# IS THE INITIAL ASSESSMENT OF STUDY MODELS UTILIZING THE DENTAL AESTHETIC INDEX RELIABLE?

**A Preliminary Investigation into the Categorization of Orthodontic Treatment Difficulty**

**by**

**Nicki De Francesco**

A thesis submitted to the Faculty of Graduate Studies

of the University of Manitoba

in partial fulfillment of the requirements for the degree of

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## ABSTRACT

Variations in how orthodontics is practiced are widely acknowledged but infrequently studied. These differences are commonly accepted as reflections of the "art of dentistry". An alternative view holds that such variations identify aspects of the specialty where there is disagreement concerning the most effective approach to the treatment for malocclusions.

Increasing demands for quality assurance pose a serious threat to dental service providers. This is particularly relevant to the provision of orthodontic services. For instance, whereas the early provision of orthodontic services is conventionally assumed to improve the resolution of Class II malocclusions, more recent evidence suggests that little advantage is to be gained by early intervention (Tulloch et al 1997).

The progressive provision of services by non-specialist providers previously considered the exclusive domain of the orthodontic specialist is not the principal market threat, however, but their quality assurances. The potential impact of these threats may be illustrated when a provider (specialist or generalist) fails to identify a true Class III malocclusion, e.g. where the mandible is rotated down and back to a moderate Class II relationship. If the provider then applies a Class II functional appliance to such a camouflaged Class III malocclusion, the outcome will exacerbate rather than resolve the skeletal anomaly (Woodside 1998). Similar concerns apply to the use of conventional functional appliances in cases characterized by excessive lower anterior face height, since they may potentially induce further increases in lower face height, increased downward and backward mandibular rotation and anterior open bite (Woodside 1998). Clearly such market threats will only be resolved by strategic development to improve the quality assurances of patient assessments (diagnosis) prior to treatment planning.

In order to examine the consistency of orthodontic care, the pretreatment dental records (radiographs, study models, and photos) of four patients representative of the range of Class II division I malocclusions were examined by two groups of specialists and then checked against their Handicapping Labiolingual Index (HLD). The first group of 42 specialists used both the dental aesthetic index (DAI) and a ten-point visual-analog (Likert-type) scale, to assess the treatment difficulty of the cases. The second group of 241 volunteer specialists simply assessed these cases against the Likert-type scale. The results not

only showed significant variation in case-assessments between different specialists, but also significant contrasts depending on the index used for their assessment. These conflicts were illustrated by Case #4, where both the mean analog (6.0) and the DAI (32.4) scores, indicated that the malocclusion was not severe enough to warrant treatment. By contrast the HLD Index (55) indicated Case #4 had a severe malocclusion (with a palatally impinging overbite, > 9mm severe overjet, and a posterior bilateral crossbite).

The data therefore indicated that assessments of orthodontic treatment difficulty may be too complex for consistent assessments by simplistic indices.

# INTRODUCTION

## Contents

This section is divided into two main areas:

### Section 1 – Introduction to Indices



### Section 2 – Literature Review

# INTRODUCTION AND LITERATURE REVIEW

## Section I – Introduction of Indices

### 1.0 Indices in Orthodontics

As researchers push the boundaries of the known into the realm of the unknown, the area of epidemiology with respect to orthodontics, has become an increasingly important area of study. It behooves the present day orthodontic clinical researcher to assess the criteria that have become the foundations of treatment planning in orthodontics and extract the crucial elements and incorporate them into a manageable epidemiological index derived from the already existing treatment planning indices.

There have been many Herculean attempts to condense the knowledge and judgement of an experienced orthodontist into five categories of indices; epidemiological, treatment need, treatment success, treatment complexity, subjective quantitative assessment. The pivotal problem is how to assess case difficulty. More research is needed since adequate data regarding the reliability and validity of currently available indices does not exist in North America at this time (Wheeler1993).

All indices have deficiencies because they are basically occlusal indices and do not take into account the patient's skeletal characteristics, age, sex, race, growth patterns and many other factors which would make the index too unwieldy to use in a clinical screening of a large number of potential patients (Proffit & Ackerman, 1973).

### 1.1 Types of Indices

The most important requirement of any index is that it allows reliable intra- and inter-examiner assessments of a malocclusion (Otuyemi and Jones, 1995). The criteria identified for evaluating indices includes; validity, reliability, modifiable, simplicity, comprehensive, prioritized, useful, psycho-social (Wheeler, 1993). The following is a review of the five types of indices and the potential methods which have been developed of assessing and grading malocclusion:

**Table 1.1** **EPIDEMIOLOGICAL INDICES**

| TYPE | METHOD | DISADVANTAGES |
|---|---|---|
| Dento-Facial Index (DFI) (Elsasser, 1953; Pelton, & Elsasser, 1953) | Dentofacial Morphometric measurements | Anthropological studies |
| Index of Tooth Position (ITP) (Massler & Frankel, 1951) | Quantitative measurements based on individual teeth as units of occlusion and recorded as "maloccluded" or "aligned" | Unreliable (no indication of relative severity) |
| Malalignment Index (MI) (Van Kirk & Pennell, 1959) | Each arch was divided into three segments; two posterior and one anterior. A score of; '0' = ideal alignment '1' = minor malalignment '2' = major malalignment | Unreliable (did not take into account the relationship between the upper and lower teeth in occlusion) |
| Occlusal Feature Index (OFI) (Poulton & Aaronson, 1961) | Population studies. Most important features of occlusion; lower anterior crowding, cuspal interdigitation, vertical overbite, horizontal overjet. Reliable in a validation study with reasonable inter-examiner reliability and good correlation with treatment need | Subjective (scores were allocated on a scale of 0-9; where '0' = 'normal' occlusion) |
| An Objective Method of Epidemiological Registration of Malocclusion (Bjork, Krebs & Solow, 1964) | 567 symptoms which allowed the data to be analysed by a computer. Based on in three main criteria; 1.13anomalies in the dentition b) anomalies in the occlusion c) deviations in space conditions | Unwieldy and too complex for clinical use |
| "FDI" Commission on Classification and Statistics for Oral Conditions (COCSTOC) (Baume et al, 1973) | Records three categories of occlusal features; dental anomalies intra-arch and inter-arch relations. FDI system is used to describe individual tooth malrelations | Designed for clinical examination of patients with a full complement of permanent teeth (excluding third molars) |
| Quantitative Assessment of the Occlusal Features (Kinaan & Burke, 1981) | Each arch was divided into three segments; two posterior, and one anterior. Measures five main occlusal features for epidemiological studies; overjet, overbite, posterior crossbite, buccal segment crowding, incisor segment alignment | Four instruments were required to aid in the intra-oral measurement of the occlusal features |

**Table 1.2 INDICES OF TREATMENT NEED**

| TYPE | METHOD | DISADVANTAGES |
|---|---|---|
| Handicapping Labio-Lingual Deviation Index (HLDI) (Draker, 1960) | No special equipment necessary Presence or absence of specified criteria was noted and scored; cleft palate, trauma-related malocclusions, overjet, labiolingual spread (severe displacement of teeth) | Does not account for missing, impacted or spacing between teeth. Ignores transverse discrepancies such as midline deviations and cross-bites. Component weightings are subjective. |
| Treatment Priority Index (TPI) (Grainger, 1967) | 375 twelve year old children from three Ontario communities. Defined seven "syndromes" of malocclusion. Five grades of treatment need were determined based on 10 criteria of malocclusion | Does not account for spacing, midline deviations, arch asymmetry, missing teeth due to trauma or caries. Lack of mixed dentition analysis. Cannot be applied to cases with missing first molars. |
| Handicapping Malocclusion Assessment Record (HMAR) (Salzman, 1968) | Endorsed by the AAO and the ADA. No need for a millimetre guage, therefore fewer clerical errors | Subjective component weightings. Cannot be used in the mixed dentition. No intermediate severity levels. Poorest levels of reliability and validity |
| 'Summers' Occlusal Index (SOI) (Summers, 1971) | One of the most reliable and valid indices of treatment need. Two divisions and seven syndromes described using the Occlusal Index | Criticized for being time-consuming and a cumbersome scoring system. Fails to score missing teeth other than upper incisors. Penalizes cases with a full unit pre-or post-normal molar relation although they do not cause static or functional occlusal interferences |
| Matched-Pair Similarity Technique (Freer, 1972) | Population was divided into two groups. 40 attributes were measured with a score of 'near perfect' to 'extreme malocclusion' | Inadequate theoretical basis |
| Swedish Index for Need of Orthodontic Treatment (Linder-Aronson, 1974; Ingervall & Ronnerman, 1975) | Initially designed to designate dental health and aesthetic Impairment Eventually a morphological and a functional index were added | Vague and arbitrary grade divisions lead to low levels of reproducibility |
| Norwegian Index (Norges, 1986) | Four categories of treatment need from 'very great need' to 'little or no need' | Based on morphological and functional indices |
| Index of Orthodontic Treatment Need (IOTN) (Brook & Shaw, (1989) | Ranks malocclusion based on occlusal traits for dental health and aesthetic impairment Incorporated a Dental Health Component (DHC) and an Aesthetic Component (AC). | Criticized due to lack of ability to assess dento-facial imbalance in the antero-posterior plane |

| TYPE | METHOD | DISADVANTAGES |
|---|---|---|
| Dental Aesthetic Index (DAI) (Cons, Jenny & Kahout, 1986) | Based on an evaluation of aesthetic factors/psychosocial handicap. Used as an epidemiological tool and accepted by the WHO. Ten criteria included to assess aesthetic impairment. | Criticized due to its failure to assess other important aesthetic anomalies such as: dental midline discrepancy, traumatic deep overbite, buccal cross-bite, open-bite, inability to assess mixed dentition cases |
| Standardized Continuum of Aesthetic Need (SCAN) (Evans & Shaw, 1987) | Based on perception of dental aesthetics in the U.K. using ten photographs with a scale from 1 (attractive) to 10 (unattractive). Simple to use with a high level of reliability even when used by non-dental personnel | Criticized for using only a two-dimensional guide (photos) with an insufficient catalogue of dental aesthetics (only ten photos), and the photographic view itself may affect the perception of dental attractiveness |
| California Modified Index (CalMod) ( Parker, 1998) | If any of the five conditions is present, the score column is marked with an "X" and there is no need to score further; cleft palate, deep impinging overbite, crossbite of individual anterior teeth, severe traumatic deviations, overjet greater than 9mm with incompetent lips or reverse overjet greater than 3.5mm with reported masticatory and speech difficulties. | Has been tested in the courts in California twice. A "lawsuit" driven index. |

**Table 1.3 INDICES OF TREATMENT SUCCESS**

| TYPE | METHOD | DISADVANTAGES |
|---|---|---|
| Efficiency of Orthodontic Treatment (Eismann, 1974) | Based on fifteen morphological criteria. Points were assigned with more severe conditions rating a higher score | Subjective nature of the allocation of points |
| Grading Orthodontic Treatment (Gottlieb, 1975) | Based on ten accepted criteria for orthodontic correction. 'Percentage achievement' was obtained for each factor which required correction | Method of grading was biased towards improvement with five points allotted for full correction of a feature but only one point deducted for worsening of the condition |
| Critical Evaluation of Orthodontic Treatment (Berg, 1979) | Skeletal and dental outcome criteria included; sagittal, vertical, transverse occlusion, alignment, axial inclination, apical resorption. First attempt to incorporate iatrogenic tooth damage into an index of treatment outcome | Inadequate theoretical basis |
| Peer Assessment Rating (PAR Index) (Richmond & Shaw, 1992) | Based on five criteria; upper and lower anterior contact point displacement, right and left buccal occlusion in three planes of space, overjet, overbite, dental centreline relation. Percentage PAR score change is reliable providing a quantitative and reproducible measure of treatment success. High reliability when used by non-dental personnel | Criticized for failing to assess axial inclination of anterior teeth post-treatment, for only measuring static tooth position, ignoring dynamic occlusion, facial aesthetics, iatrogenic decalcification, root resorption, and periodontal breakdown |

**Table 1.4 INDICES OF TREATMENT COMPLEXITY**

| TYPE | METHOD | DISADVANTAGES |
|---|---|---|
| Index of Complexity Outcome and Need (ICON) (Richmond, 1999) | Based on expert opinion of 97 practicing specialist orthodontists from 9 countries. For use clinically or on study models. For use in clinical governance, audit, research and decision making. Five weighted components taking approximately 1 minute to answer; aesthetic component (IOTN), upper arch crowding/spacing and impacted teeth, crossbite, incisor open bite, incisor overbite, buccal segment antero-posterior | Inadequate theoretical basis. Has not been validated. |

**Table 1.5 SUBJECTIVE QUANTITATIVE ASSESSMENTS**

| TYPE | METHOD | DISADVANTAGES |
|---|---|---|
| Likert (Visual – Analog) Scale (Bagozzi & Phillips, 1982) | A 10-point Likert-type (Analog) scale used for assessment of treatment difficulty, anchored by the statements "very difficult" (10) and "relatively simple" (0) with 7-4 representing moderately difficult to slightly complex Simple and effective way to assess the complexity or treatment need for orthodontics.Most commonly used method of assessing treatment need | Subjective method of evaluation |

## 1.2 Validity, Reliability and Weighting of Indices

The primary method of validation of indices has been to compare the scores derived from the index being tested with the traditional subjective quantitative assessment by orthodontists using the Likert (Visual-Analog) Scale (Bagozzi & Phillips, 1982). This method has been criticized by some authors (Carlos, 1970; Buchanan, 1991) who felt that the judgement of the clinician is not independent of the index being evaluated, and by other researchers (Jarvinen & Vaataja 1987) as more or less arbitrary calculations because knowledge of the consequences of untreated malocclusion remains inadequate.

Various weightings are given to each of the criteria in the index being tested in order to reflect the orthodontists' experience and contemporary clinical opinions. These weightings can be varied which gives the index flexibility with respect to geographic variations and clinical training of the orthodontists using the index. This method of giving certain criteria greater priority has been criticized by some authors ( Foster & Menezes, 1976) due to the fact that the basis on which the weightings were assigned was subjective creating a hierarchy of dental anomalies which warranted treatment more so than others.

## 1.3 Why Use Indices?

Increasing demands for quality assurance (i.e. service accountability, cost-effectiveness, etc.) from an increasingly informed, educated (either via secondary school education or by television advertisements), and image-conscious, litigious public may pose a serious conflict to the future delivery of dental services by the dental profession. Marked discrepancies in the provision of orthodontic services either between different specialists or specialists and generalists are, however, no longer consistent with the growing demands for the transparent accountability from the public. This includes the provision of orthodontic services, illustrated by an opinion that "the inexorable unfavorable patient response from excessive use by inadequately trained orthodontists and unqualified pediatric dentists and general practitioners, has produced a wave of frustration and backlash to functional (orthodontic) appliances in many quarters" (Graber, 1997). Although the lack of adequate training by general practitioners in diagnosis and treatment planning is particularly relevant to the provision of functional appliances (Chate, 1994), this problem also embraces other orthodontic services such as space maintainers (Brothwell 1997). For instance, whereas the early provision of orthodontic services is conventionally assumed to improve the resolution of Class II malocclusions, more recent evidence suggests that little advantage is to be gained by early intervention (Tulloch, Profitt & Philips, 1997). Variable post-retention outcomes (Blake & Bibby, 1998) are also serious threats to the provision of quality orthodontic services (Melrose & Millet, 1998), although these may be resolved by reducing the marked variations in retention protocols (Proffit & Fields, 1993; Graber & Vanarsdall, 1994). Meticulous strategic planning will therefore be mandatory to maintain future market growth for orthodontic services, especially in view of the marked variation in these threats across different locales (Richmond & Daniels, 1998).

The provision of orthodontic services was considered previously as the exclusive domain of those with advanced training, for example, orthodontic specialists (Moyers, 1990). However, it is not the progressive provision of such services by non-specialists that is perceived as a "market threat"; but the lack of quality assurances (Moyers, 1990). The potential impact of these threats may be illustrated when a provider (specialist or generalist) fails to identify a true Class III malocclusion, e.g. where the mandible is rotated down and back to a moderate Class II relationship. If the provider then applies a Class II functional appliance to such a camouflaged Class II malocclusion, the outcome will exacerbate rather than resolve the skeletal anomaly (Woodside, 1998). Similar concerns apply to the use of conventional functional appliances and cervical pull headgear in cases characterized by excessive lower anterior face height, since they may potentially induce further increases in lower face height, increased downward and backward mandibular rotation and anterior open bite (Woodside, 1998). Clearly such orthodontic failures will only be resolved by strategic development of diagnostic protocols to improve the quality assurances of patient assessments (diagnosis) prior to treatment planning.

In order to appreciate the importance of these market threats, regional discrepancies in the provision of orthodontic services will first be reviewed, followed by a discussion of the principle threats to the specialist orthodontic market. These are then followed by consideration of the need to priorize orthodontic service complexity and the utility of clinical evidence-based guidelines to constrain the provision of inappropriate services. This thesis is primarily centered on Class II malocclusions, although the market threats apply to services for all forms of malocclusion.

## 1.4 Why discrepancies in the provision of healthcare (including orthodontic) services pose significant market threats?

The most serious threats to the orthodontic market are the result of the wide discrepancies in the provision of services (Antkowiak & Knuty, 1993; Richmond & Daniels, 1998a; Woodside, 1998), since matching epidemiological data in support of the differential prevalences in malocclusions are limited (Jacobson & Lennartsson, 1996; Proffit, Fields & Moray, 1998; Sheats *et al.*, 1998a). Such concerns are not unique to orthodontics, but are generic to other dental markets (Bailit & Clive, 1981; Gotowka & Clive, 1988; Grembowski, Milgrom & Fiset, 1990a; Bader & Shugars, 1995a; Kostopoulou *et al.*, 1997), in addition to surgical deliveries (Wennberg, 1987), tonsillectomies (Lewis, 1980) and hysterectomies (Roos, 1984), hospital (e.g. admission rates) (Knickman & Foltz, 1984; Grembowski, Milgrom & Fiset 1990a) and physician visits (Chassin, Kosecoff & Park, 1989). Numerous hypotheses have been advanced to account for these discrepancies in the provision of health care services. These generally center around either patient (e.g. disease prevalence, socioeconomic characteristics, etc.) or provider characteristics (e.g. specialists or generalists providing the service). Unfortunately, relatively few studies have been undertaken to evaluate the clinical aspects of these discrepancies or their differential service outcomes (Roos, Roos & Henteleff, 1977; Leape *et al.*, 1990). Moreover, the principal concerns tend to center on the provision of excessive services by some providers, rather than the under servicing by others (Chassin, 1997), although the latter may be equally reprehensible.

