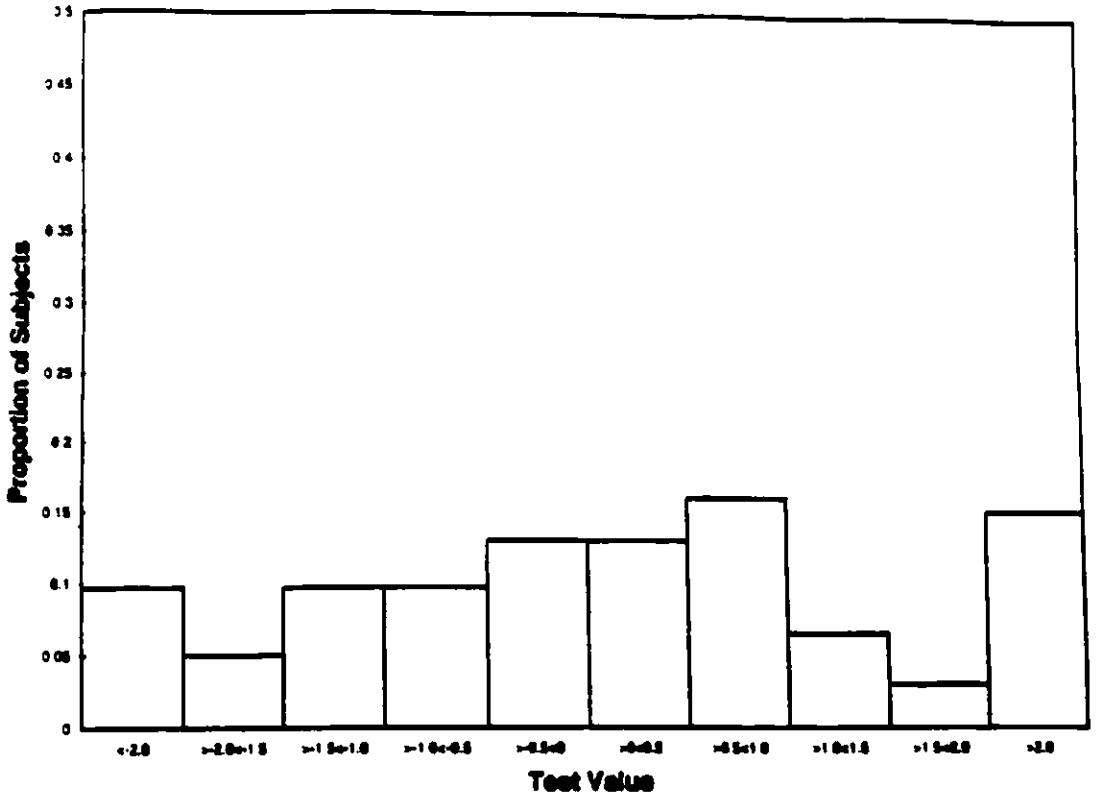


Figure 1. Distribution of cephalometric scores in the control group.

Experimental Group

The sensitivity of the cephalometric index determined from the experimental group was 73.3%. The number of scores below zero indicating a cephalometric need for orthodontic treatment was 22. The number of scores above zero, representing misclassifications was 8. A distribution of the cephalometric scores for the experimental group is depicted in Figure 2.