Strategic development to accommodate these concerns is however, complicated by the tendency for service excesses to be provided by outlier groups (Leape et al., 1990), although these anomalies usually become evident only when they are retrospectively assessed by "expert" panels (Roos, Roos & Henteleff, 1977). These concerns are particularly relevant to the provision of orthodontic services, although a recent British study considered there was no justification for singling out outliers for special audits due to the lack of objective methods to assay service quality (Turbill, Richmond & Wright, 1998). Nevertheless, if strict criteria of an "ideal occlusion" are applied to define orthodontic service need, approximately 97% of the population would be defined in need (Jago, 1974). The provision of such service volumes would be difficult to rationalize, however, since resources will never be sufficient to provide unlimited demands, regardless of their mode of financing. These concerns are further underscored by discrepancies between traditional methods to assess the needs for orthodontic services. For instance, based on the 5-point scale of the Sweden National Board of Health and Welfare, 64 % for one child population sample were identified to be "in need of" orthodontic services (Bassler-Zeltman, Kretschmer & Goz, 1998), whereas when the Treatment Priority Index was applied to a similarly aged but different sample, 38% were "in need of" such services (Ugur *et al.*, 1998). As such discrepancies cannot be rationalized by epidemiological data, the need to devise scientifically supported clinical guidelines to define the most cost-effective services for specific occlusal discrepancies cannot be overstated. For instance, even when orthodontic service expenditures are entirely covered by state-benefits, a recent review of 1584 adolescents (15-16 years of age) showed that the provision of orthodontic services were not solely determined by the degree of malocclusion, but also the dental attendance record of the mother, in addition to other factors (Breistein & Burden, 1998).

Marked discrepancies in the provision of healthcare (including orthodontic) services may alternatively reflect professional uncertainties regarding the most appropriate services to provide for particular conditions (Wennberg, 1987; Liou & Huang, 1998; Davies, Turner & Sandy, 1998). Proponents of this "uncertainty hypothesis" maintain that reasonable specialist and non-specialist providers may be anticipated to arrive at different conclusions regarding the provision of orthodontic services in absence of accurate comparative data on their effectiveness. This hypothesis also implies that, whereas specialist and non-specialist providers may agree on the indications for orthodontic services that are clearly appropriate and on those that are clearly inappropriate, there are significant controversies for the large middle gray area. But whereas this uncertainty hypothesis may explain wide discrepancies in the provision of orthodontic services that fall within this gray area, there is no consensus whether the greatest source of uncertainty (e.g. premolar extraction) relates to the precision of the diagnosis or the outcome of a particular service (Ribarevski *et al.*, 1996).

Existing evidence is, however, most consistent with a differential "enthusiasm" hypothesis. This contends that discrepancies in the provision of services primarily reflect variations in the prevalence of providers who are "enthusiasts" about particular services or service groups (Chassin, Kosecoff & Park, 1987; Leape, Park & Solomon, 1989). Although the supportive data primarily relate to the provision of surgical services (Leape, Park & Solomon, 1989), there is a general consensus that such enthusiasm may originate from local training (e.g. continuing education courses), in which a particular authority communicates his/her enthusiasm to the audience. Converted "enthusiasts" may then convince his/her referral base concerning the potential advantages of such services, which may then be reflected by large discrepancies in their local provision. Moreover, services are even more susceptible to such "enthusiasm" when specialists are not required, since then primary providers (generalists) both evaluate the service need and subsequently provide the service (Chassin, 1993b).

Whereas these hypotheses furnish potentially useful explanations for discrepancies in the provision of orthodontic services by different providers, their eventual impact will depend on the variable and differential weighted primary determinants. (**Table 1.6**)

**Table 1.6 Causes of small/large area variations in orthodontic services**

| Cause | Potential Impact |
|---|---|
| Malocclusion prevalence | Differential orthodontic service rates may be correlated with variations in malocclusion prevalence in the local area |
| Access to specialist services | Variation in specialist service access for an area may be a function of their orthodontic service demands |
| Clinical judgement | Unique practice styles of different communities may correlate with the supplies of specific services |
| Quality of care | Lack of appropriate care by one class of providers may result in increased demands for others to rectify the service outcome |
| Patient behaviour | Local communities may have inherent characteristics that influence (how and when) their demands for specific orthodontic services |
| Random | Small populations with apparently analogous occlusal discrepancies may experience random demands for specific services. |
| Fees | Fees vary in different areas of the country and between rural versus urban areas |
| Advertising | The type of advertising whether it is by the local provincial orthodontic association or by the Canadian Orthodontic Association, or the internal advertising which is done by the individual practice. |

(Adapted from Chassin 1993a, Parchman 1995)

In view of complex interactions between such market determinants generally two basic formats are evident. The first is generally designed to determine if significant discrepancies actually exist, with the primary objective to ascertain whether they are greater than expected by chance (Folland & Stano, 1990). The second type of study is designed to evaluate the basic causes of provider discrepancies, mainly centering on the relationships between dependent and independent determinants of service need. The advantages of this latter type of study are illustrated by data from New England, which indicated that the provision of surgical services is a function of the number and type of specialists in the area (Wennberg, Barnes & Zubkoff, 1982). Although analogous data apply to the provision of orthodontic services (Pietila *et al.*, 1997), little data is available concerning the differential provision of orthodontic services by non-specialists. Moreover, the interpretation of data from these studies tend to be compromised by significant methodological and statistical deficiencies, that are difficult to resolve (Table 1.7).

**Table 1.7 Methodological and statistical design concerns for studies on service discrepancies**

| Potential deficiency | Center of controversy |
|---|---|
| Definition of small area | Is data for the provision of orthodontic services related to a coherent catchment area? |
| Population at risk | Is the population used to construct the orthodontic service rate truly representative of the population at primary risk? (i.e. do the samples comprise the diverse socioeconomic proportions characteristic of the community?) |
| Sample mix | Are there enough small areas included in the analysis to detect significant differences in orthodontic service provisions? |
| Statistical versus clinical significance | Is the variation in the provision of orthodontic services clinically significant? |
| Case mix adjustment | Is the adjustment for the underlying malocclusion prevalence and orthodontic service demand appropriate? |
| Stability of rates | Are the observed variations in the provision of orthodontic services stable over time? |

(Adapted from Chassin, 1993a)

The most logical strategic response to these factors which impact on the provision of orthodontic services involves the development of evidence-based clinical practice guidelines to define the most appropriate orthodontic service for specific malocclusions. Progress in this regard has, however, been lamentably slow in comparison with many medical conditions (Bader & Shugars, 1995). Yet if they are not devised by the profession, they will clearly be developed and imposed on service delivery by some (e.g. government or insurance) third-party. In order to underscore the need for such guidelines, the most serious threats to the provision of quality orthodontic services are reviewed.

## Section 2 – Literature Review

### 1.5 The principal threats to the specialist orthodontic market

Potential threats from the continued specialist manpower education are relatively insignificant compared to those following the progressive adoption of market-driven healthcare reforms (managed care and preferred provider options, etc.) by private (e.g. insurance) and public (e.g. government) institutions. For instance, third-party payments have become increasingly important economically for patients, providers and the insurance industry, due to spiralling dental service costs, i.e. eligibility for private dental insurance benefits in the U.S. have increased from 4.5 million dollars (1967) to 100 million dollars (1985) (Furino & Douglass, 1990). As most private third party basic dental insurance benefits have been broadened to include contributions for specialty (e.g. orthodontic) services, the potential impact of the recently introduced American healthcare reforms on the orthodontic market cannot be overtstated (Grembowski & Conrad, 1984). These threats are particularly relevant to specialists, since the constraint of specialist referral systems is such an integral component of these reforms (Block, 1997; Dugal, 1997; Scutchfield, Lee & Patton, 1997; Bramson, Noskin & Ruesch, 1998). Moreover, these concerns are particularly relevant to the provision of orthodontic services, due to the lack of an objective system to distinguish between the services provided by specialists as opposed to non-specialists (Graber, Rakosi & Petrovic, 1997).

Recent reductions in the general population of dental caries prevalence is a subtle, but significant, threat to the demand for dental (including orthodontic) services. This reflects the growing realization that socioeconomic improvements are primarily responsible for these changes, rather than the provision of dental services (Sheiham, 1997). As a result, third-party indemnity programs are unlikely to allocate additional resources for the provision of dental (e.g. orthodontic) services, without more evidence for their inherent benefits. But if the provision of orthodontic services increasingly becomes the domain of generalists, due to their lower service fees, then the potential market threat will be their inadequate quality assurances.

Discrepancies in the perceived need for orthodontic services between different (specialist or generalist) providers are, however, potentially more serious factors (Birkeland, Boe & Wisth, 1996; Sheats *et al.*, 1998a), due to their inferred inconsistent initial patient assessments (i.e. diagnoses). These concerns were recently underscored by comparisons of the orthodontic service needs based on the assessments of 240 casts by 97 orthodontists from 9 European countries (Richmond & Daniels, 1998a). These data indicated that the country of origin and method of payment were primary determinants of the providers' prescribing behaviors, rather than the specific orthodontic needs of patients (Richmond & Daniels, 1998a). This inevitably leads to the suspicion that significant discrepancies between the European and North American requirement for specialist orthodontic services primarily reflect the differential availability of specialist service access and priorities assigned to the public's discretionary funds (Richmond & O'Brien, 1996) rather than differences in the prevalence of malocclusions.

Such epidemiological comparisons are, however, further compromised by national and regional discrepancies in healthcare (including orthodontic) service fees. For instance, since all healthcare providers tend to maximize their incomes by adjusting their work patterns, then marked discrepancies in the provision of orthodontic services may reflect the higher case-loads required to compensate the low service fees in fee-for-service payment systems (Grytten, Holst, Grytten, 1992). Similarly, the increased provision of orthodontic services by non-specialist providers may be a function of their reduced case load for other conventional dental services: a trend that may be exacerbated in the future (Grytten, Holst, Grytten, 1992).

A general lack of understanding on how clinicians diagnose and plan orthodontic services for their patients is a further problem. For instance, following upon the suggestion that a problem-based approach would facilitate the evaluation of medical records (Weed, 1969), a similar system has been devised for the provision of orthodontic services based on five major characteristics of a malocclusion (Ackerman & Proffit, 1969). Essentially, this comprised synthesis of the Angle (1899) classification with a Venn diagram to improve analysis of the interrelationships between dependence on study models for initial case assessments (Atchison, Luke & White, 1991; Han *et al.*, 1991) are therefore alarming, since they may be responsible for some of the unacceptable discrepancies in the orthodontic services provided to homologous groups of patients. These discrepancies are illustrated by data derived from the examination of pretreatment records of 148 subjects by 5 orthodontic specialists (Baumrind *et al.*, 1996), where disagreements in their classifications were reported for 29% of the adult subjects and 27% of the adolescents. Moreover, these orthodontists failed to agree either to extract or not to extract teeth as part of the orthodontic services for more than one third of the patients. In addition, one or more of the specialists believed that surgery was probably or definitely the most appropriate service for 29% of the adults and 23 % of the adolescents, although the initial criteria for sample selection specifically excluded the need for orthognathic surgery.

These concerns were further underscored by a more recent study, where 39 orthodontic specialists evaluated pretreatment records (study models, radiographs, photographs etc.) for 6 patients (Luke, Atchison & White, 1998). In addition to surprising variations in their classifications of maxillary and mandibular molar relationships, significant discrepancies were reported for their assessments of crowding or spacing and overbite. These data therefore underscored the fact that some of the orthodontists included in this study not only failed to provide precise assessments, but their discrepancies would have resulted in either incorrect or inappropriate service (i.e. the 39 orthodontists included in this study recommended 39 different forms of services for the 6 patient sample) (Luke, Atchison & White, 1998). Clearly, inconsistent initial assessments of potential orthodontic patients comprise fundamental market threats.

### 1.6 The need to priorize orthodontic service complexity

A more objective system is therefore necessary not only to standardize the initial patient assessment, but also to priorize their orthodontic service needs with particular emphasis on the distinction between those which could be provided more effectively by specialists as opposed to generalists. Since orthodontics cannot be transformed from an "art" to a "science" without such a system, the significance of this dilemma cannot be overstated.

Data derived from 52 Florida schoolchildren illustrate the deficiencies of the present system (Hammond, 1996), since they indicated that assessments for some variables (e.g. posterior cross bites, acceptable mandibular anterior crowding, facial convexity, overbite, overjet and molar classification) were more reliable than others (e.g. maxillary/mandibular anteroposterior position, incisor exposure, interlabial gap and maxillary overcrowding) (Hammond, 1996). Such deficiencies should be sought to be improved in this era of transparent accountability, since varying assessments of specific diagnostic parameters compromise the diagnostic process.

Marked regional disparities in the provision of orthodontic services, without supportive epidemiological data on their differential service needs, further exacerbate these concerns. They not only point to unacceptable inconsistencies in the initial orthodontic assessment (i.e. diagnosis) (Moyers & Bookstein, 1979), but also in the subsequent treatment planning and predicted service outcomes (Riolo, Moyers & Ten Hoeve, 1988).

A number of indices have been developed over time in an effort to improve initial assessments, amongst others, the Index of Orthodontic Treatment Need (IOTN) (Shaw *et al.*, 1992) and the Peer Assessment Record (Richmond *et al.*, 1992) to describe the malocclusion. There are many potential advantages for these indices, including the:

- identification of the orthodontic service need
- prediction of potential service difficulty (e.g. complexity), i.e. the discrimination between cases requiring specialist from non-specialist services.

Unfortunately, the significance of these index scores remains controversial, without a gold standard to define the orthodontic service need (De Guzman *et al.*, 1995). In addition, assessments of orthodontic service needs depend on many parameters other than the initial diagnostic evaluations (e.g. service objectives, limited or extensive, national service complexities, appliance designs, patient cooperation, growth patterns, payment systems, providers' abilities, etc.). Since these inter-related parameters are difficult to incorporate into a single index (Richmond *et al.*, 1997), the American Orthodontic Association has yet to recognize their intrinsic value.

There are, however a number of inherent reservations for the development of such an index. These include difficulties in defining service complexity, especially since mild and/or severe malocclusions may require services that are either simple and/or very complex. Moreover, the Index of Orthodontic

Treatment Need (IOTN) score is an inadequate assay for service complexity, since this index essentially grades the anticipated disadvantages of leaving malocclusions without orthodontic services (Otuyemi & Jones, 1995). The Peer Assessment Rating (PAR) Index is similarly imperfect, since the score essentially provides an index of change resulting from the orthodontic services (Otuyemi & Jones, 1995). Both forms of index are, however, relatively easy to use and their scores are functions of malocclusion severity. Unfortunately they offer no indication of the complexity of the services required to resolve a malocclusion (Holman, Nelson & Powers, 1998).

Although an Index of Orthodontic Treatment Complexity (IOTC) would conceptually offer many potential benefits, including the discrimination between services provided by specialists and non-specialists, there are also a number of potential disadvantages. For instance, such assessments may change with advances in orthodontic service technology (Holman, Nelson & Powers, 1998). In addition, there are many patient (e.g. service objective, growth potential, compliance, general and oral health) and provider (e.g. specialist and non-specialist) determinants of treatment complexity, in addition to the malocclusion itself, which are difficult to incorporate into a single index (Otuyemi & Jones, 1995). There are also concerns for the distinction between ideal and optimal services, where optimal is defined as the most appropriate that can be realistically delivered for a specific individual patient (Richmond *et al.*, 1997). There are therefore concerns whether the IOTC should be primarily directed to the provision of ideal or optimal services for a patient. This is a particular concern for epidemiological studies designed to compare the orthodontic service needs for specific populations, since the derived data are difficult to interpret if the primary ideal or optimal goals cannot be distinguished (Otuyemi & Jones, 1995).

This then begs the question how research should progress, when the real concern is to identify specific cases whose diagnosis and treatment planning should be performed by skilled and experienced orthodontic specialists. This important and fundamental concern not only relates to the provision of orthodontic services, but is equally relevant to the provision of many other healthcare services. Cases that may require services for longer periods than other must be distinguished from those that are truly complex. For instance, a service may take longer than anticipated due to poor patient compliance, but this should not be taken as an index of genuine complexity (Turbill, Richmond & Wright, 1996).

The crux of the problem, therefore, centers on the distinction between complexity and severity. Although severity can up to a point, be measured by the PAR index from study casts alone, this index does not necessarily help identify the complexity of a case. For instance, well aligned cases with either palatal canines or poor quality first molars will be scored low by the PAR Index but are amongst the most difficult cases for the provision of orthodontic services. Paradoxically, if the canine case were more crowded, then the PAR Index would be increased, although less expertise would be required, due to potential resolution of the malocclusion by permanent and deciduous canine extraction. If logistical, medical, resource and social determinants are included, the role of the PAR Index to delineate complexity will be further diminished (Turbill, Richmond & Wright, 1996).

Clearly clinical guidelines are imperative to distinguish between cases that are truly complex (i.e. should be treated by a skilled and experienced specialist) and those that could be serviced by either specialist or non-specialist providers (Turbill, Richmond & Wright, 1996).

### 1.7 Case evaluations based on the Dental Aaesthetic Index (DAI)

The DAI score was selected for this study, due to the growing acceptance of this index in the orthodontic literature. Initially derived from a regression equation linking objective measurements of ten occlusal traits to their relative social dental aesthetic acceptability (Cons & Jenny, 1994), the development of this index was based on the percentage distribution for malocclusal traits exhibited by 1,337 study casts from a New York Caucasian adolescent population (Cons, Mruthyunjay & Pollard, 1978), which led to the identification of 18 occlusal patterns (Proshek, Jenny & Cons, 1979). Subsequently, two random 100 cast sub-samples were selected from the original sample and assessed relative to the Social Acceptability Scale of Occlusal Conditions (SASOC): an instrument to define the public's perception of aesthetic acceptability (Jenny *et al.*, 1980). The SASOC score was designed by presenting stylized lip masking of the lateral and frontal photographs of the 200 dental cast subset to a group of evaluators comprising students (n = 880), their parents (n = 403) and Orthodontists (n = 66). They were asked to subjectively rate these photographs using such polar adjectives as beautiful/ugly, desirable/undesirable, etc. and these data were then subjected to uni- and multi-variate statistical analysis. The mean scores obtained from these evaluations were subsequently linked by factor analysis and stepwise multiple regression to the occlusal traits for the subsample group. The resulting regression equation then identified the weightings that should be applied to these ten occlusal traits to reflect their respective dental aesthetic significance. The application of the DAI to define a malocclusion involves placement of the score relative to a continuum, anchored by "0" = "most socially acceptable" and "100" = "least acceptable". These scores were initially based on Caucasian adolescents from the United States (Ast, Cons & Carlos, 1965), and subsequent applications of this index to Native Americans (Cons *et al.*, 1983; 1989), in addition to ethnic samples from Japan, China and other Asian countries (Ansai *et al.*, 1993; Cons *et al.*, 1994; Cons & Jenny, 1994) have confirmed the reliability of the index scores.

Subsequent applications of the DAI scores to priorize the need for orthodontic services required the establishment of meaningful cut-off points on the prioritized continuum. This was achieved from the subjective consensus of two orthodontic evaluators on the 200 study cast subset of the original sample, where threshold scores 36 or higher were deemed to reflect the differential need for orthodontic services (Jenny *et al.*, 1992). This DAI assessment of service need has been subsequently confirmed by the subjective evaluation of others (n = 10 orthodontists), where a 74% agreement was achieved for threshold scores of 32.5 (Keay & Taler, 1993). These data also showed that the DAI was sufficiently sensitive (r = 0.92) for the prediction of orthodontic service need, although the low positive predictive power for the scores (r = 0.60) suggested that the service need tended to be over-estimated. This has since been confirmed by a more recent study (Caisley, 1995), although few other tests for validity have been reported in the literature (Keay & Taler, 1993).

Nevertheless, the reliability of the DAI was considered sufficient to be incorporated into the Oral Data Collection Instrument by the WHO, although some inherent deficiencies were noted. For instance, the crowding or spacing components of a malocclusion are scored on a dichotomous scale (i.e. present or absent) and confined to the incisor region (i.e. excluding such discrepancies in the remaining teeth). The DAI was primarily based on study casts comprising permanent teeth, so that some modifications are required to evaluate mixed dentitions (e.g. a recently exfoliated deciduous tooth space should not be scored as missing if the permanent replacement will soon erupt into the location (Jenny and Cons, 1996). As such evaluations of eruption status require experienced clinical judgements, a dental auxiliary or non-dental personnel may be precluded from performing their DAI assessment. The fact that the DAI does not embrace missing molars, impacted teeth or posterior crossbites and the validity of cut-off points requires further study, this index is not without some deficiencies. But since other indices exhibit even greater deficiencies (Richmond & Andrews, 1993; Tang & Wei, 1993; Shaw *et al.*, 1995).

## 1.8 The need for guidelines to constrain the inappropriate provision of orthodontic services

Strategies to initiate the development of evidence-based guidelines for the provision of orthodontic services are more complex than traditionally envisaged. These concerns should have been anticipated, since a review of dental insurance claims for a 1.35 million child population aged 5 and 15 years over the 1986/87 period in the United States of America showed that the provision of comprehensive orthodontic services ranged from 11.6% in the MidWest region to 5% in Alaska and Hawaii (Antkowiak & Knutty, 1993), without analogous epidemiological support for such regional discrepancies in malocclusion prevalence. Similar concerns were elicited for the range of orthodontic service utilization within individual states in the United States of America, which extended from 14.3% (Washington) to 3% (Hawaii) (Antkowiak & Knutty, 1993).

The alternative notion is that these discrepancies are aspects of specialty orthodontic practice, where significant uncertainties persist for the most appropriate services for particular malocclusions. Advocates of this latter view contend that if two specialist orthodontists consistently provide either different services or different timing for a service for patients with similar malocclusions, then one must be providing less effective services than the other, unless all services lead to equivalent outcomes across the potential range. Viewed from another perspective, discrepancies in service provisions for patients with analogous malocclusions most likely reflect difficulties in their diagnosis and treatment planning. Clearly, there is an urgent need to devise clinical guidelines to provide more consistent orthodontic services (i.e. to improve their quality assurance), particularly the distinction between services provided by specialists rather than non-specialists.

## 1.9 Malocclusion assessments

Although the objective of this study was to compare the independent evaluations of envisaged treatment difficulty by two methods of assessment, the notion of an objective index to quantify the deviation of an occlusion from normal is controversial. This primarily reflects the multiple components that variably contribute to craniofacial form (Foster & Menezes, 1976). The fact that malocclusions comprise deviations from accepted ideals, rather than specific diseases or abnormalities, further compounds this dilemma. Objective craniofacial evaluations therefore depend on the combined assessments of the contributory occlusal, aesthetic and functional components.

### 1.9A Occlusal Factors

Despite many attempts to define "ideal occlusions" no general consensus has yet emerged (Hellman, 1921; Carlos & Ast, 1966; Andrews, 1972; Ramfjord & Ash, 1983; Mohl *et al.*, 1988). Nevertheless, the occlusal components of malocclusion severity are obviously important, although they are only weakly correlated with temporomandibular disorders (Horup, Melsen & Terp, 1987; Helm & Petersen, 1989; Davies *et al.*, 1991; Pullinger, Seligman & Gornbein, 1993). Clearly, assessments of occlusal parameters are not the sole determinants of orthodontic service complexity.

### 1.9B Aesthetic Factors

Since a person may be disqualified from full social acceptance when his/her physical attributes deviate too far from conventional norms (Burstone, 1958; Shaw, Reed & Dawe, 1985; Kenealy, Frude & Shaw, 1989; Albino *et al.*, 1991), aesthetic criteria are integral to any assessment of orthodontic service difficulty.

### 1.9C Functional Factors

Evaluation of occlusal function may facilitate the detection of deleterious interferences resulting in occlusal trauma, although evaluations of mandibular function or centric relation proved too controversial to be incorporated into an index of service complexity (Ash, 1995).

An easier alternative method to grade malocclusion involves separate evaluations of the component malocclusion deviations from the ideal in the form of an indexed approach. This approach was endorsed by the World Health Organization (1966) and contributed to the development of specific guidelines for the development of occlusal indices. Due to subsequent concerns that these guidelines were insufficiently specific for epidemiological studies (Salzmann, 1968; Summers, 1971) a list of ideal criteria was subsequently devised for an occlusal index (Shaw *et al.*, 1991):

a) reliability

b) validity

c) acceptable to the public and the profession

d) sensitive to the needs of the patient

e) sensitive throughout the scale

f) amenable to statistical analysis

g) able to detect shifts in group conditions

h) administratively simple for non-dental personnel operation

i) examination should require minimum judgement

These criteria were then applied to the two service difficulty assessment methods applied to the present case sample.

## 1.10 Variations in the evaluation of Class II malocclusions

Although a study based on the assessment of pretreatment records by 30 orthodontic specialists indicated that malocclusion severity and service difficulty are in fact discrete entities (Rowe, 1989), these two parameters are in fact intimately related. For instance, service difficulty is only one of many determinants of orthodontic service outcome (i.e. others include patient cooperation, specialist access [e.g. rural versus urban], provider type [specialist or non-specialist] and interceptive versus corrective services (Bergstrom et al., 1998). In addition, malocclusion severity is not necessarily correlated with service difficulty, since major tooth/arch discrepancies may be primarily resolved by extractions, whereas complex services may be required to resolve subtle malocclusions. Class I crowded cases with the 4 canines buccally blocked out of the arch, can more easily be treated with 4-first bicuspid extractions (taking into consideration the profile) than a Class II Division 1, deep bite, large overjet, which may require growth modification and is very dependent upon patient compliance with either headgear wear or Class II elastic wear, and also depends on the age of the patient and the vagaries of differential growth patterns of males and females.

Data from private third party indemnity programs, indicate that 55.7% of the orthodontic service claims in North America are for Class II malocclusions (Antkowiak & Knutty, 1993), although diagnoses for this generic category are complicated by their six horizontal and five vertical component categories (Moyers *et al.*, 1980). Such inherent complexities impact on all aspects of their services (Bookstein & Moyers, 1982), although their precise diagnosis is central to their treatment planning and therefore their service outcomes. But the inappropriate increase in the provision of orthodontic services by non-orthodontically qualified general practitioners and paedodontists of this malocclusion category will not be resolved until strategies have been devised to facilitate their more consistent evaluation. This is crucial for the development of evidence-based clinical guidelines for the most appropriate orthodontic services for specific malocclusions.

## 1.11 Purpose of the Study

This study was therefore undertaken to evaluate two aspects of this dilemma: the need for evidence-based guidelines to improve the consistency for the diagnosis of patients with Class II malocclusions, and to evaluate the consistency of pretreatment record assessments for 4 patients with Class II malocclusions by orthodontic specialists.

# MATERIALS AND METHODS

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# MATERIALS AND METHODS

## 2.0 Initial sample screening

The growing realization that the generic Class II division 1 malocclusion category actually comprises numerous subcategories, although no consensus has yet been devised for their specific definitions, was the main selection criteria for the initial sample. In order to resolve this dilemma for this study, the case records for 600 adolescent patients with Class II division 1 malocclusions, treated in the Graduate Orthodontic Clinic at the University of Manitoba over the past 5 years were studied. Initially, these were all screened to evaluate the range of Class II malocclusion discrepancy contained in this sample.

The selection criteria for this initial screening comprised the following:

- Complete A (prior to treatment), B (completion of active phase) and D (4 years post retention) records comprising study models for Class II malocclusions, in addition to the associated radiographs and photographs;
- Class II skeletal relationships;
- Pre-pubertal to Adolescent (age range = 10-16 years)
- No evidence of poor compliance during the active treatment phase noted in the chart.

Their pretreatment case records were then laid out on a long table top counter and were graded visually by one experienced orthodontist (Dr. A. Baker), based on the following criteria:

- Degree of first permanent molar disclusion;
- Degree of skeletal arch discrepancy;
- Degree of horizontal craniofacial discrepancy;
- Degree of vertical craniofacial discrepancy.

This initial screening process essentially resulted in four principal Class II malocclusion subcategories **(Table 2.1)**

**Table 2.1 Descriptive summary of the Four Class II division 1 subcategories**

| Subcategory | Description |
| --- | --- |
| A Grower | Class I dental, on a Class II skeletal base Mandibular deficiency Type II (medium mandibular plane angle), short Lower Anterior Face Height (LAFH) |
| B Grower | Class II, division 1, large OJ=8mm, deep OB=70% palatally impinging, Mandibular deficiency Type I (low mandibular plane angle), short LAFH |
| C Non-grower | Class II, division 1, large OJ=9mm, deepOB=100% palatally impinging, Mandibular deficiency Type III, (high mandibular plane angle), long LAFH |
| D Non-grower | Class II, division 1, large OJ=9mm, moderately deep OB=40%, Mandibular deficiency Type II, (medium mandibular plane angle), long LAFH |

(Note: These subcategories noted in the Manitoba sample do not necessarily apply to other samples or to Moyer's description of Class II division 1 subcategories.)

Subsequently, the cases contained within each of these subcategories were further scrutinized by an experienced orthodontist (Dr. A. Baker) based on the following criteria:

- Quality of "A" records;
- Absence of significant right- and left - sided craniofacial asymmetry;
- Absence of gross caries
- Severity of overjet
- Severity of crowding
- All permanent teeth present (no mutilated dentitions)
- Age of the patient/bone density (all were adolescents)
- Grower/non-grower

One experienced orthodontic specialist ultimately selected 2 cases from each of the 4 subcategories for scrutiny. The principal objective of this final selection process was to ensure that each case exhibited the following characteristics:

- Class II dental bases
- Intact dental arches, with no history of prior permanent tooth extraction or orthodontic services;
- High quality pretreatment records;
- Post treatment records showing improved occlusal relationships.

The 4 cases were chosen by the primary researcher and an experienced orthodontist. The identity of each case was then obscured to maintain patient confidentiality and avoid potential bias. They were subsequently duplicated, prior to transportation to two Specialty Conventions for their independent evaluation of service difficulty by "volunteer" assessors, who were attendees at the two conferences.

## 2.1 Pretreatment evaluation of the four selected cases

The pretreatment assessments of each case are considered with respect to their histories, in addition to evaluations of their study models, photographs, panorex and other radiographs, in addition to their cephalometric evaluations. The prime objective was for the reader to be fully conversant with each case, prior to their differential evaluations by various specialist assessors.

Clearly the four pretreatment cases selected for this study were uniquely different. Moreover, their proposed treatment plans also confirm their unique differences. The following is a summary, from the original charts, of the diagnostic findings, treatment plan and "B" report findings for each of the four cases.

**2.1.1 Case 1**

**Case History** - 10 year 5 month old female at 'A' records, mesomorphic, no allergies, no medical problems.

**Clinical evaluation** - Class I (Class II tendency) dental on a Class II skeletal base (retrognathic mandible); overjet - 12 mm, overbite - 50%, palatally impinging, short lower anterior face height, everted lower lip, upper incisor's protruded and proclined, lower incisor's retruded and retroclined, 36, 46 mesially tipped, 35, 45 not erupted, upper 55 and 65 still present, deep Curve of Spee in the mandible.

**Cephalometry**

(A) Manitoba analysis shows:

1). Class I skeletal bases,

2). Obtuse nasolabial angle,

3). short lower anterior face height,

4). retroclined lower incisor's

(B) Wits Analysis = -2 (within normal limits indicating Class I)

**List of major and minor orthodontic problems:**

1). 12-22 have enamel hypoplasia and there are labially tipped metal crowns on 55, 65

2). Mentalis hyperactivity (strong lower mentalis, strong orbicularis oris muscles)

5). History of habits - lower lip biting and nail biting. No thumb sucking habits.

6). Lips apart at rest (incompetent lips)

8). Severe lower Curve of Spee

9). Lack of cuspid guidance

10). Oral hygiene - fair to poor

**Proposed treatment plan for Case I**

Phase I: 1). Lip bumper

2). then utility arch to intrude the mandibular incisors 42- 32, in conjunction with a,

3). bionator;

4). Full banding in the mandibular arch

Phase II: Full banding in the maxillary arch.

**Summary 'B' Report of Treatment:**

1). Lip bumper - was used for 5 months, without obvious success in uprighting 36 and 46

2). Utility Arch – was used for 11 months (July 84 – Aug 85) in conjunction with a,

3). Bionator – which was used for 13 months (June 84 - June 85)

4). Full fixed multibanded appliances (.022 set up) were placed in the mandibular arch (Mar 85)

5). Full fixed multibanded appliances (.022 set up) were placed in the maxillary arch (Aug 5)

6). Class II elastics were worn for 5 months

7). Total treatment time - 24 months (fixed and functional phases)

**2.1.2 Case 2**

**Case History** -13 year 2 month old male at 'A' records with fair facial aesthetics, mesomorphic, no medical problems, no allergies

**Clinical evaluation** - Class II Division 1 dental on a Class II skeletal base, (retrognathic mandible), retrognathic convex profile with short lower anterior face height. Obtuse nasolabial angle, large overjet = 8 mm, overbite = 70%, palatally impinging, narrow maxillary arch with posterior bilateral crossbite, severe crowding in maxilla. Moderate crowding in mandible. 55, 85 present. Minimal attached gingiva (MAG) on the lower incisors, upper and lower lip eversion, proclined and protruded upper incisor's, retroclined and retruded lower incisor's

**Cephalometry**

(A) Manitoba Analysis shows:

1). Class II skeletal bases;

2). Obtuse nasolabial angle;

3). Short lower anterior face height;

4). Steep mandibular plane angle

(B) Wits Analysis = 4 mm (indicates a Class II case)

**List of major and minor orthodontic problems:**

1). Cross bite - 16/46, 65/75, 26/36

2). Lack of canine guidance

3). Deep Curve of Spee in mandibular arch

**Proposed treatment plan for Case 2**

1). Extract 14, 24. Maximum anchorage in the maxillary arch with Cervical Pull Headgear

2). Band and bond upper and lower 6 - 6, with quad helix soldered to 16, 26; remove quad helix after expansion

3). Initial alignment

4). Correct overbite by bicuspid extrusion

5). Retract upper cuspids individually

6). Retract incisors with closing arches

7). Ideal arches.

**Summary 'B' Report of Treatment:**

Extraction of 14, 24. Maximum anchorage in the maxillary arch.

Quad helix - 8 months

Full fixed multibanded appliances (.018 set up) with Class II elastics (1 month)

Total treatment time - 19 months

**2.1.3 Case 3**

**Case History** - 15 year 10 month old female at 'A' records with poor facial aesthetics

**Clinical evaluation** - Class II Division 1 malocclusion on a Class II skeletal base (retrognathic mandible), acute nasolabial angle, two plane occlusion in maxilla, upright and protruded upper incisors, retroclined and retruded lower incisors, incompetent lips at rest with everted lower lip, 1 mm slide from centric relation – centric occlusion, overjet = 9 mm, overbite – 100% palatally impinging, high smile, severe crowding in maxillary and mandibular arches. Maxillary midline to left, Bolton 1.4 mm mandibular '6' excess. Steep mandibular plane, long lower anterior face height, severe Curve of Spee (COS) in mandible and Reverse Curve Of Spee (RCOS) in maxilla (due to extruded incisors).

**Cephalometry**

(A) Manitoba Analysis shows:

1). Class II skeletal bases;

2). Long lower anterior face height;

3). Retroclined upper incisor's

(B Wits Analysis = 5 mm (indicates a Class II case)

**List of major and minor orthodontic problems:**

1). 12, and 22 lingually positioned

2). 33, and 43 are mesio-buccally positioned

3). Lack of canine guidance

**Proposed treatment plan for Case 3**

1). Extraction 14, 24, 34, 44

2). Align and level both arches

3). Maximum anchorage with high pull headgear (HPHG)

5). Enmass closure of lower spaces

6). Surgical maxillary impaction (one-piece) and mandibular advancement.

**Summary 'B' Report of Treatment:**

Extraction of 14, 24, 34, 44. Maximum anchorage with High-pull headgear.

Surgery - one piece maxillary impaction and mandibular advancement, full multibanded appliances (.018 setup)

Pretreatment phase - 26 months

Total treatment time - 37 months (3 years, 1 month),

Post surgery - vertical and triangular Class II elastics for 3 months, temperomandibular joint problems reported 2 months post surgery

### 2.1.4 Case 4

**Case History** - 21 years 8 months, female, at 'A' records with fair facial aesthetics

**Clinical evaluation** - Class II dental on a Class II skeletal (mandible retrognathic, convex profile, obtuse nasolabial angle, upper incisor's proclined and protruded, and lower incisor's proclined, severe crowding in the maxillary and mandibular arches, posterior bilateral crossbite of 16/46, 26/36, balancing contacts exist in lateral excursions, lack of canine guidance, 1 mm slide centric relation – centric occlusion. Temperomandibular joint sounds when patient eats. Overjet = 9 mm, overbite = 40%, upper and lower arches, deep Curve of Spee in mandible. Normal smile line, mandible plane angle - normal or flat. Speech normal.

**Cephalometry**

(A) Manitoba Analysis shows:

1). Class II skeletal bases;

2). Obtuse nasolabial angle;

3). Long lower anterior face height;

4). proclined lower incisor's

(B) Wits Analysis = 0 mm (within normal limits indicating a Class I)

**List of major and minor orthodontic problems:**

1). 12 and 22 are lingual

2). 13 - blocked out labially

3). 42 is lingually positioned

4). 43 is mesio-labially positioned

5). 35 and 45 are mesio-lingually positioned

**Proposed treatment plan for Case 4**

1). Band 16, 26, 36, 46. Use crossbite elastics to correct crossbites

2). Extract 14, 24.

3). Retract 13, 23 with a removeable cuspid retraction appliance. Insert HPHG

4). Band and bond upper and lower 6 - 6. Align arches.

5). Anterior box elastics to maintain overbite

**Summary 'B' Report of Treatment:**

1). Extraction of 14 and 24, maximim anchorage, transpalatal arch and High-pull headgear

2). Removeable cuspid retraction appliance

3). Crossbite correction of 16/46, 26/36 with elastics

4). Full multibanded appliances (.018 setup) and Class II elastics and anterior box elastics (openbite) 3 months

Total treatment time - 31 months.

## 2.2 Synopsis

Although these cases exhibited Class II malocclusions, their pretreatment orthodontic concerns were uniquely different. These differences are best summarized in tabular form and by superimposition of their cephalometric tracings. (See Apendix 1)

### 2.2.1 Definitive pretreatment record assessments

This comparative study was therefore designed to examine the relative consistency in pretreatment record assessments for 4 patients aged 10 to 16 by volunteer specialist orthodontist attendees at two annual Orthodontic Congresses: one in Canada and the other in the United States. Whereas all these attendees were recognized orthodontic specialists, their independent evaluations of this 4-case sample were either based on the respective Dental Aesthetic Index (DAI) [Canadian Congress] or Analog (Likert-type) scores [American Congress], whereas the HLD (CalMod) Index scores determined by the primary investigator served as the "gold-standard".