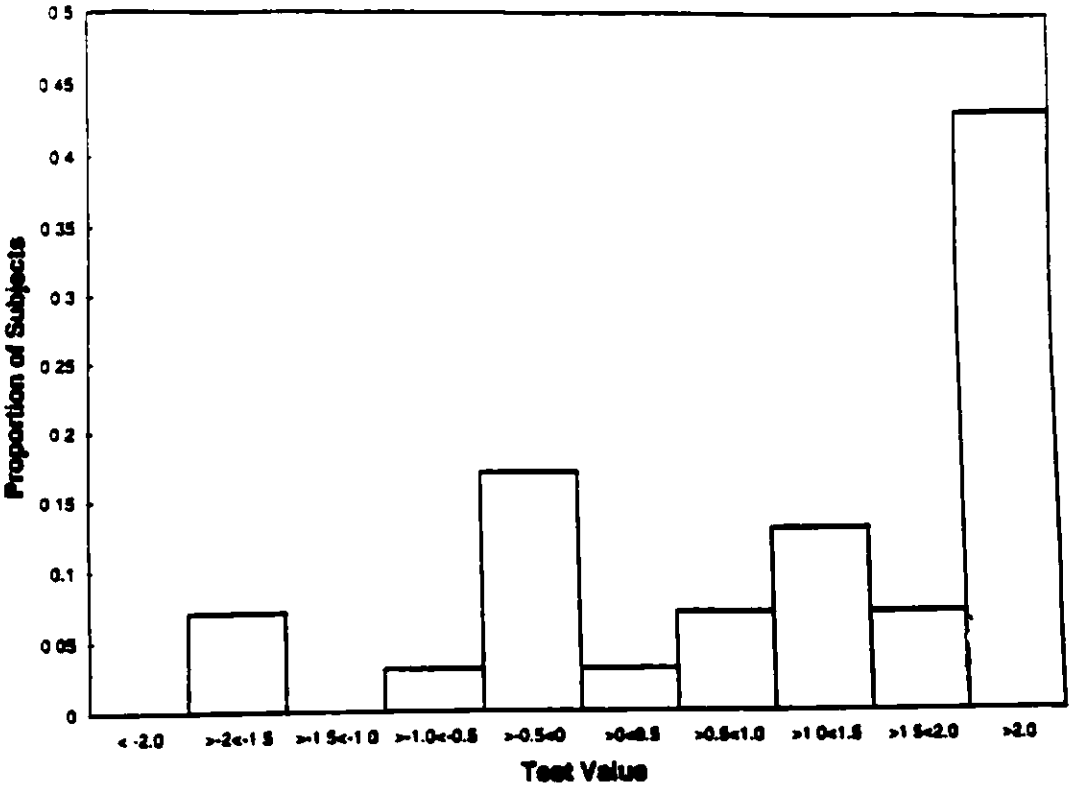


Figure 2. Distribution of cephalometric scores in the experimental group.

Misclassifications

The number of misclassifications in the control group was 33. Review of the misclassified subjects did not display any discernable pattern. However, it was observed there was a large number of borderline cases with cephalometric scores close to zero. Borderline cases have been defined as having cephalometric index scores above zero (indicating a cephalometric need for orthodontic treatment) but less than one. The number of subjects with

borderline scores was eighteen and if these cases are included in the correctly identified treatment not needed group the specificity increases to 75.8%.

The number of misclassifications in the experimental group was eight. Review of the misclassified subjects in the experimental group displayed the following cephalometric patterns; one subject had a class I skeletal pattern, one subject had a class II skeletal pattern, five subjects had class III skeletal patterns and two subjects had skeletal open bite tendency (with one subject displaying both an open bite tendency and a class III skeletal pattern). Borderline cases in the experimental group were defined as having scores between zero and minus one. The number of borderline cases in the experimental group was six and if these cases are included in the treatment need group the sensitivity increases to 93.3%.

The cut-off point of the cephalometric index was initially determined to be zero and thus the validity of the cephalometric index must be evaluated at this cut off value. Scores above zero suggest a cephalometric indication for orthodontic treatment while scores below zero suggest no cephalometric indication for orthodontic treatment. However, due to the large number of borderline cases in both the control and experimental groups it was

decided to evaluate the sensitivity and specificity for different cut-off values. The sensitivity and specificity at different cut-off values is depicted in Table 2 and a receiver operating characteristic curve is depicted in Figure 3. The original cut-off value of zero has been suggested to be ideal because the sensitivity is maximized while the specificity remains approximately 50%.

Table 2.--Sensitivity and Specificity of the Cephalometric Index at Various Cut-Off Values.

Cut Off Value	Sensitivity	Specificity
-1.00	93.3%	25.8%
-0.75	90.0%	33.8%
-0.50	90.0%	35.4%
-0.25	73.3%	38.7%
00.00	73.3%	46.7%
+0.25	70.0%	54.8%
+0.50	66.6%	61.3%
+0.75	66.6%	67.8%
+1.00	56.6%	75.8%