The DAI is currently considered the most appropriate index to define the malocclusion severity of a case (Cons et al., 1986; Otuyemi & Jones, 1995). The DAI score was therefore applied to evaluate the 4-case sample by the volunteer assessors from the Canadian Congress. (A sample of the DAI case-score sheet is listed in Appendix 2).

### 2.2.2 The DAI scoring technique

The DAI case scores were evaluated by 'volunteer' specialists attending only the Canadian Association of Orthodontists evaluations. As listed in Appendix 2, a standard protocol must be applied to determine the DAI score for each case, based on the summation of differentially weighted parameters, plus a constant. The DAI scores were, therefore, essentially based on measurements of the pretreatment study models, where their higher scores signify greater difficulty in the treatment required to resolve the malocclusion (i.e. priorized treatment need).

### 2.2.3 Case evaluations based on the Likert (Visual-Analog) Scale

The pre-treatment orthodontic records (n=4) for the same case sample were subsequently evaluated by another (United States of America) group of orthodontic specialist assessors. These case assessments of malocclusion severity were based on their "usual" methods applied in the office, where their priorization was defined by utilization of a 10 point Visual Analogue Scale (VAS) anchored by the terms "mild" = 1 to "very severe" = 10. The validity and reliability of this VAS evaluative system has been previously tested in the development of other indices (Cons, Jenny & Kohout, 1986; Bennet *et al.*, 1991; Richmond *et al.*, 1992a) and was used in the present study to ensure sufficient "volunteers" evaluated the 4-case sample while attending the congress. (See Appendix 3 for an example of the data collection form).

### 2.2.4 The Likert-type scoring technique

The Likert-type case scores were evaluated by 'volunteer' specialists attending both congresses; the Canadian Association of Orthodontists and American Association of Orthodontists Annual Congresses.

This technique required each specialist to examine the records for each case and then provide an overall grade (1-10) of service difficulty anchored by the terms 1 = simple and 10 = very difficult. The intention was for each case to be assigned a grade, based on examination of their diagnostic records, to reflect the degree of anticipated difficulty in the treatment plan required to resolve the malocclusion.

### 2.2.5 Case evaluations based on the HDL (CalMod) Index

In order to evaluate the relative significance of the two sets of DAI and VAS case-scores, the HDL (CalMod) Index scores for each case was determined by the primary investigator. The HDL (CalMod) Index was selected since this modification of the Draker Handicapping Index (Draker, 1960) was primarily developed in response to a number of lawsuits against individual states with medically necessary handicapping malocclusions defined by the Medicaid statutes (April, 1988) specifically described in The State Medicaid Manual (Part 5) of the Early Periodic Screening Diagnosis and Treatment Program (EPSDT) of the department of Health Care Financing Administration (HCFA). These direct each state to provide orthodontic services for medically necessary handicapping malocclusions. As more States are under progressive pressure to ensure that they are delivering the kind of service intended under the Medicaid regulations, the HDL (CalMod) index is currently accepted in the most litigationalist state (California). Since the HLD (CalMod) index went into official use (1991), the potential applications for patient screening has withstood rigorous legal scrutiny. For instance, 135,655 patients had been examined orally by qualified orthodontists and screened using the index by 1997 (Parker, 1998). As 49,537 (37%) were assigned the CalMod Index scores of 26 or greater, they were accepted for orthodontic services, depending on other criteria (e.g. age, particular occlusal anomaly, etc.). Although there are deficiencies in this index, an experienced biostatistician (Hassard, 1998) advised that the case-scores would provide appropriate "gold-standards" to evaluate those obtained for the same sample at the two Orthodontic Congresses. (See Appendix 4 for detailed description of CalMod Index assessment).

## 2.3 Selection of Assessors

Each "volunteer" assessor was an attendee at either the annual Canadian (DAI score) or American Orthodontic Congress (VA score) and was asked to evaluate each of the 4-case sample independently based on the forms listed in the Appendices 2 and 3. This, therefore, was not a random sample of all potential orthodontic specialists who attend the North American Congresses, but was considered sufficiently representative to form an opinion of the consistency in pretreatment record assessment. In addition, each volunteer was asked to complete a summarized biographical sketch to evaluate the impact of other parameters (e.g. location of post-graduate training, experience etc.) on their case assessments. All the data were subsequently entered onto a spreadsheet to facilitate their statistical analysis.

## 2.4 Statistical analysis

Initially, the DAI (standard and modified) and VA case scores were evaluated independently, after careful scrutiny to ensure accurate data transfer to the spreadsheets. Based on the evaluation of scatter plots of the scores for each case, the biostatistician consultation considered univariate statistical analysis and bar-graphs were most appropriate forms of data analysis. These were then determined for the two assessor groups as a whole, but were subsequently segregated based on various aggregates (e.g. assessor experience, place of postgraduate training etc.). Subsequently, the plots of the two forms of case-scores (DAI [standard and modified] and VA) were superimposed, along with those derived from the CalMod Index. The prime objective was:

- To define whether the DAI (standard or modified) or VA scores provided the most consistent determination of service difficulty for the 4-case sample
- To evaluate the relationship between DAI and VA scores with those based on the CalMod Index

These data were then interpreted relative to data derived from the case and "B" records, with the objective of determining the association between pretreatment case assessments and their subsequent service outcomes.

# RESULTS

## CONTENTS

# RESULTS

## 3.0 Review of the Purpose of the Study

This study was primarily undertaken to evaluate the relative merits of the assessment of four Class II cases relative to their subjective VA scores compared to their more objective DAI evaluations. Due to the lack of a reference gold standard to determine the relative consistency of these assessments, their CalMod index was used as a substitute reference in this study. This index was then applied to four (4) Class II division 1 cases by 42 Canadian orthodontists, where all cases were selected (a) to exceed the threshold of orthodontic service need and (b) to represent the range of difficulty commonly encompassed in a specialty office. These same four cases were then taken to the American Association of Orthodontists conference in Dallas, Texas on May 18-19, 1998, where 241 volunteer orthodontists assessed the four cases using the Likert (Visual-Analog) Scale. In order to consider the uniqueness of each case in the context of the study's objective, their pretreatment evaluations must be considered in some detail.

## 3.1 Synopsis

Although these cases exhibited Class II malocclusions, their pretreatment orthodontic concerns were uniquely different. These differences are best summarized in Table 3.1 and by superimposition of their cephalometric tracings **(See Appendix 1- Superimposed lateral cephs on sella-nasion).**

**Table 3.1 Summarized differential assessments of the four study cases**

| PARAMETER | CASE 1 | CASE 2 | CASE 3 | CASE 4 |
|---|---|---|---|---|
| Age | 10 year 5 month | 13 year 2 month | 15 year 10 month | 13 year 6 month |
| Growth Potential | Grower | Grower | Non-grower | Non-grower |
| Sex | Female | Male | Female | Female |
| Overjet | 12 mm | 8 mm | 9 mm | 9 mm |
| Overbite | 50% Pal Imp | 70% Pal Imp | 100% Pal Imp | 40% Pal Imp |
| Dental Relationship | Class I | Class II, Div I | Class II, Div I | Class II, Div I |
| Skeletal Relationship | Class II | Class II | Class II | Class II |
| ANB | 3° | 5° | 5° | 6° |
| Incompetent Lips | Yes | Yes | Yes | Yes |
| Nasolabial Angle | 114° | 114° | 107° | 114° |
| Lower Anterior Face Height | 59 mm | 62 mm | 75 mm | 68 mm |
| Lower Incisor to Apt-Pog | 0.5 mm | 0.0 mm | 0.0 mm | 2.5 mm |
| Upper Incisor – Lower Incisor | 118° | 110° | 126° | 110° |
| Post crossbite | No | Yes, Bilateral | No | Yes, Bilateral |
| Maxillary Anterior Crowding | 0 | Moderate (4-5 mm) | Severe 8+ | Severe 8+ |
| Mandibular Anterior Crowding | 0 | Mild (0-4 mm) | Severe 8+ | Moderate (4-5 mm) |
| Incisor exposure (High smile) | 30% (No) | 90% (No) | +5 mm gingival display 100% (Yes) | +1 mm gingival display 100% (No) |
| Wits | -3 mm | +3 mm | +6 mm | -3 mm |
| Mandibular Plane-Sella-Nasion | 35° | 35° | 40° | 36° |
| Mandibular Plane to Frankfurt Horizontal | 29.5° | 26° | 38° | 21° |
| Mandibular Deficiency Type | Type II | Type I | Type III | Type II |

### 3.2. Case-assessments by their Likert-type scores

As illustrated in Table 3.2 and Figure 3.1, there were inconsistencies in the Likert scores assigned to the four cases between the assessors attending the Canadian and American Congresses.

**Table 3.2 Relative differences in Canadian/American volunteer Likert-type case scores**

| Case | Number of Volunteer Assessors | Mean | SD | SE | Median | CV |
|---|---|---|---|---|---|---|
| 1 | 42 Canadian | 6.91 | 1.797 | 0.277 | 7 | 3.540 |
| | 241 American | 7.06 | 2.093 | 0.135 | 8 | 4.380 |
| 2 | 42 Canadian | 6.79 | 1.536 | 0.237 | 8 | 2.360 |
| | 241 American | 5.59 | 2.939 | 0.125 | 6 | 3.759 |
| 3 | 42 Canadian | 7.79 | 1.712 | 0.264 | 8 | 2.931 |
| | 241 American | 7.30 | 1.986 | 0.128 | 8 | 3.942 |
| 4 | 42 Canadian | 7.26 | 1.329 | 0.205 | 7 | 1.766 |
| | 241 American | 5.97 | 2.141 | 0.138 | 6 | 4.582 |

SD = standard deviation; SE = standard error; CV = coefficient of variation

**Figure 3.1 Relative differences in Canadian/American volunteer Likert-type case scores**

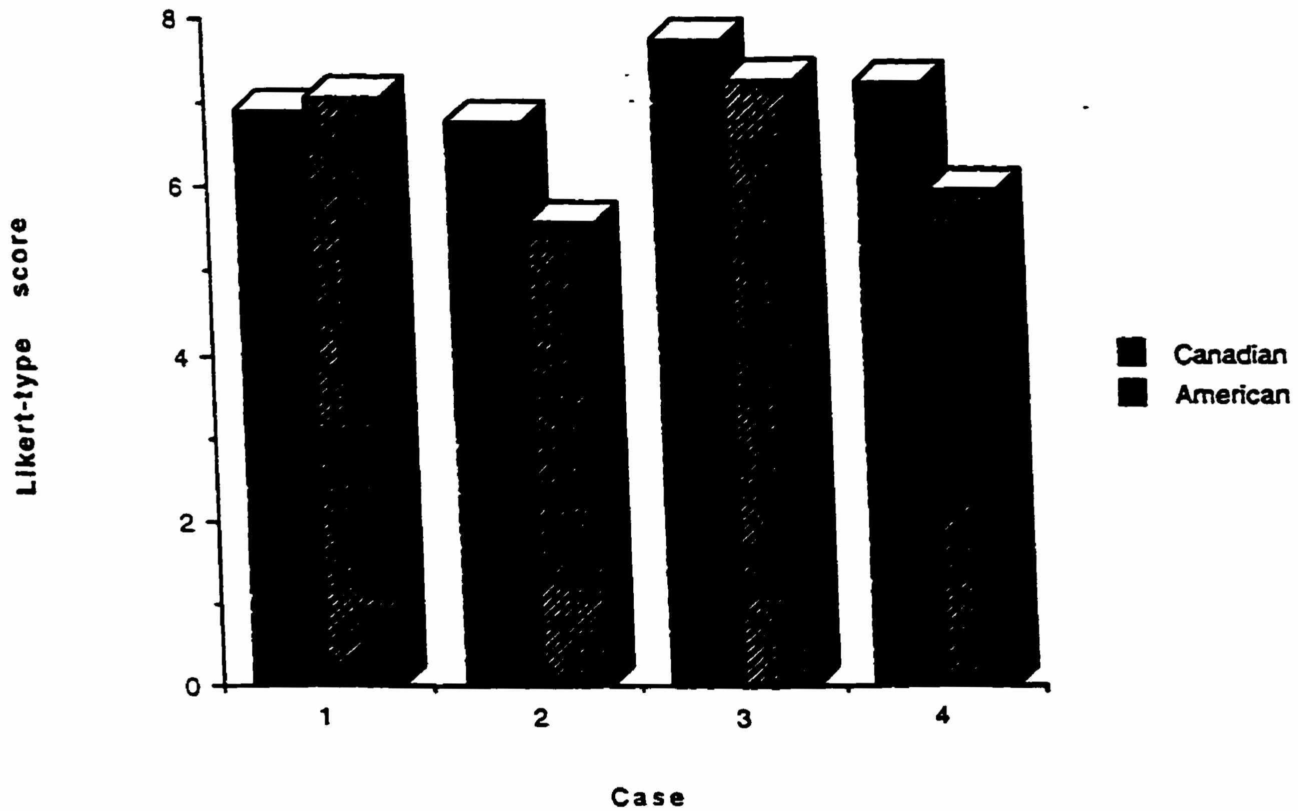

**Table 3.3 Mean $\pm$ one standard deviation Likert scores assignments applied to the four cases at the Canadian Congress**

| CASE | MEAN - SD | MEAN | MEAN + SD |
|---|---|---|---|
| 1 | 5.11 | 6.91 | 8.71 |
| 2 | 5.25 | 6.79 | 8.33 |
| 3 | 6.08 | 7.79 | 9.50 |
| 4 | 5.93 | 7.26 | 8.59 |

**Table 3.4 Mean $\pm$ one standard deviation Likert scores assignments applied to the four cases at the American Congress**

| CASE | MEAN - SD | MEAN | MEAN + SD |
|---|---|---|---|
| 1 | 4.97 | 7.06 | 9.15 |
| 2 | 2.65 | 5.59 | 8.53 |
| 3 | 5.31 | 7.30 | 9.29 |
| 4 | 3.83 | 5.97 | 8.11 |

### 3.3 Case-assessments by their DAI scores

**Table 3.5 Relative differences in Canadian volunteer DAI case scores**

| Case | Number of Volunteer Assessors | Mean | SD | SE | Median | CV |
|---|---|---|---|---|---|---|
| 1 | 42 Canadian | 35.48 | 3.617 | 0.558 | 35 | 13.085 |
| 2 | 42 Canadian | 33.55 | 2.898 | 0.447 | 33 | 8.400 |
| 3 | 42 Canadian | 36.17 | 3.42 | 0.529 | 36 | 11.752 |
| 4 | 42 Canadian | 32.36 | 3.222 | 0.497 | 32 | 10.382 |

**Figure 3.2 Differential DAI case-scores**

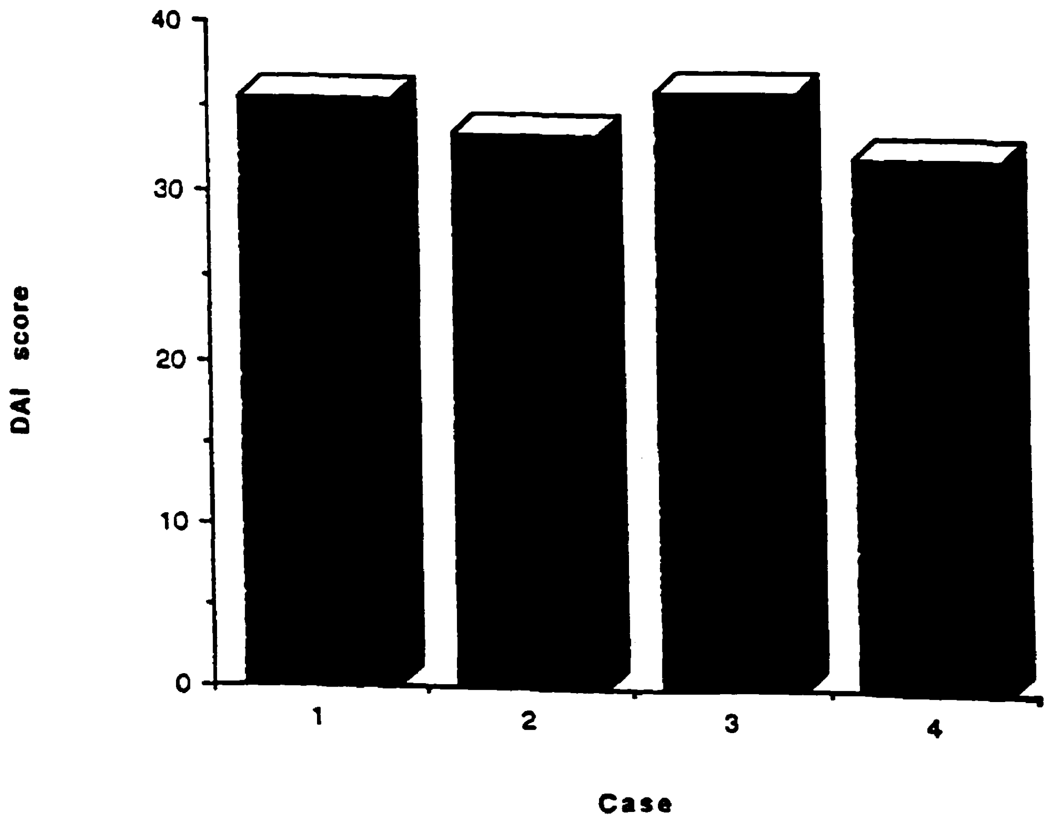

**Table 3.6 Mean ± one standard deviation DAI scores assignments applied to the four cases at the Canadian Congress**

| Case | Mean - SD | Mean | Mean + SD |
|---|---|---|---|
| 1 | 31.86 | 35.48 | 38.65 |
| 2 | 30.65 | 33.25 | 36.45 |
| 3 | 32.74 | 36.17 | 39.60 |
| 4 | 29.14 | 32.36 | 35.58 |

### 3.4 Correlation Between Scores

From the results obtained at the Canadian Association of Orthodontists meeting where 42 orthodontists evaluated the four (4) cases, case No. 3 was given the highest mean DAI score of 36.2, with case No. 1 coming in as the second most difficult with a mean DAI score of 35.5, Case No. 2 came in third with a mean DAI score of 33.6, and Case No.4 came in fourth as the least difficult with the mean DAI score of 32.4. (See Fig. 3.3)

The results from the 42 Canadian orthodontists when using the Visual-Analog scale also indicated that case No.3 was the most difficult with a Visual-Analog mean score of 7.8, and case No.4 as the second most difficult with a Visual-Analog mean score of 7.3. The third most difficult was Case No. 1 with a Visual-Analog score of 6.9 and the least most difficult case was No. 2 with a Visual-Analog score of 6.8 (See Fig. 3.4).

The results from the American Association of Orthodontists where 241 volunteer specialists assessed a subsample of 4 cases indicated that case No. 3 was the most difficult with a Visual-Analog mean score of 7.3, followed by case No. 1 as the second most difficult with a Visual-Analog mean score of 7.1. Case No. 4 was the third most difficult case with a Visual-Analog score of 6.0 and Case No. 3 was the least difficult with a Visual-Analog score of 5.6 (See Fig. 3.5).