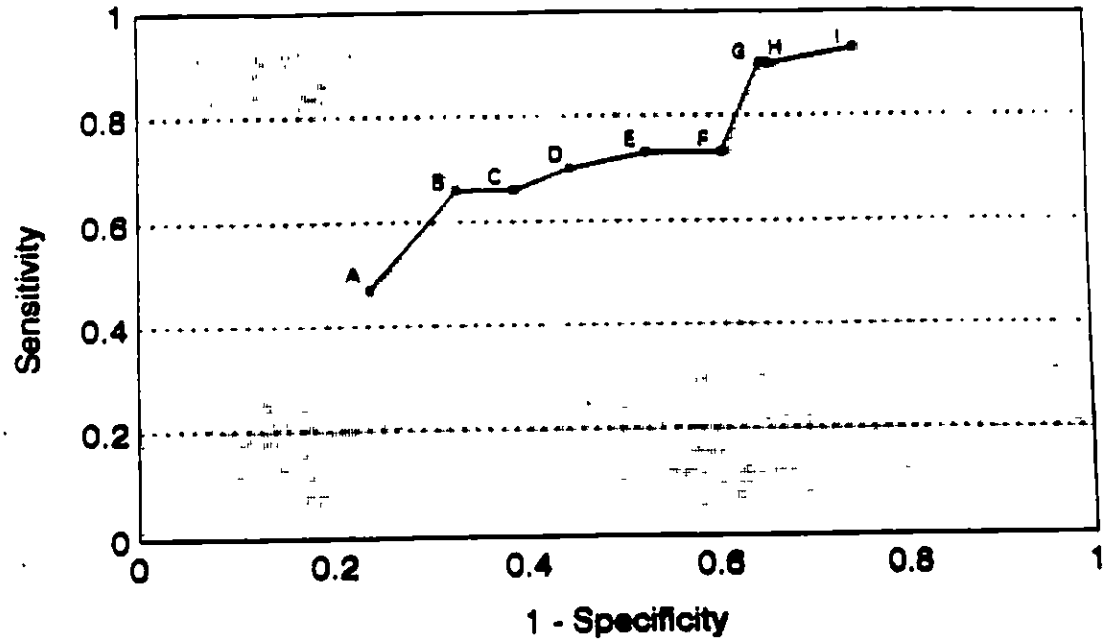


Figure 3. Receiver operating characteristic curve for different cut off values of the cephalometric index, with the cut-off values being as follows; A=1.0, B=0.75, C=0.5, D=0.25, E=0, F=-0.25, G=-0.5, H=-0.75, I=-1.0.

Error Study

Approximately 10% of the total sample (N=9) was retraced and digitized to detect any tracing or digitizing error. Intra-class correlation coefficients were computed, there was no significant difference between the two sets of data indicating tracing and digitization errors were minimal.The intra-class coefficinets for the nineteen variables is depicted in Table 3.

Table 3--Intra-class Coefficients of the Nineteen Variables in the Error Study.

Variable*	Intra-class Coeffecient
APTNPERP	0.98
FACLCNVX	0.97
LOWR1APO	0.98
LOWR1MPL	0.90
LOWRLIPE	0.98
MANDLGTH	0.96
MANPLAGL	0.98
MANPROGN	0.83
MLSULCUS	0.99
NASLBANG	0.91
OCCLPLAN	0.99
PALPLANE	0.90
POSFACHT	0.94
SADANGLE	0.99
SNA	0.95
SNB	0.99
UFH:LFH	0.99
UPLIPLTH	0.97
UPPER1FH	0.98

*See appendix B for a definition of each variable.

DISCUSSION

The purpose of this study was to evaluate the validity of the cephalometric index for determining orthodontic treatment need with statistical tests for sensitivity and specificity. The control group or treatment not needed group consisted of sixty-two lateral cephalograms of twelve year olds with equal proportions of males and females. The cephalometric index correctly identified 46.7% of the control subjects. The experimental group or treatment needed group consisted of thirty lateral cephalograms of twelve year olds, with equal proportions of males and females. The cephalometric index correctly identified 73.3% of the subjects in the experimental group.

Thus, the specificity (46.7%) and sensitivity (73.3%) are significantly lower than the number of correctly classified subjects in Dhingra's initial sample. A likely reason for this discrepancy is that the discriminant function which was initially created was based on a relatively small sample and then tested on the same sample from which it was derived. It is apparent that the discriminate function was very accurate in being able to

correctly identify subjects in the original sample but was clearly not as accurate in discriminating treatment needed subjects from the no treatment needed subjects when applied to a new sample. There are several other explanations which might account for this discrepancy and these are discussed independently below.