When comparing the same Likert (Visual-Analog) scores for the same four cases from both the Canadian and the American orthodontists, case No. 3 is scored by both groups as the most difficult case. The Canadian orthodontists mean Likert score was 7.8 and the American orthodontists mean Likert score was 7.3 (See Fig. 3.5).

When comparing the results of both the DAI and the Visual-Analog scores to the CALMOD Index, both Case 2 and 4 score much higher on the CALMOD and would have been considered the least difficult by the first two indices. Both case No. 2 and 4 scored low on the Visual-Analog scale. Case No.2 would have been considered a borderline case using the DAI index with a mean DAI score of 33.6. Case No. 4 had a mean DAI score of 32.4 and would not have made the cut-off score using the DAI index. (See Fig. 3.6)

Figure 3.3

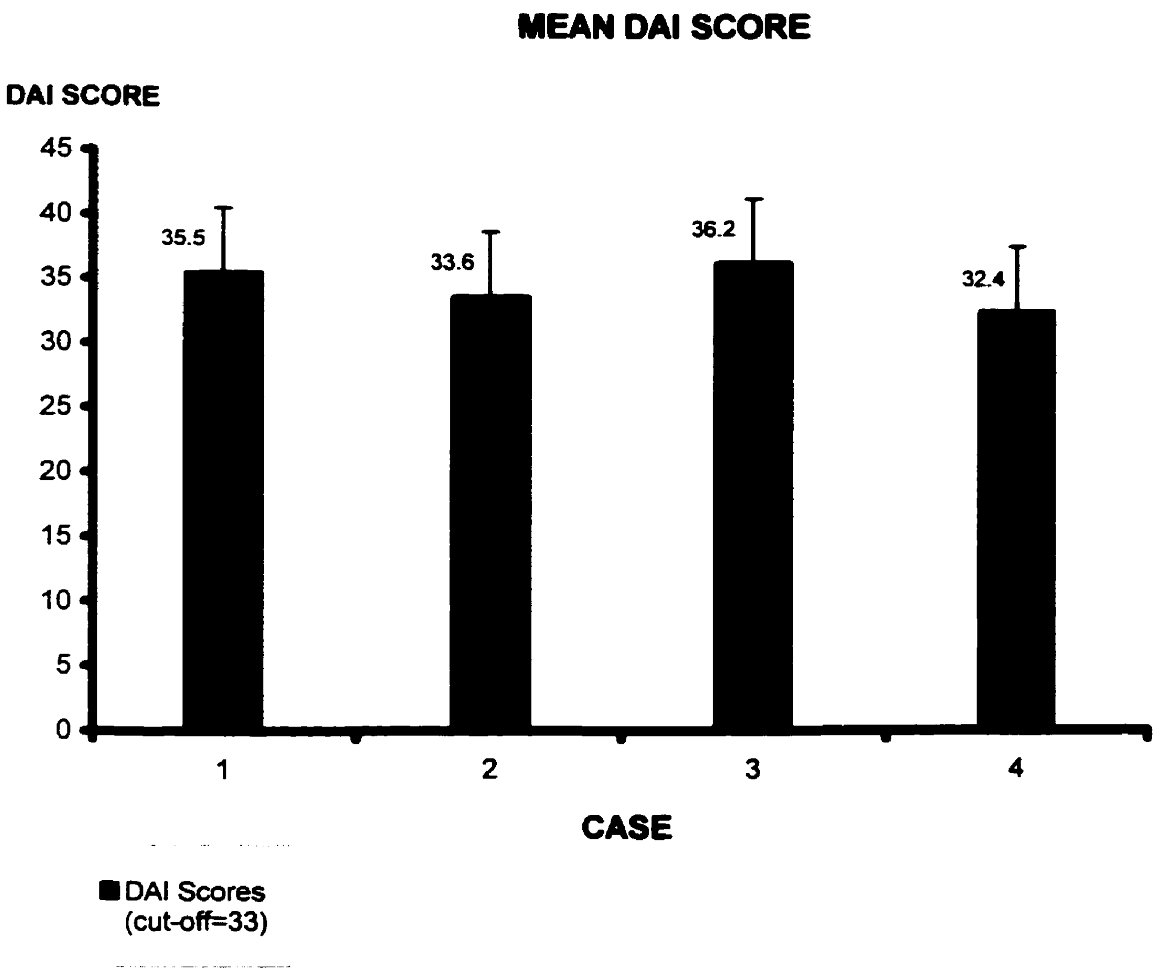


Fig. 3.3: The scores from the Canadian Association of Orthodontists Conference indicated that case No. 3 was the most difficult with the highest mean DAI score of 36.2, and Case No.4 as the least difficult with the mean DAI score of 32.4.

**Figure 3.4**

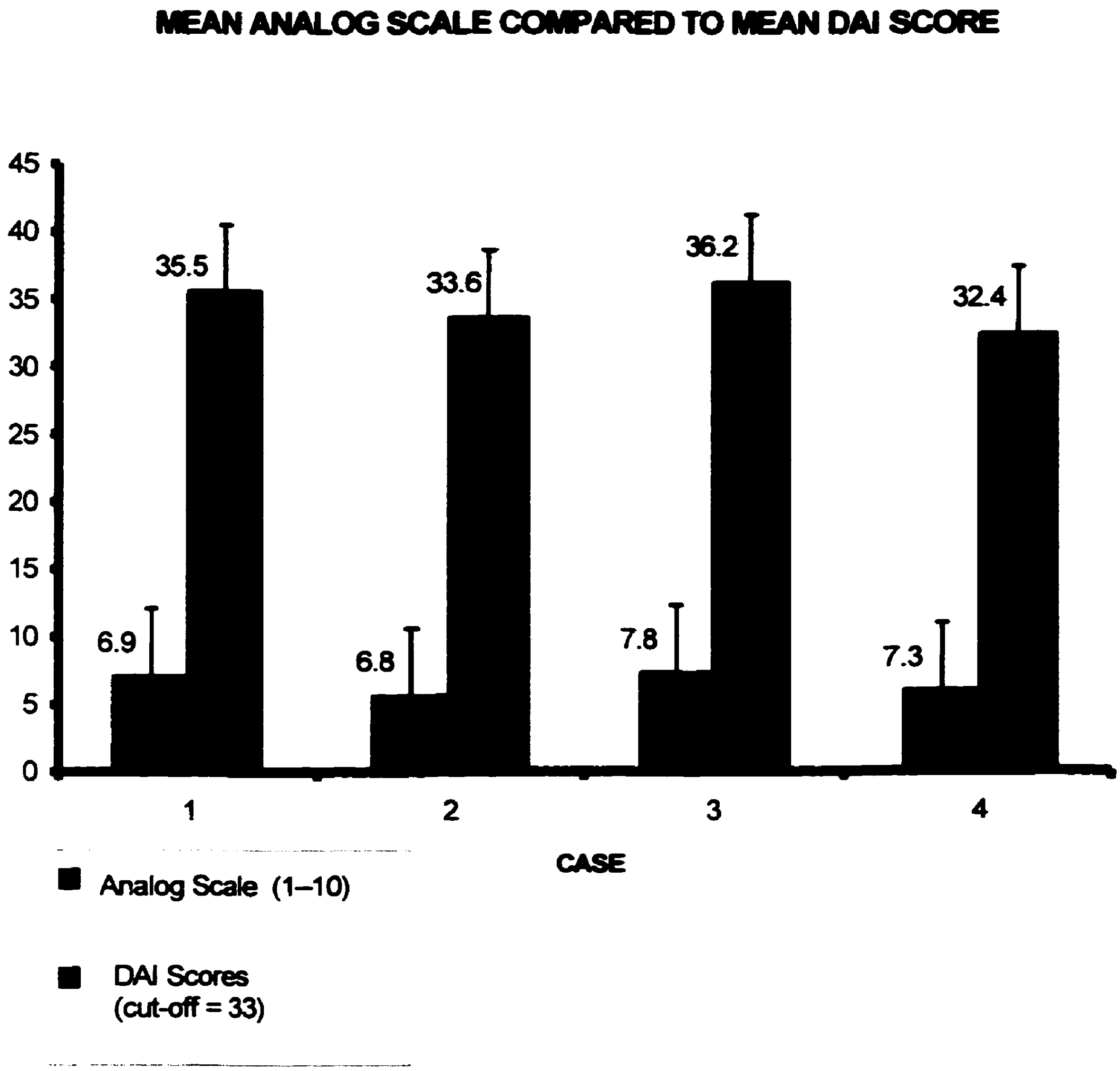


**Fig. 3.4:** The results from the Canadian Association of Orthodontists Conference when using the Visual-Analog scale also indicated that Case No.3 was the most difficult with a Visual-Analog mean score of 7.8, which correlates to the DAI score results.

Case No.4 was scored as the second most difficult with a Visual-Analog mean score of 7.3 and the least most difficult case was Case No. 2 with a Visual-Analog score of 6.8.

**Figure 3.5**

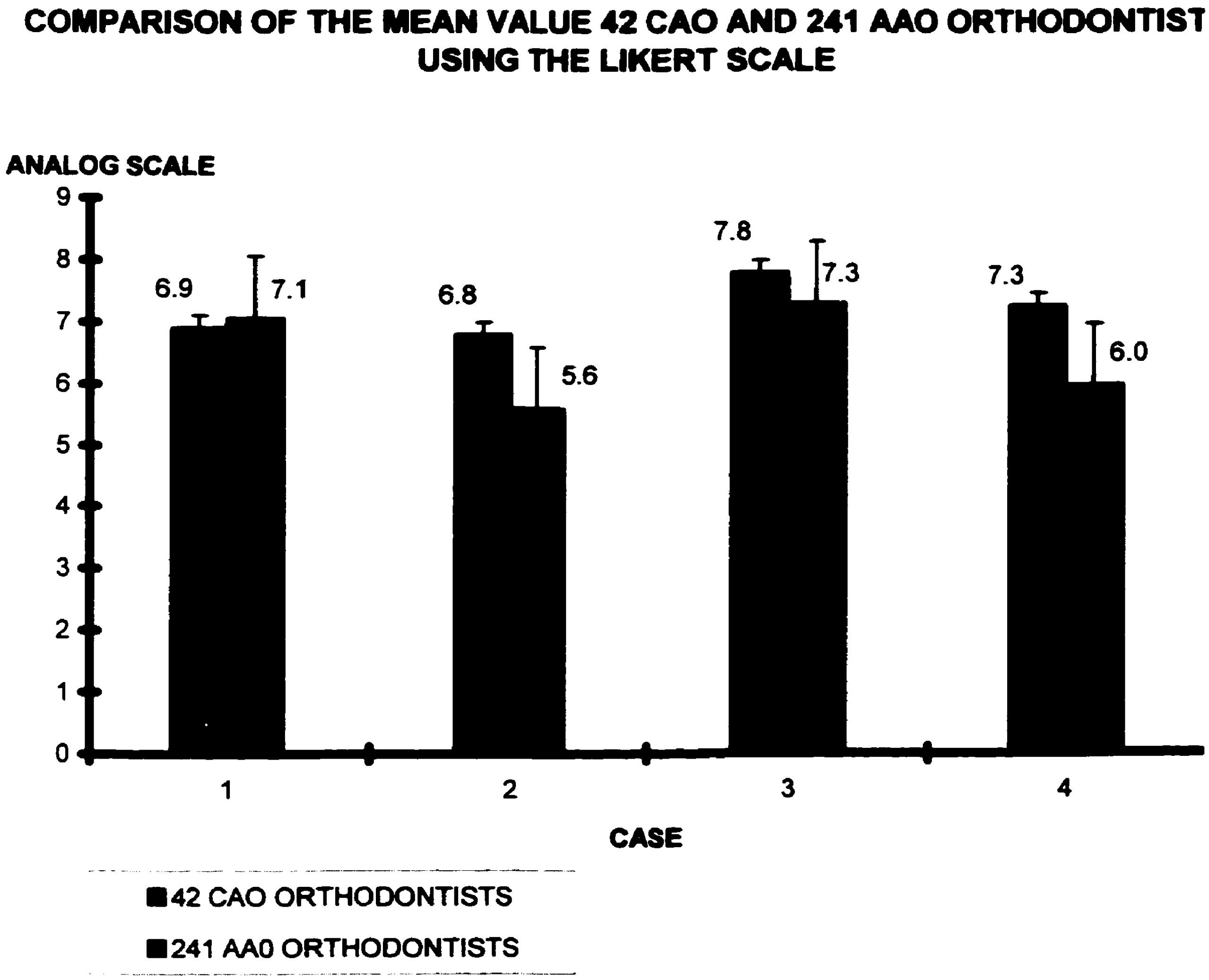


**Fig. 3.5:** A comparison of the scores of the Likert (Visual-Analog) for the same four cases by both the Canadian and the American orthodontists, indicated that case No. 3 was scored by both groups as the most difficult case. The Canadian orthodontists mean Likert score was 7.8 and the American orthodontists mean Likert score was 7.3

**Figure 3.6**

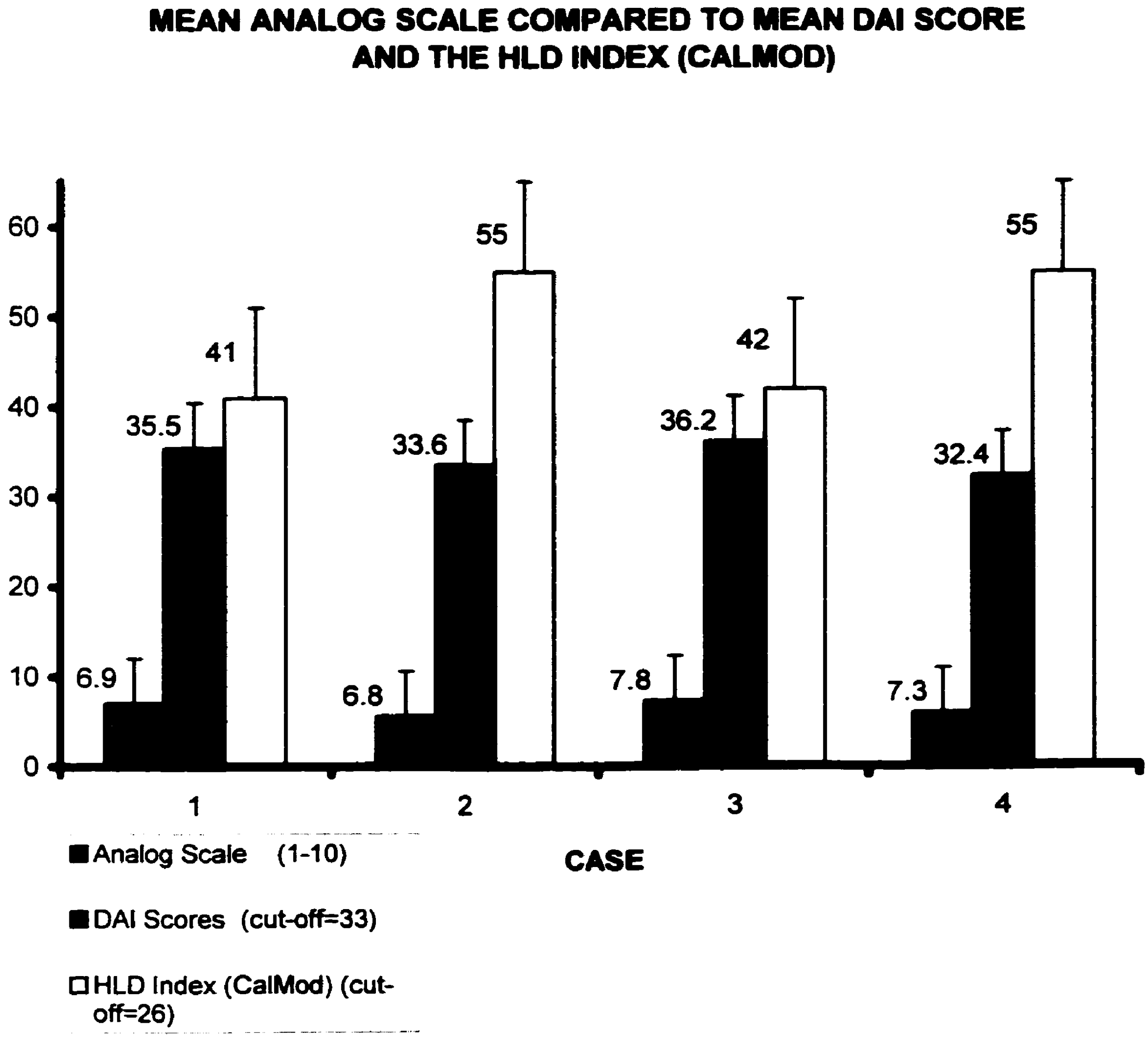


**Fig. 3.6:** A comparison of the results of both the DAI and the Visual-Analog scores to the CALMOD Index indicated that Case 4 scored much higher on the CALMOD Index. Case No. 4 had a mean DAI score of 32.4 and would not have made the cut-off score using the DAI index, whereas it would be automatically accepted for treatment according to the CALMOD Index.

### 3.5 Statistical Analysis

The mean, standard deviation, standard error, median and correlation of variance was calculated for the Canadian orthodontists using the DAI index and the Likert (V-A) scale, and also for the American using the Likert (V-A) scale (See tables 3.2, 3.3, 3.4).

Using the Pearson Correlation Coefficient analysis, it indicates that there is no significant difference ( $p = .0069$) between the scores of the Canadian or American volunteer orthodontists when using the DAI index, or the Likert-Analog Scale. (See Table 3.7, 3.8, 3.9).