Specificity of the Cephalometric Index

The specificity or the ability of the cephalometric index to identify subjects with no cephalometric indications for orthodontic treatment was poor. The cephalometric index correctly identified twenty-nine subjects in the control group while thirty-three subjects were misclassified. The original coefficients for the nineteen variables used in the cephalometric index were determined by discriminant analysis between a no treatment needed group and a treatment needed group. The original no treatment needed group consisted of thirty subjects from the Bolton Brush Growth Study identified as Bolton standards. The Bolton standards were used to create the Bolton templates, based on the fact that the standards possessed ideal dental, skeletal and facial relationships. However, it is not exactly clear how these relationships were evaluated and we can only assume that these subjects used in creating the index had no cephalometric indication

for orthodontic treatment. Thus, the validity of the original no treatment needed group is questionable and may account for the low specificity of the cephalometric index when applied to a new control group.

The same problem was encountered when trying to identify an adequate control sample for this study. In this study, sixty-two lateral cephalograms from the Burlington Growth Study were used as the control group or no treatment needed group. These subjects were selected as not needing orthodontic treatment based on the following assumptions; they were untreated and were offered treatment if the initial examiner felt it was warranted, they consisted of class I dental and skeletal patterns, and they displayed an average vertical growth pattern. To further verify there was no cephalometric indication for orthodontic treatment, three experienced orthodontists on faculty at the Case Western Reserve University Department of Orthodontics evaluated the control subjects. If any one of the orthodontists felt there may be a cephalometric indication for orthodontic treatment in an individual they were eliminated from the control sample. However, we can still only assume that there is no cephalometric indication for orthodontic treatment in the control sample and the validity of this control sample is questionable.

The difficulty in identifying subjects with no cephalometric indication for orthodontic treatment results from the lack of an appropriate gold standard. Many medical conditions are dichotomous, i.e., biopsies for colon cancer are either postive or negative; this is not the situation with orthodontic problems. The difference between normal occlusion and malocclusion is not point specific, but rather falls into a broad gray range between normal variation and deviation. Without specific criteria which identify cephalometric indications for orthodontic treatment, selection of an appropriate control sample becomes inherently biased.

Many of the cephalometric norms in use today were developed from 1945 to 1955, when cephalometrics was first gaining importance as a diagnostic tool. Downs (1948) published his cephalometric norms based on twenty-five children, between the ages of 12-17, meeting his criteria of clinically excellent occlusion and facial proportions. Steiner, apparently based his norms from the cephalometric values of one Hollywood actress. The Tweed diagnostic triangle is based from a sample of ninety-five individuals, who Tweed believed to have satisfactory facial esthetics, with little emphasis being put on the occlusion. Orthodontists, routinely used these norms as treatment

goals, and thus these values are important in determining orthodontic treatment need. It is important to realize that most of these norms are based from very small samples and from one clinician's opinion.

The samples from which these normal cephalometric values have been determined also exemplify the concept that normality is a continuum rather than located at a specific value. In Tweed's own selected sample the norms for FMA, FMIA and IMPA are suggested to be 25°, 65°, and 90°, however in his control sample, FMA ranged from 15° to 36°, FMIA ranged from 56° to 80° and IMPA ranged from 76° to 99°. Casko and Shepherd (1984) identified seventy-nine adults with no history of orthodontic treatment, and in their opinion had ideal occlusion. Using this sample they calculated the mean, standard deviation, mode and range of thirty popular cephalometric measurements. All of the cephalometric measurements for these normal individual's showed a wide range of variation, i.e., ANB ranged from -3° to 8°, and interincisal angle ranged from 107° to 147°. There appeared to be a significant amount of variation among individual's with normal occlusion, and if only cephalometric means were used in determining treatment need, many of these subjects would have been classified as

abnormal and recommended for orthodontic treatment.

The large range of normal variation among normal individual's may account for the large number of control subjects with borderline scores misclassified by the cephalometric index. The coefficients used in the cephalometric index were calculated using the means of the nineteen measurements. In the same manner in which Casko (1984) pointed out the limitations of using cephalometric means as treatment goals, the same limitations apply in using cephalometric means to determine the coefficients for the cephalometric index. Borderline cases have been defined as having cephalometric index scores above zero (indicating a cephalometric need for orthodontic treatment) but less than one. The number of subjects with borderline scores was eighteen and if these cases are included in the correctly identified treatment not needed group the specificity increases to 75.8%.

Sensitivity of the Cephalometric Index

The sensitivity or the proportion of subjects correctly identified by the index to have cephalometric indications for orthodontic treatment was 73.3%. Twenty-two subjects were correctly identified by the index while eight subjects were misclassified. Unlike in the control group, in which there was no recognizable pattern amongst the

misclassified subjects, a very clear pattern was evident amongst the misclassified subjects in the experimental group. Five out of the eight misclassified subjects in the experimental group had class III skeletal and dental patterns. In fact all of the class III individual's in the experimental group were classified as not needing treatment. The cephalometric index was constructed by comparing the means of the nineteen measurements in a no treatment needed group to a treatment needed group. The means of the no treatment needed group probably accurately represent normal values. However, the same assumption can not be made for the treatment needed group. Abnormal measurements or measurements indicating a cephalometric indication for orthodontic treatment fall on both sides of a cephalometric norm. If the means are used to represent the treatment needed group then deviations away from normal values are underestimated, if the treatment needed group contains individuals with opposite problems. For example, review of Dhingra's initial treatment needed sample revealed only two subjects with class III skeletal patterns while the majority of the sample consisted of class II individuals, since means were used to calculate the coefficients of the cephalometric index, it becomes clear why the cephalometric index was not able to identify class

III individuals as needing treatment. The same problem exists for all the coefficients used in the cephalometric index.

Limitations

Three experienced orthodontists were used to verify that the subjects in the control and experimental groups concurred with their ideas of cephalometric indications for orthodontic treatment. In evaluating the lateral cephalograms, the orthodontists were not given any cephalometric measurements. There decision on treatment need was based recognizing dental, skeletal, and soft tissue patterns and how these patterns compared to their ideal of normality. The low specificity of the cephalometric index may be the result of the limitations of only using numbers to determine cephalometric indications for orthodontic treatment, while the orthodontists made their decisions based on pattern recognition. Discriminating two groups based on numerical measurements can easily be accomplished using mathematical relationships, while, discriminating two groups based on pattern recognition may not be feasible with mathematical relationships and is likely only a quality inherent to human rationale. Natural dental compensations may result in an ideal occlusion even with underlying skeletal

discrepancies, and therefore may not have any indication for orthodontic treatment. These patterns are easily recognized by the orthodontist but unlikely to be detected by the cephalometric index. Indices can not substitute for clinical judgement.

Cephalometric radiographs provide a two dimensional image of anatomic structures located in three dimensions. Lateral cephalograms are useful in evaluating structures in the vertical and antero-posterior dimensions but are incapable of providing information in the transverse dimension.

Soft tissue measurements taken from lateral cephalograms are often dependent on lip posture at the time of exposure of the radiograph. Soft tissue measurements are also highly variable due to individual variation in tissue thickness, nose size and chin protrusion. Five out of the nineteen measurements used in the cephalometric index are based on soft tissue relationships. Inconsistencies in lip posture and difficultly in identifying soft tissue landmarks were present in both the control and experimental groups.

The lack of an appropriate gold standard for which cephalometric norms are established makes it very difficult in determining cephalometric indications for

orthodontic treatment. This is confounded by the fact that individuals exhibit large ranges of normal variation. The dividing line between normal variation and deviation is likely dependent on how well skeletal and dental relationships can compensate for each other. For example, the same high ANB angle in one individual may constitute a cephalometric need for orthodontic treatment, while in another individual with an accomadating steep occlusal plane, there may be no indication for orthodontic treatment.

With the large amount of individual variation and the lack of an appropriate gold standard, how much emphasis should cephalometrics have on orthodontic diagnosis and treatment planning? Han et al., (1991) pointed out that there was no single positive criterion to distinguish patients with "normal" skeletodental relationship and facial form from those considered to be "abnormal". This study evaluated how incremental information obtained from different types of diagnostic records contributes to the determination of orthodontic treatment decisions. They reported, in the majority of cases, study models alone provided adequate information for treatment planning, and incremental addition of information from other types of diagnostic records only made small

differences. Atchinson et al., (1992) investigated the orthodontists' rationale for ordering pretreatment radiographs and the impact these radiographs had on diagnosis and treatment planning. They found that pretreatment radiographs produced a 16% change in diagnosis and a 20% change in treatment plans. If lateral cephalograms only have a small impact in orthodontic diagnosis, then a cephalometric index which predicts orthodontic treatment need would also be of limited value.