**Table 3.7 Canadian Dental Aesthetic Index (DAI) Scores**

| CANADA DAI SCORES | | | | | |
|---|---|---|---|---|---|
| CASE | MEAN | ST DEV | ST ERROR | MEDIAN | CORR VAR |
| 1 | 35.48 | 3.617 | 0.558 | 35 | 13.085 |
| 2 | 33.55 | 2.898 | 0.447 | 33 | 8.400 |
| 3 | 36.17 | 3.428 | 0.529 | 36 | 11.752 |
| 4 | 32.36 | 3.222 | 0.497 | 32 | 10.382 |

**Table 3.8 Canadian Likert (Visual-Analog) Scores**

| CANADA LIKERT SCORES | | | | | |
|---|---|---|---|---|---|
| CASE | MEAN | ST DEV | ST ERROR | MEDIAN | CORR VAR |
| 1 | 6.91 | 1.797 | 0.277 | 7 | 3.540 |
| 2 | 6.79 | 1.536 | 0.237 | 8 | 2.360 |
| 3 | 7.79 | 1.712 | 0.264 | 8 | 2.931 |
| 4 | 7.26 | 1.329 | 0.205 | 7 | 1.766 |

**Table 3.9 American Likert (Visual-Analog) Scores**

| U.S. LIKERT SCORES | | | | | |
|---|---|---|---|---|---|
| CASE | MEAN | ST DEV | ST ERROR | MEDIAN | CORR VAR |
| 1 | 7.06 | 2.093 | 0.135 | 8 | 4.380 |
| 2 | 5.59 | 2.939 | 0.125 | 6 | 3.759 |
| 3 | 7.30 | 1.986 | 0.128 | 8 | 3.942 |
| 4 | 5.97 | 2.141 | 0.138 | 6 | 4.582 |

**Table 3.10 A list of the DAI parameters and their mean and standard deviation**

| DAI PARAMETERS SCORES | | | | | |
|---|---|---|---|---|---|
| PARAMETERS | MEAN | ST DEV | ST ERROR | MEDIAN | CORR VAR |
| MISSING TEETH | 0 | 0 | 0 | 0 | 0 |
| CROWDING | 1.42 | 0.785 | 0.121 | 2 | 0.617 |
| SPACING | 0.17 | 0.390 | 0.060 | 0 | 0.152 |
| DIASTEMA | 0.23 | 0.437 | 0.068 | 0 | 0.191 |
| ANT IRREG MAX | 4.60 | 1.635 | 0.252 | 5 | 2.674 |
| ANT IRREG MAND | 1.95 | 1.619 | 0.250 | 2 | 2.621 |
| OJ MAX | 10.11 | 2.034 | 0.314 | 10 | 4.137 |
| OJ MAND | 0 | 0 | 0 | 0 | 0 |
| OPENBITE | 0.04 | 0.316 | 0.049 | 0 | 0.100 |
| MOLAR REL | 1.72 | 0.725 | 0.112 | 2 | 0.526 |

Table 3.11 **Differential case-ranks based on Likert and DAI scores**

| | **Canadian Likert** | | | **American Likert** | | | **Canadian DAI** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Case** | **Mean - SD** | **Mean** | **Mean + SD** | **Mean - SD** | **Mean** | **Mean + SD** | **Mean - SD** | **Mean** | **Mean + SD** |
| 1 | 3 | 4 | 2 | 2 | 2 | 2 | 3 | 4 | 2 |
| 2 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 4 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 2 | 2 | 3 | 3 | 3 | 4 | 2 | 2 | 3 |

Table 3.12 **Differential case ranks based on Median Likert and DAI scores**

| **Case** | **Canadian Likert** | **American Likert** | **Canadian DAI** |
|---|---|---|---|
| 1 | 2 | 3 | 1 |
| 2 | 3 | 1 | 3 |
| 3 | 1 | 1 | 1 |
| 4 | 4 | 3 | 3 |

**Table 3.13 Proportion (%) of assessors outside range of mean ± 1SD Likert and DAI case scores**

| **Assessment** | **Case** | **Above range** | **Below range** | **Total Misdiagnoses** | **Average** |
|---|---|---|---|---|---|
| Can. Likert | 1 | 11.8 | 11.8 | 23.6 | |
| | 2 | 10.5 | 0 | 10.5 | |
| | 3 | 21.9 | 9.4 | 31.3 | |
| | 4 | 14.7 | 8.8 | 23.5 | **22** |
| Am Likert | 1 | 5.3 | 11.1 | 16.4 | |
| | 2 | 5.9 | 3.2 | 9.1 | |
| | 3 | 6.8 | 14.5 | 21.3 | |
| | 4 | 8.8 | 9.3 | 18.1 | **16** |
| Can. DAI | 1 | 5.6 | 11.1 | 16.7 | |
| | 2 | 0 | 7.7 | 7.7 | |
| | 3 | 5.9 | 17.6 | 23.5 | |
| | 4 | 11.4 | 8.6 | 20.0 | **17** |

**Table 3.14 Variation in assessor training and experience (%)**

| Assessment | Case | Above range | Below range | Total Misdiagnoses | Average |
|---|---|---|---|---|---|
| Can. DAI | 1 | 5.9 | 11.8 | 17.7 | |
| | 2 | 2.8 | 8.4 | 11.2 | |
| | 3 | 8.3 | 5.6 | 13.9 | |
| | 4 | 2.8 | 13.9 | 16.7 | **14.9** |

### 3.6 Implications of insensitivity of Likert and DAI assays

Due to the 16-22% of assessors that 'mis-categorized' the four cases, consideration must be given as to the implications of these 'errors'. The logical approach is to review the treatment plans and B-records of the four cases. Treatment plans of 4 cases:

Case 1 Non-extraction, lip bumper, bionator, full fixed multibanded appliances

Case 2 14, 24, maximum anchorage, quad helix, full fixed multibanded appliances

Case 3 Extract 14, 24, 34, maximum anchorage, surgery-one-piece maxillary impaction and mandibular advancement, full multibanded appliances

Case 4 Extract 14, 24, maximum anchorage, Transpalatal Arch, High Pull Headgear

| | |
|---|---|
| B records of Case 1 | Class I molar and canine, OJ = - 2 mm, OB = 20%, midlines coincident |
| B records of Case 2 | Class II molars, Class I canine, OJ = - 2 mm, OB = 5%, mandibular midline, 2 mm to the Left |
| B records of Case 3 | Class I molars, Class I canines, OJ = - 2 mm, OB = 20%, midlines coincident, decreased interlabial gap, decreased lower anterior face height |
| B records of Case 4 | Class II molars, 1/2 cusp Class II canines, OJ = - 4 mm, OB = 20%, mandibular midline = 2 mm to L, increased lower anterior face height |

Review of the evidence listed above shows that although a satisfactory outcome emerged for each case, there were also some less than ideal results.

There was no significant difference between the 43 volunteer orthodontists when comparing the region of the country in which they practice or the University from which they graduated. The volunteer orthodontists from the Canadian conference practiced in 6 provinces in Canada, (including; Nova Scotia, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia) and graduated from 11 different specialty programs, most of them in Canada and some from the United States or abroad. (See Table 3.15).

**Table 3.15 University of Graduation of the CAO Orthodontist Attendees**

| University of Graduation | Number | % of Total |
|---|---|---|
| U of Manitoba | 16 | 37.2% |
| U of Alberta | 11 | 25.6% |
| U of Toronto | 5 | 11.6% |
| U of Western Ontario | 4 | 9.3% |
| U of Minnesota | 2 | 4.7% |
| Other | 5 | 11.6% |
| Total : | 43 | 100.0% |

("Other" – includes the Universities of Connecticut, Montreal, Pretoria, St. Louis, Washington).

The 241 volunteer orthodontists attending the American conference graduated from a total of 136 different specialty programs from 26 countries around the world. The orthodontists who lived in the U.S. practiced in 27 states including; Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Massachusetts, Missouri, Michigan, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Texas, Tennessee, Utah, Virginia, and Washington, D.C. (See Table 3.16).

**Table 3.16 Country of Origin of the AAO Orthodontist Attendees**

| Country of Origin | Number | % of Total |
|---|---|---|
| United States | 88 | 36.5% |
| Mexico | 30 | 12.4% |
| Brazil | 25 | 10.2% |
| Japan | 14 | 5.7% |
| United Kingdom | 12 | 5.1% |
| Germany | 7 | 2.9% |
| Columbia | 7 | 2.9% |
| France | 5 | 2.2% |
| Sweden | 5 | 2.2% |
| Canada | 3 | 2.2% |
| Australia | 5 | 2.2% |
| Italy | 5 | 2.2% |
| Argentina | 4 | 1.5% |
| Korea | 4 | 1.5% |
| Portugal | 4 | 1.5% |
| Other | 21 | 8.8% |
| Total: | 241 | 100.0% |

("Other" includes the countries of Belgium, China, Finland, Norway, Peru, South Africa, Spain, Switzerland, Taiwan, Turkey, Venezuela, and five 'No Answer').

## 3.7 Years in Practice/Teaching

There is no correlation between the years in practice/teaching for the Canadian orthodontists when looking at their respective scores for Cases 1-4 using the DAI index (See Figures; 3.7, 3.8, 3.9, 3.10) or the Likert (V-A) scale (See Figures; 3.11, 3.12, 3.13, 3.14).

There is also no correlation between the years in practice/teaching for the orthodontists who attended the American Association of Orthodontists Congress when looking at their respective scores for Cases 1-4 using the Likert (V-A) scale (See Figures, 3.15, 3.16, 3.17, 3.18).

### 3.8 Year of Graduation

For the Canadian Association of Orthodontists Conference, volunteer orthodontists, the year of graduation included the years between 1960-2000, with three operators graduating prior to 1970, 9 operators graduating between 1970-1980, 10 operators graduating between 1980-1990 and 20 operators graduating between 1990-2000 (See Fig. 3.19).

For the CAO volunteer orthodontists in Practice/Teaching, only 2 operators had over 30 years of experience, 7 operators had between 20-25 years of experience, 3 operators had between 15-20 years of experience, 5 operators had between 10-15 years of experience, 3 operators had between 5-10 years of experience, and 20 operators had less than 5 years of experience (See Fig. 3.20).

For the American Association of Orthodontists volunteer orthodontists, the year of graduation included from 1955-2000, with only 2 operators graduating prior to 1960, and the majority of the operators graduated between the years 1980-1990 (See Fig. 3.21).

For the AAO volunteer orthodontists, years in practice/teaching, only 2 operators had more than 40 years of experience, and the majority of the operators had between 5-15 years of experience (See Fig. 3.22).

**Figure 3.7**

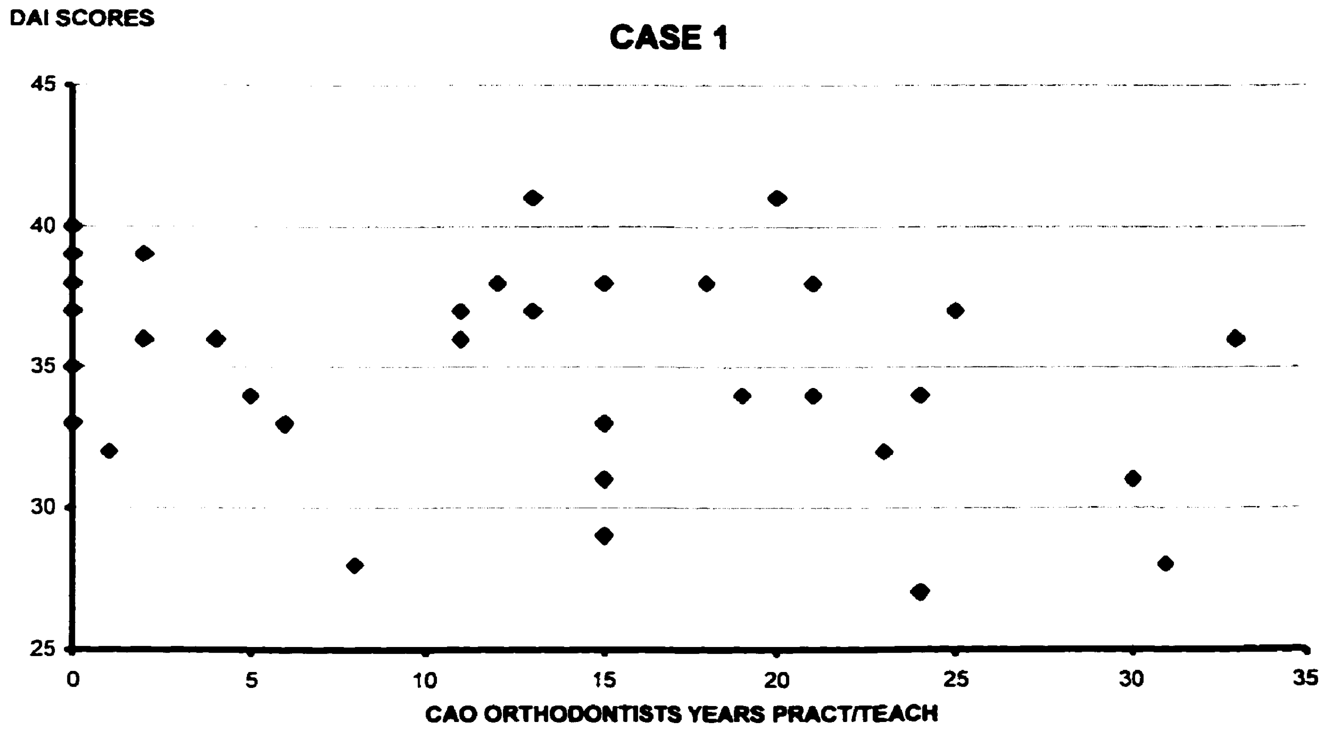


**Fig. 3.7: Case 1** – Dental Aesthetic Index scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.8**

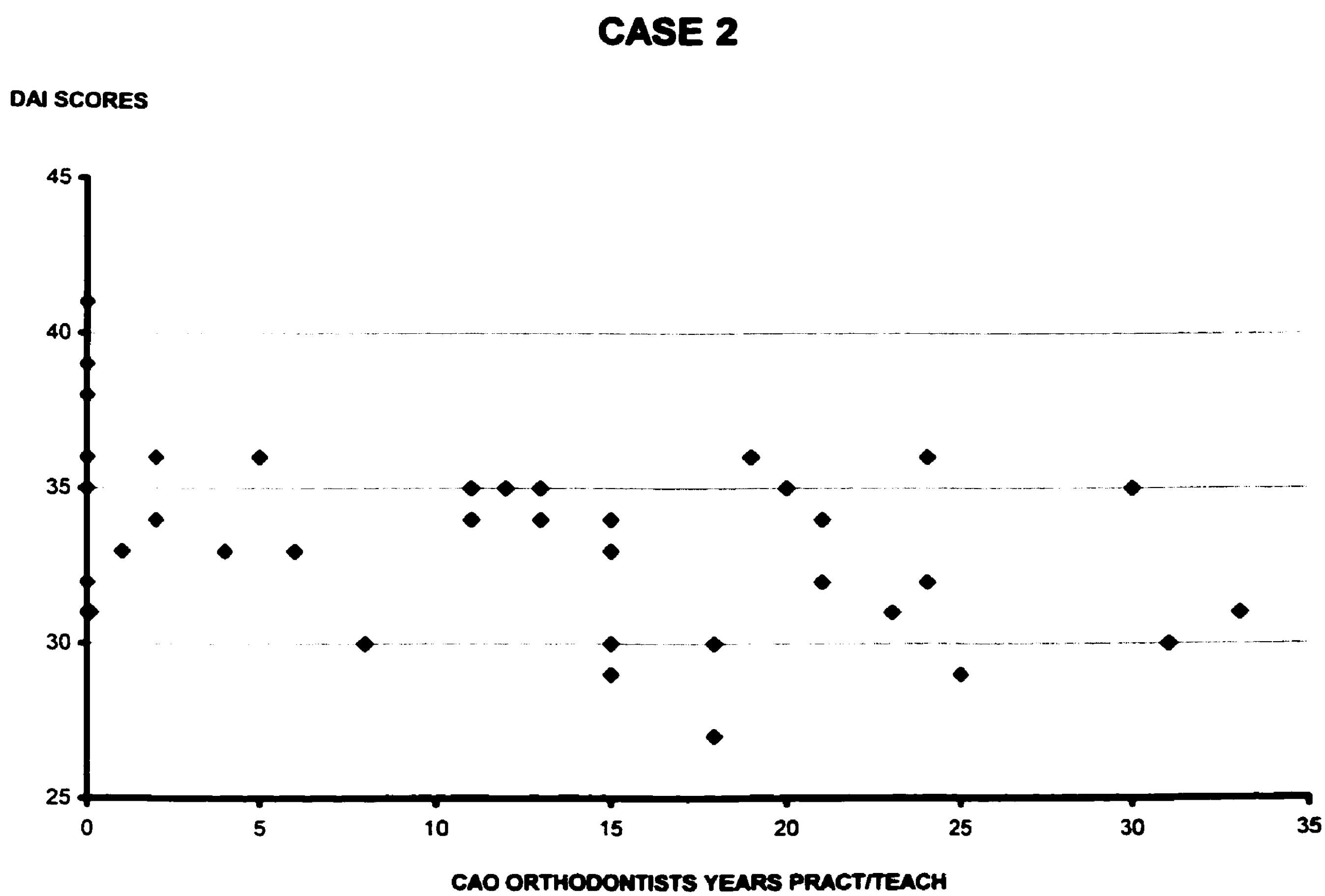


**Fig. 3.8: Case 2** – Dental Aesthetic Index scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference (p < .02). Scores may be superimposed, giving some dots higher significance.

**Figure 3.9**

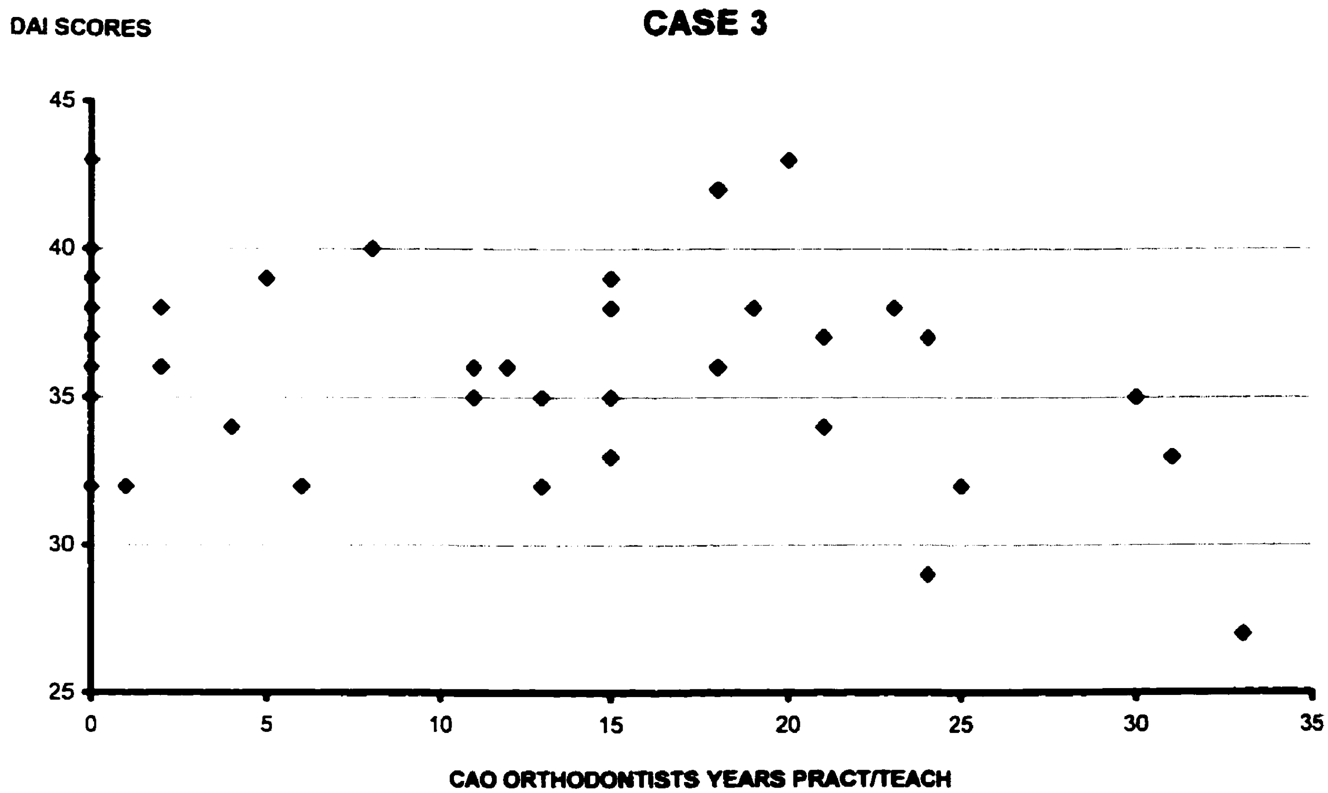


**Fig. 3.9: Case 3** – Dental Aesthetic Index scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.10**

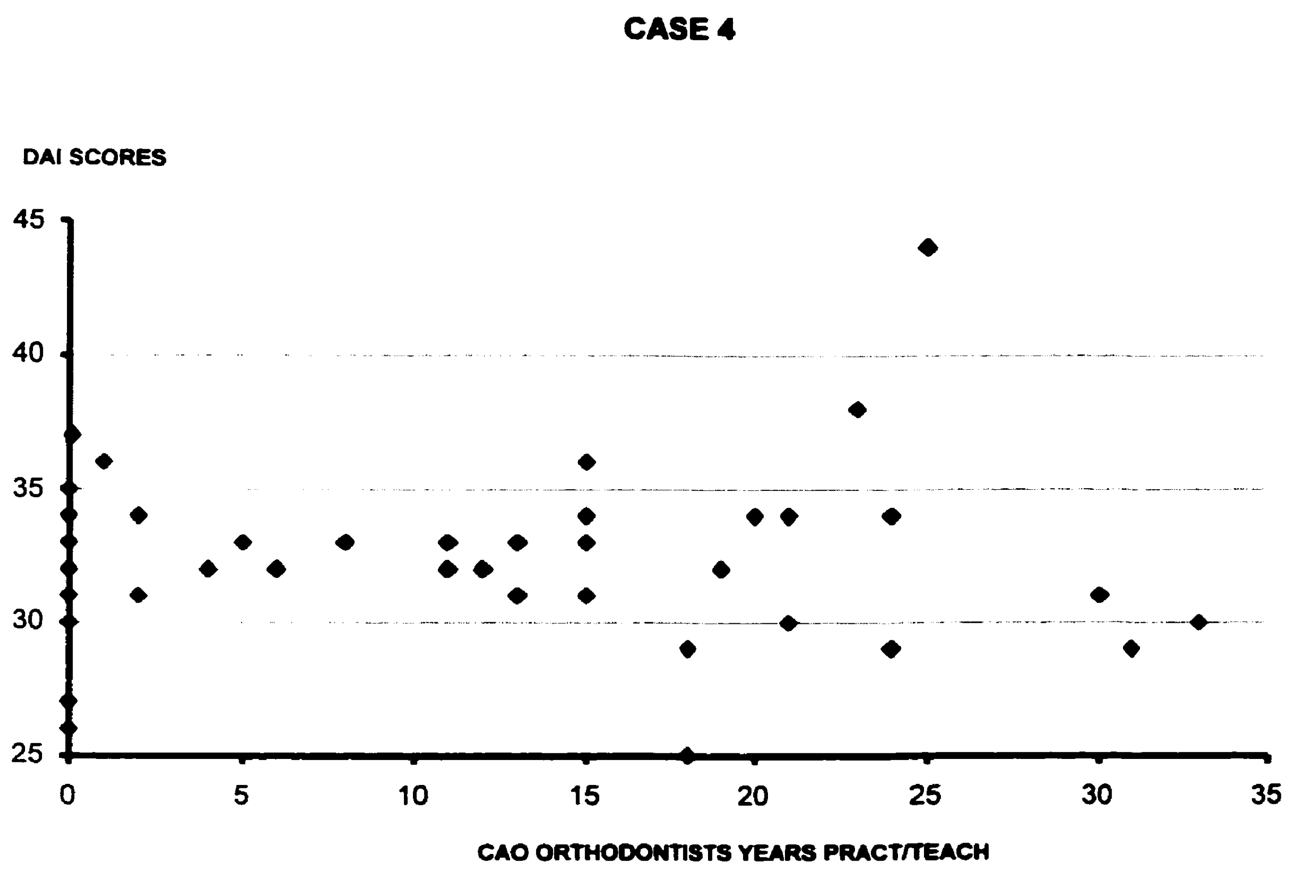


**Fig. 3.10: Case 4** – Dental Aesthetic Index scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.11**

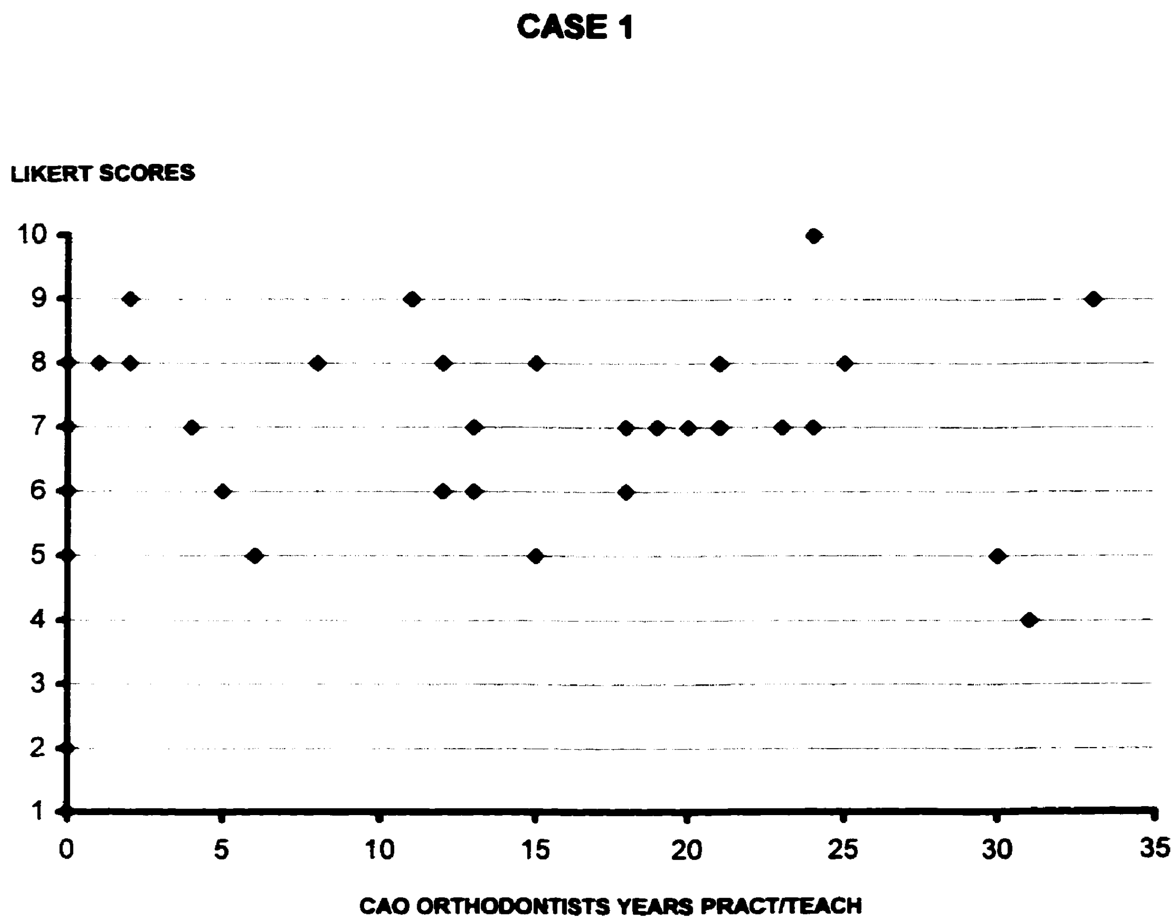


**Fig. 3.11: Case 1** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.12**

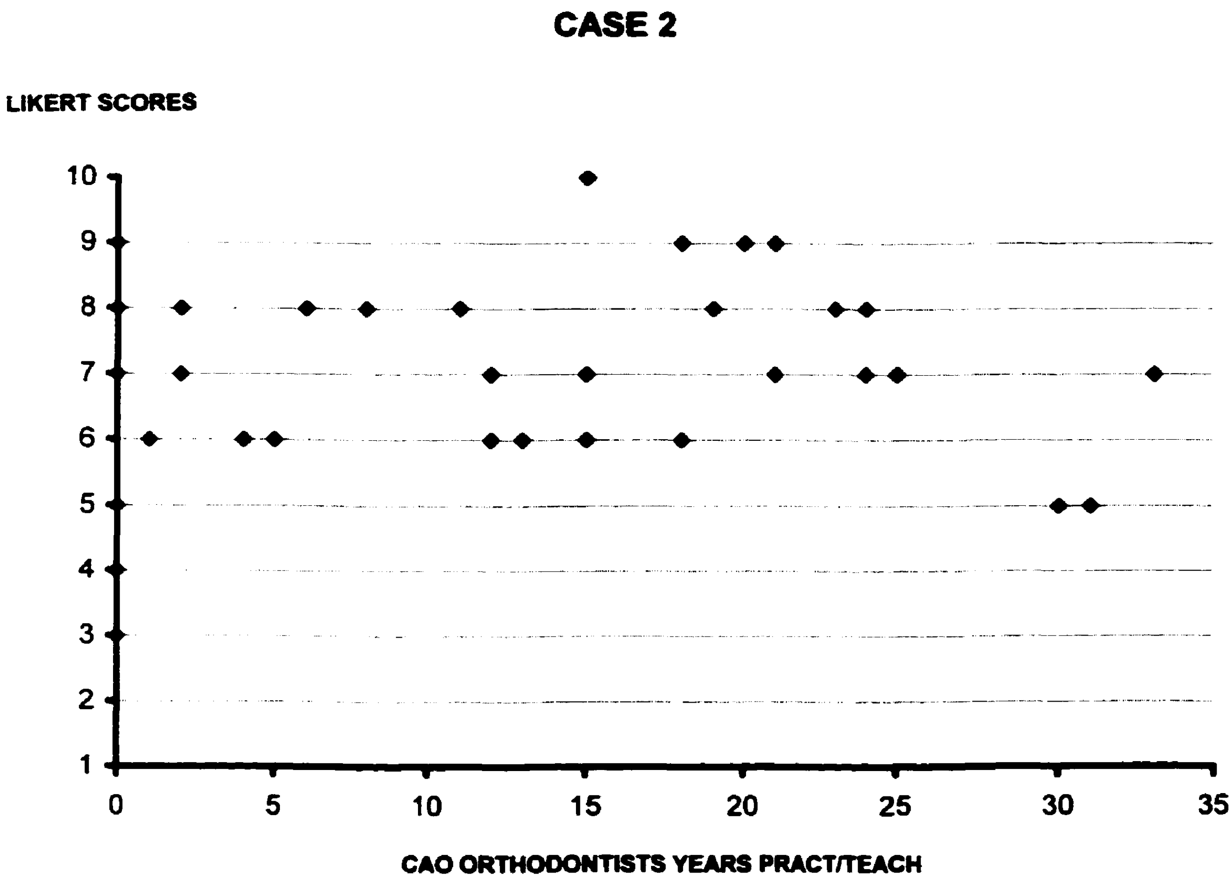


**Fig. 3.12: Case 2** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.13**

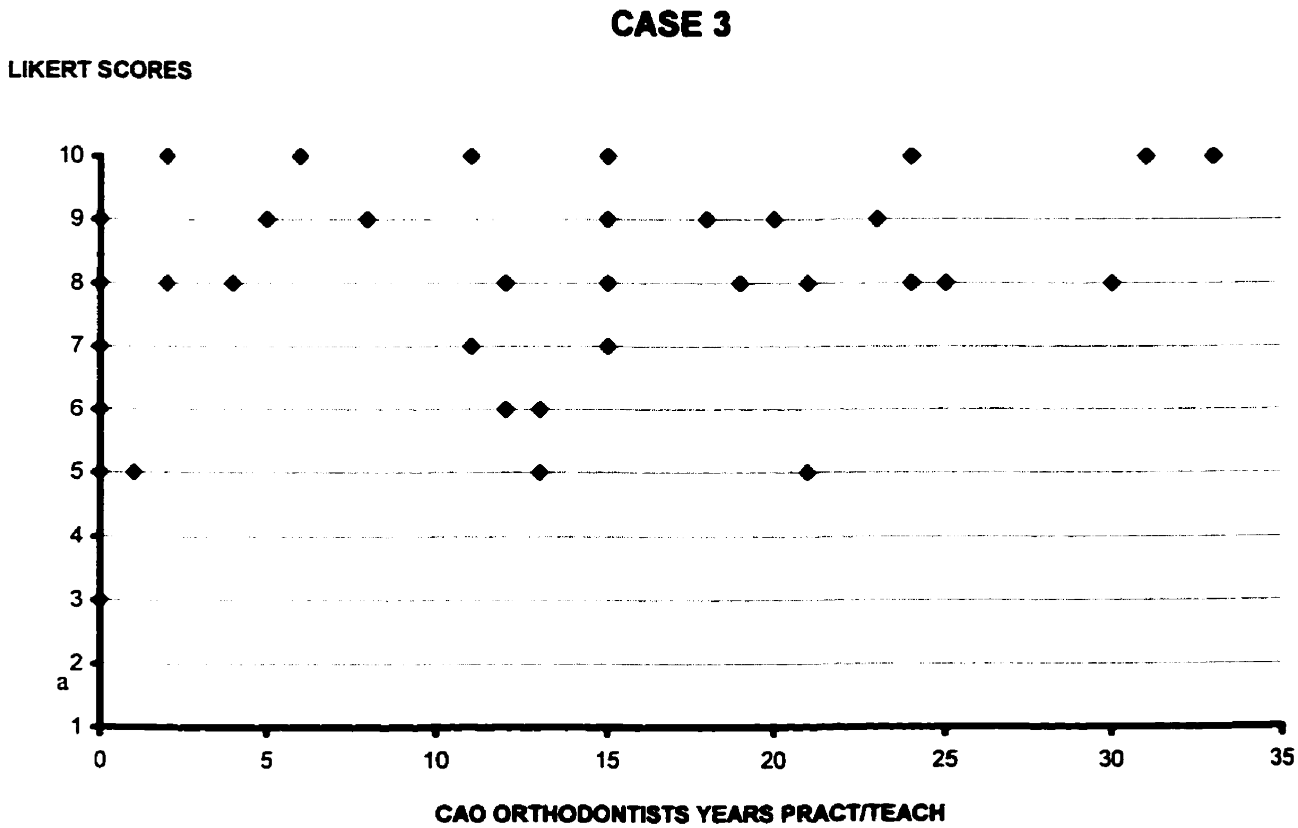


**Fig. 3.13: Case 3** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.14**

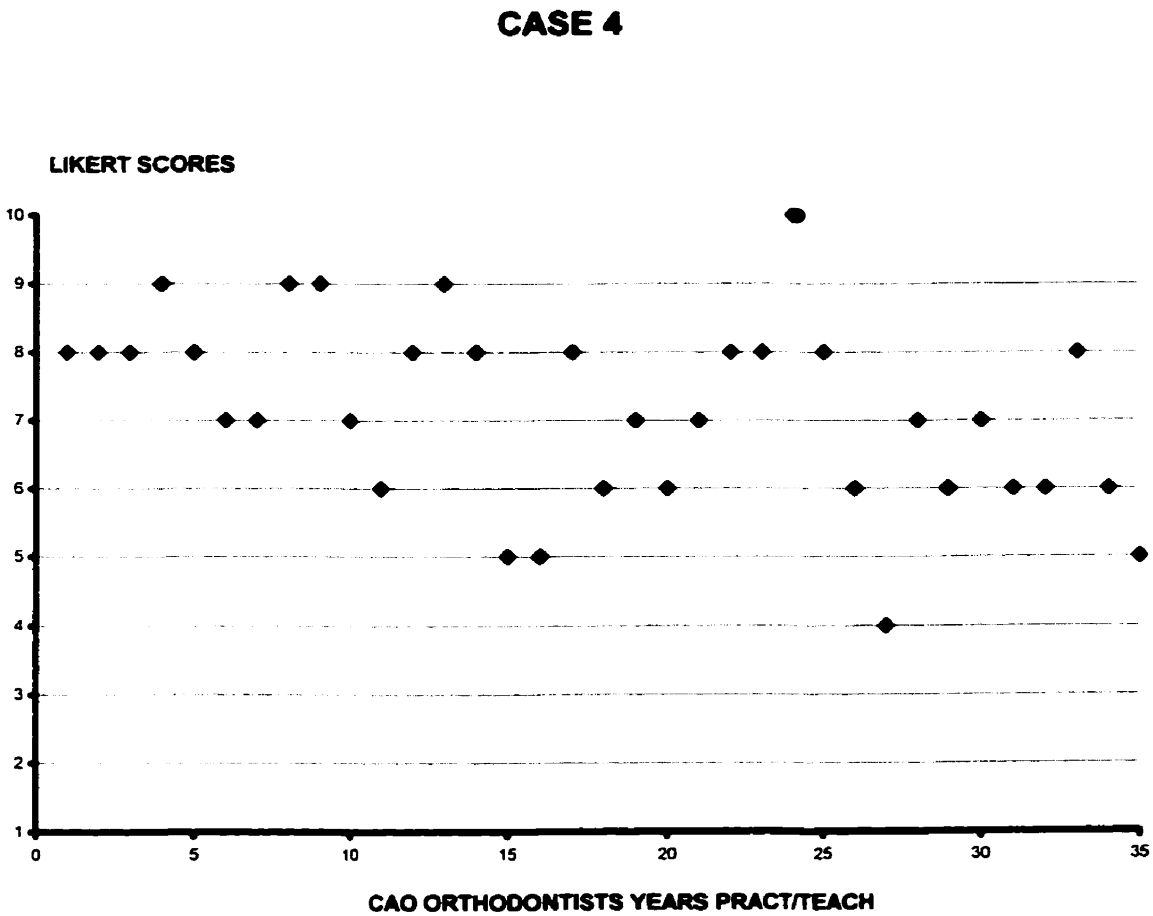


**Fig. 3.14: Case 4** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the Canadian Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.15**