Future Studies

The logical next step is to re-derive the cephalometric index based on deviations from normal values as opposed to using the means of the nineteen measurements for a treatment needed group and a no treatment needed group. It is clear that there exists a range of normality and values outside of this range should have a cumulative effect on the cephalometric index scores regardless of which side of the mean they are on. The range of normality needs to be defined for each of the nineteen measurements. In determining cephalometric indications for orthodontic treatment, appropriate weightings should be placed on the cephalometric measurements which fall outside their normal range. These measurements should be weighted based on their

diagnostic importance.

To achieve an accurate range of normal variation the sample size of the no treatment needed group should be enlarged and include all ethnic groups. This perhaps, can be initially achieved by combining Dhingra's initial no treatment needed group with the no treatment needed group used in this study.

The variables used in the cephalometric index were selected based on their diagnostic importance to five orthodontists in the Cleveland, Ohio area. In order to ensure these variables are generally accepted throughout the profession, it would be beneficial to re-select variables used in the cephalometric index with a larger number of orthodontists in a variety of geographic locations.

The limitations of cephalometrics and occlusal indices have been discussed. A more reliable index of orthodontic treatment need would likely be achieved if an index could be developed which encorporated both cephalometric and occlusal variables. By combining the cephalometric index with an occlusal index, the limitations of both these types of indices could be minimized. If such an index could be created to evaluate orthodontic treatment need, such an index may prove useful in evaluating orthodontic treatment outcome.

SUMMARY AND CONCLUSIONS

The validity of a cephalometric index used to predict orthodontic treatment need was evaluated by using statistical tests for sensitivity and specificity. The control group or treatment not needed group consisted of sixty-two lateral cephalograms and the experimental group or treatment needed group consisted of thirty lateral cephalograms, the average age of both samples was twelve years of age and consisted of equal proportions of males and females. Analysis of the data lead to the following conclusions:

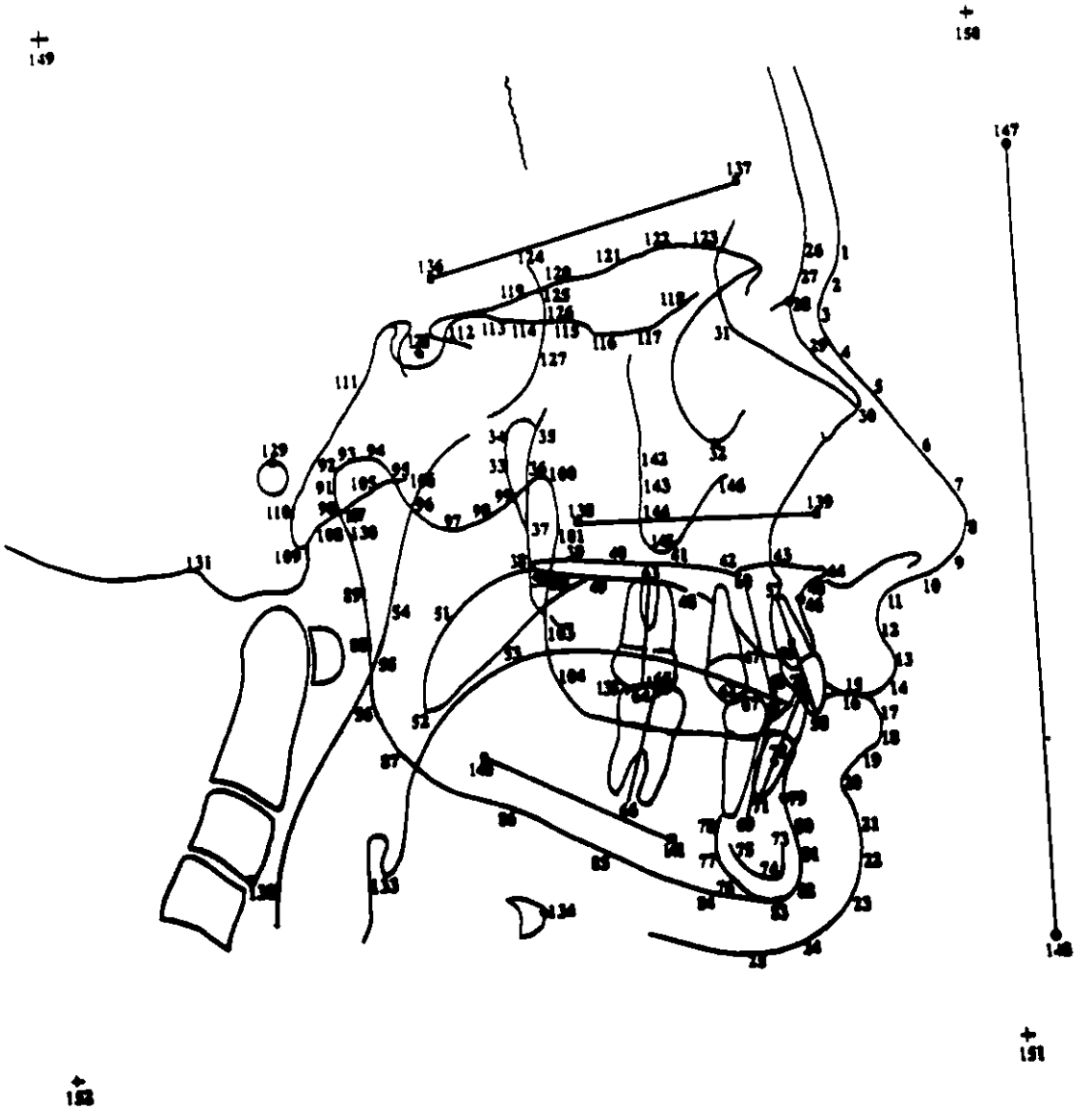
1) The specificity or the proportion of subjects correctly identified by the cephalometric index not to have any cephalometric indications for orthodontic treatment was 46.7%.

2) The sensitivity or the proportion of subjects correctly identified by the cephalometric index to have cephalometric indications for orthodontic treatment was 73.3%.

3) The current limitations of the cephalometric index have been discussed and methods to improve the applicability of the cephalometric index to determine orthodontic treatment need have been suggested.

APPENDIX A

CWRU tracing regimen.



APPENDIX B

Variables used in the cephalometric index are defined as follows:

1. Posterior face height (POSFACHT) - The linear measurement between the cephalometric landmarks sella and gonion.

2. Mandibular length (MANDLGTH) - The linear distance between the cephalometric landmarks condylion to gnathion.

3. Upper lip length (UPLIPLGHT) - The linear distance between the anatomical landmarks anterior nasal spine and the embrasure area of the lips

4. Lower incisor to mandibular plane (LOWR1MPL)- The angle formed by the mandibular plane and the long axis of the incisor.

5. Lower incisor to A-Po (LOWR1APO) - The angle formed by the anatomical planes: the long axis of the lower incisor and the A-point to pogonion plane.

6. SNA- The angle formed by the anatomic landmarks sella,nasion, and A-point.

7. SNB - The angle formed by the anatomical landmarks sella, nasion, and B- point.

8. Mandibular prognathism (MANPROG) - The linear distance between soft tissue pogonion to the plane glabella perpendicular to Frankfort-Horizontal.

9. A point to N perpendicular (APTNPERP) - The linear distance A-point and the plane nasion perpendicular to Frankfort-Horizontal.

10. Lower lip to E plane (LOWRLIPE) - The linear distance between the most prominent point on upper lip and the esthetic (nose -chin) plane.

11. Nasolabial angle (NASLBANG) - The angle formed by columella and the drape of the upper lip.

12. Facial convexity (FACLCNVX) - The angle formed by the anatomical planes Frankfort-Horizontal and nasion-pogonion.

13. Palatal Plane Angle (PALPLANE) - The angle formed by the anatomical planes Frankfort-Horizontal and the palatal plane (ANS-PNS).

14. Mandibular plane angle (MANPLAGL) - The angle formed by the anatomical planes mandibular plane (gonion-menton) and Frankfort-Horizontal.

15. Occlusal plane angle (OCCLPLAN) - The angles formed by the anatomical planes Frankfort-Horizontal and the occlusal plane.

16. Saddle angle (SADANGLE) - The angle formed by the anatomical landmarks nasion, sella, and articulare.

17. Upper incisor to FH (UPPER1FH) - The angle formed by the anatomical planes long axis of upper incisor and Frankfort-Horizontal.

18. Mentolabial sulcus (MLSULCUS) - The linear distance from the mentolabial sulcus to he plane labrale inferiorus-pogonion.

19. UFH:LFH - The soft tissue ratio of upper facial height to lower facial height, expressed as a percentage.

Note: All linear measurements are expressed in millimeters. The Frankfort-Horizontal plane was determined by using the sella-nasion plane -7°

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