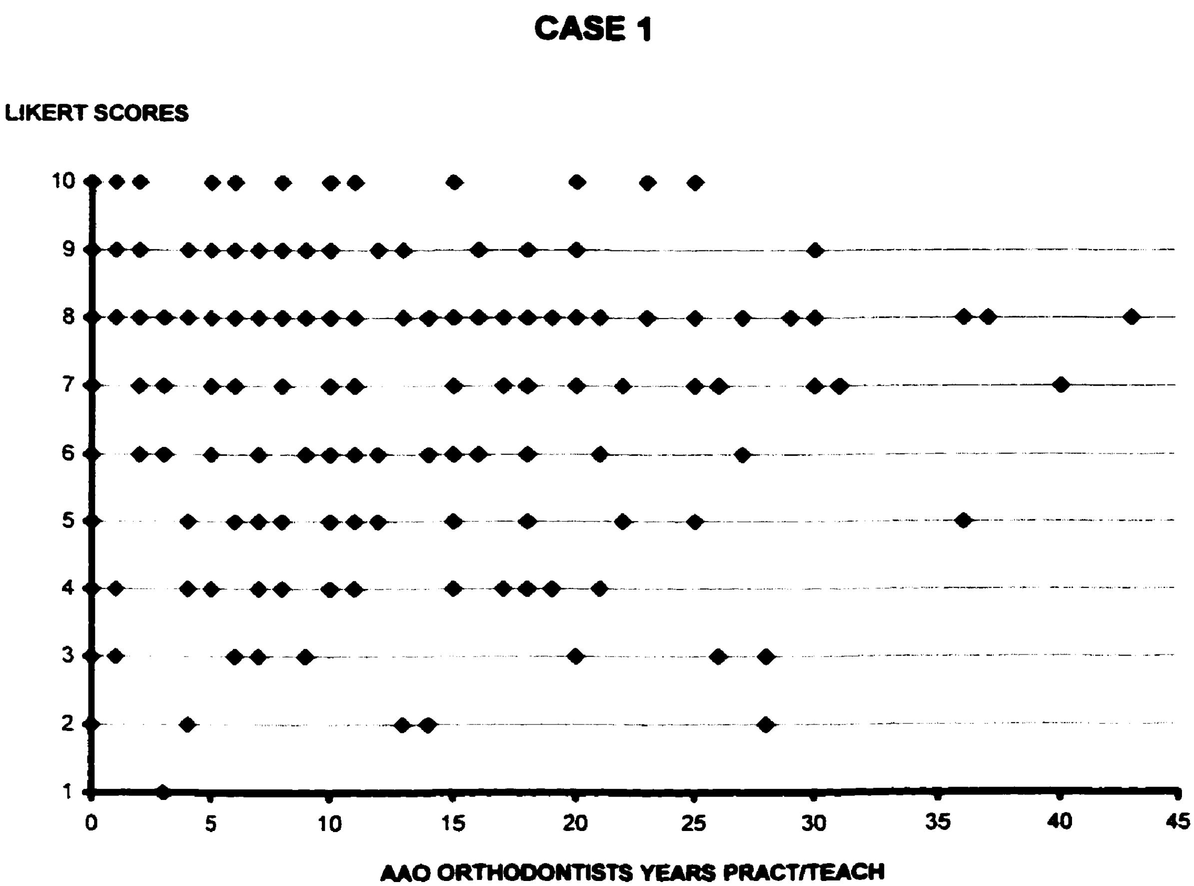


**Fig. 3.15: Case 1** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the American Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.16**

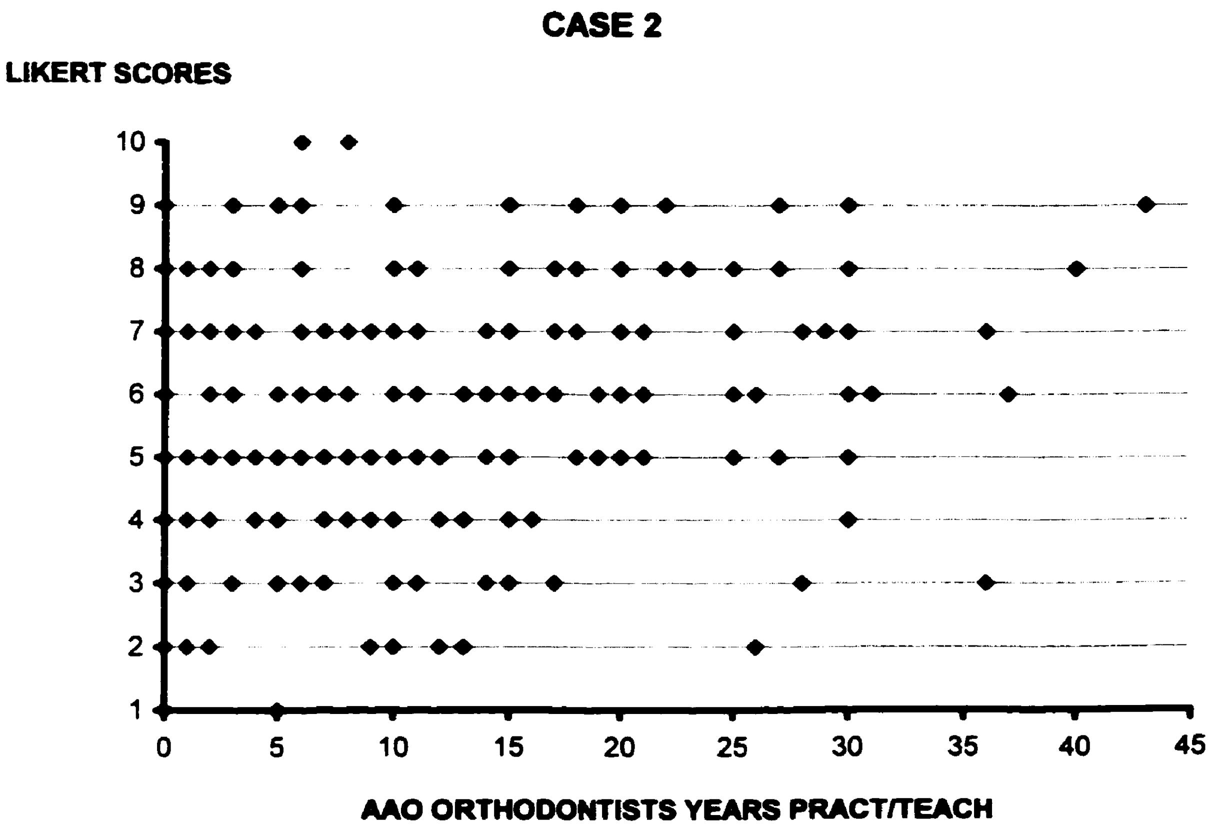


**Fig. 3.16: Case 2** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the American Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.17**

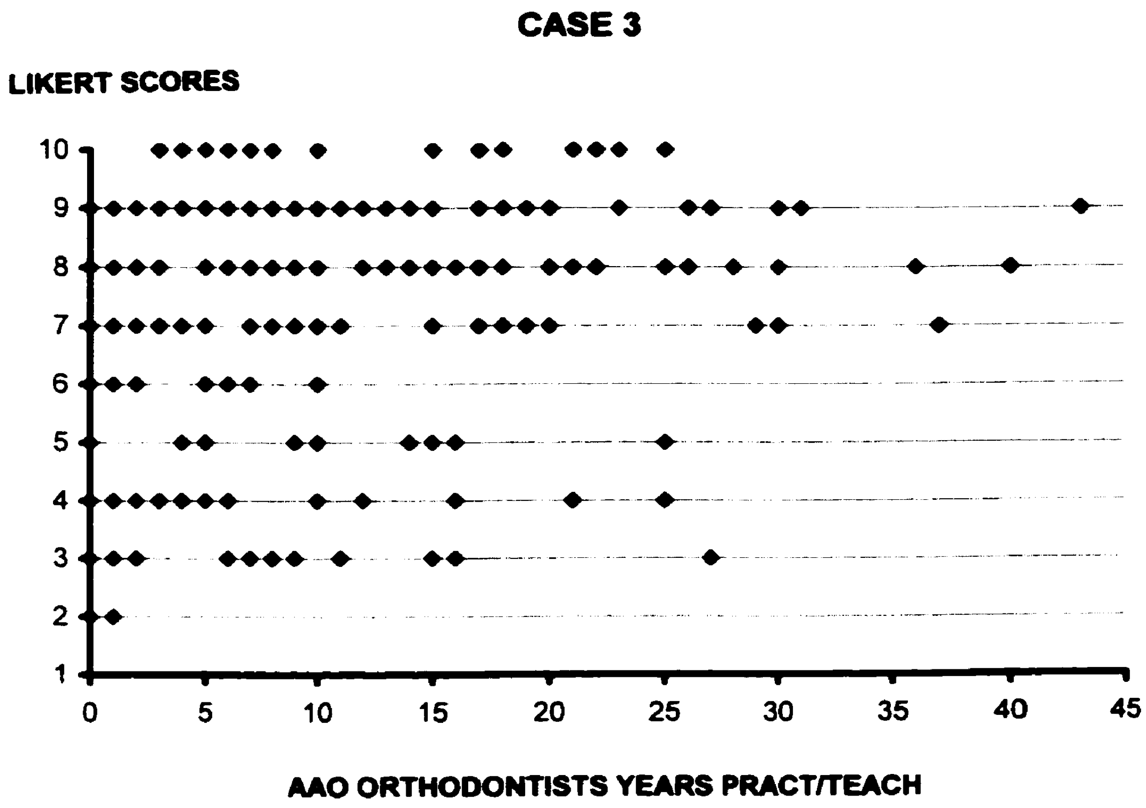


**Fig. 3.17: Case 3** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the American Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.18**

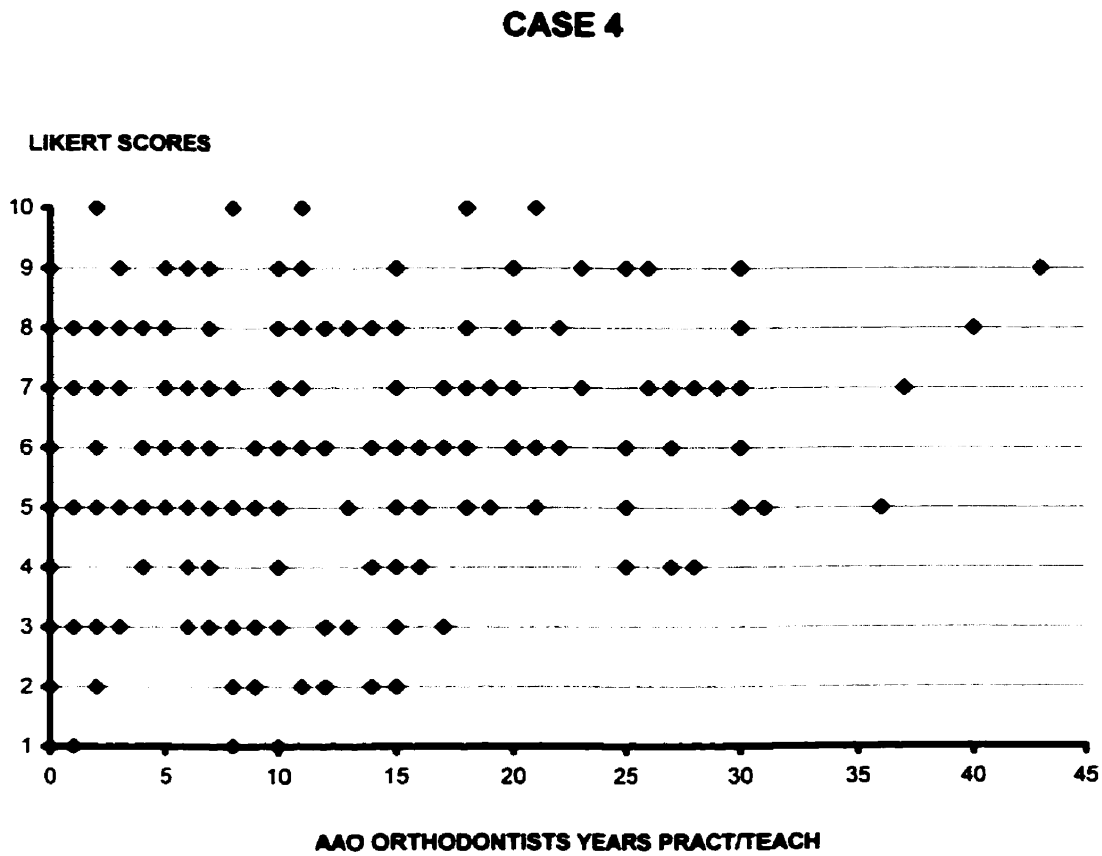


**Fig. 3.18: Case 4** – Likert Visual-Analog scores versus years of practice/teaching experience of the 43 orthodontists who attended the American Association Conference. No significant difference ($p < .02$). Scores may be superimposed, giving some dots higher significance.

**Figure 3.19**

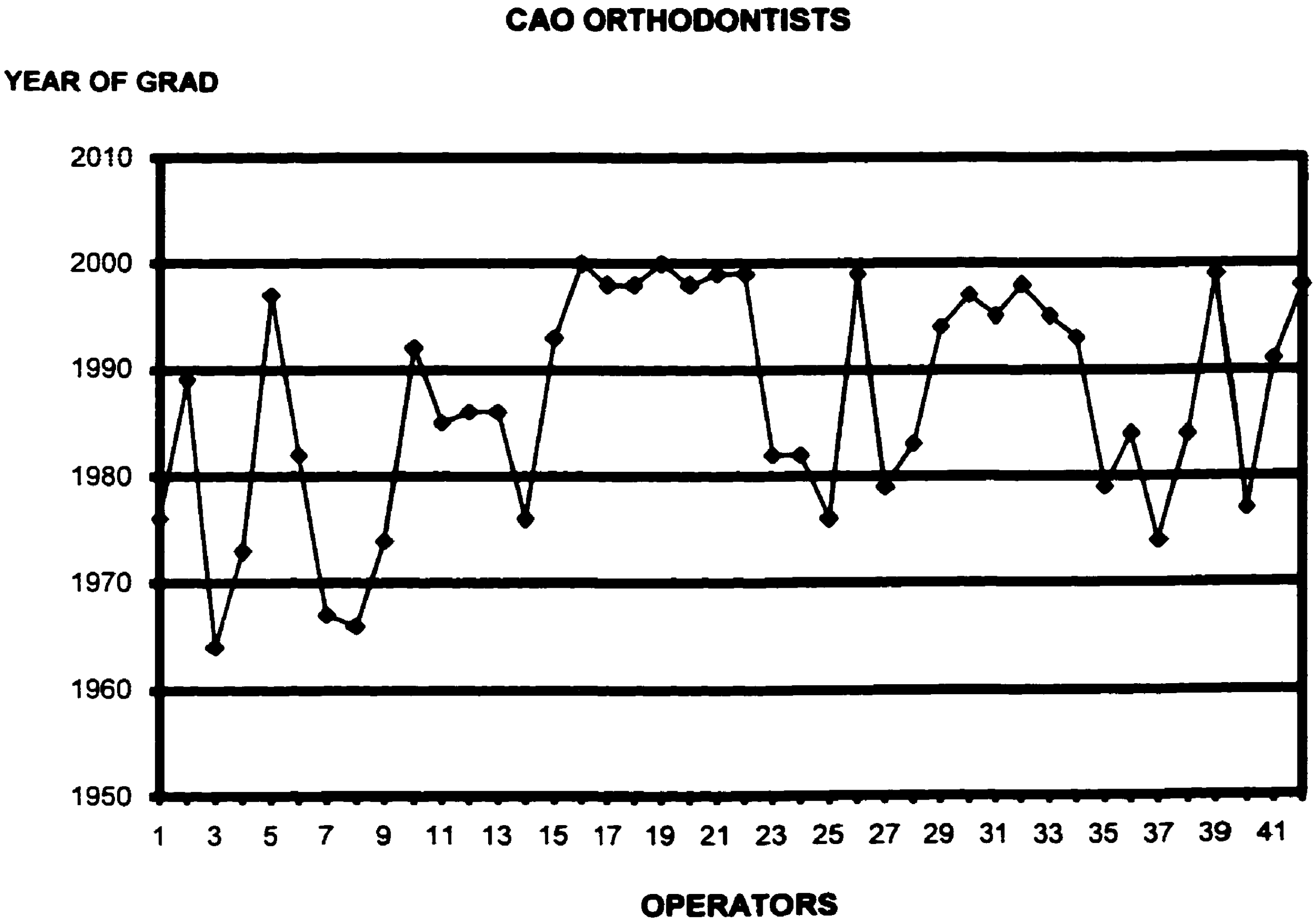


**Fig. 3.19:** The above graph indicates the Year of Graduation of the orthodontists attending the Canadian Association of Orthodontists Conference.

**Figure 3.20**

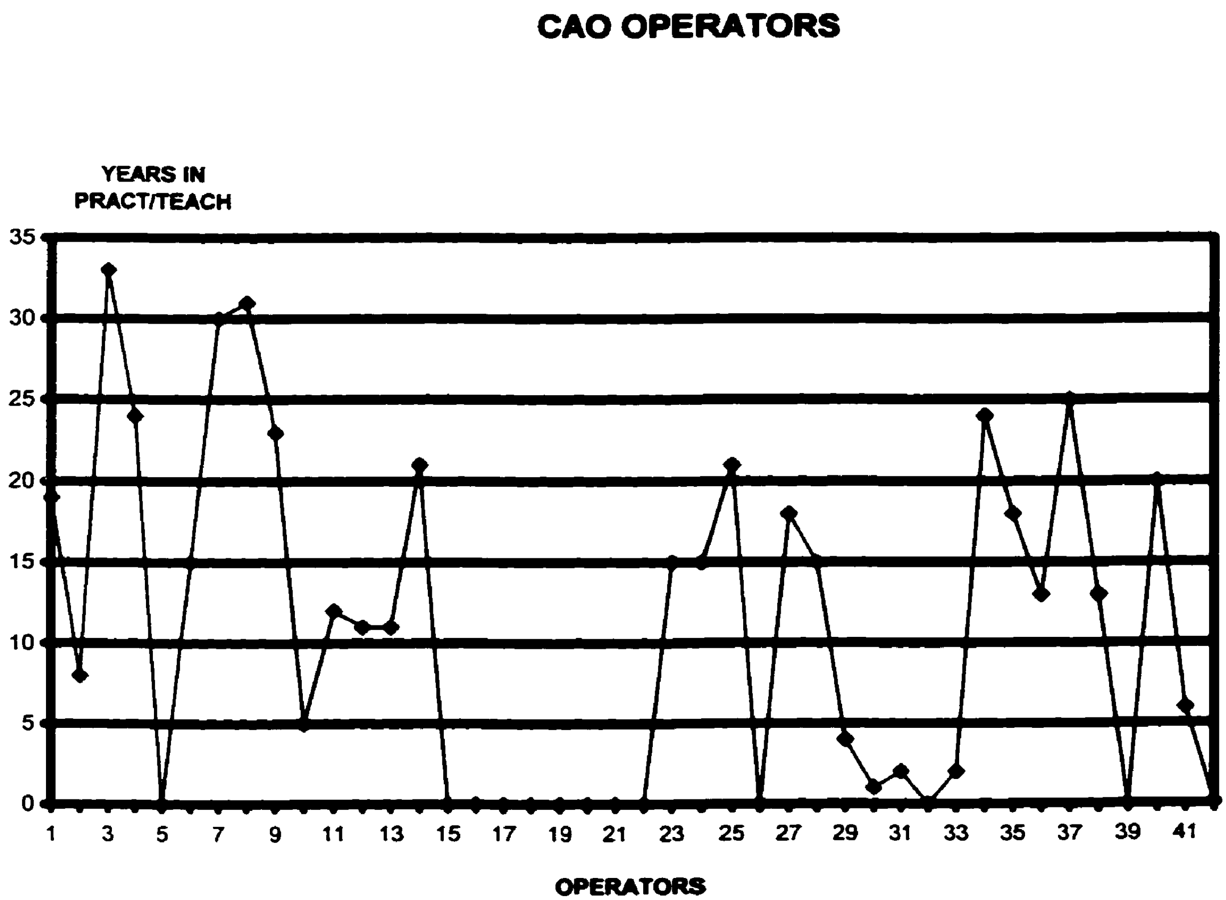


**Fig. 3.20:** The above graph indicates the number of Years in Private Practice/Teaching of the orthodontists attending the Canadian Association of Orthodontists Conference.

Figure 3.21

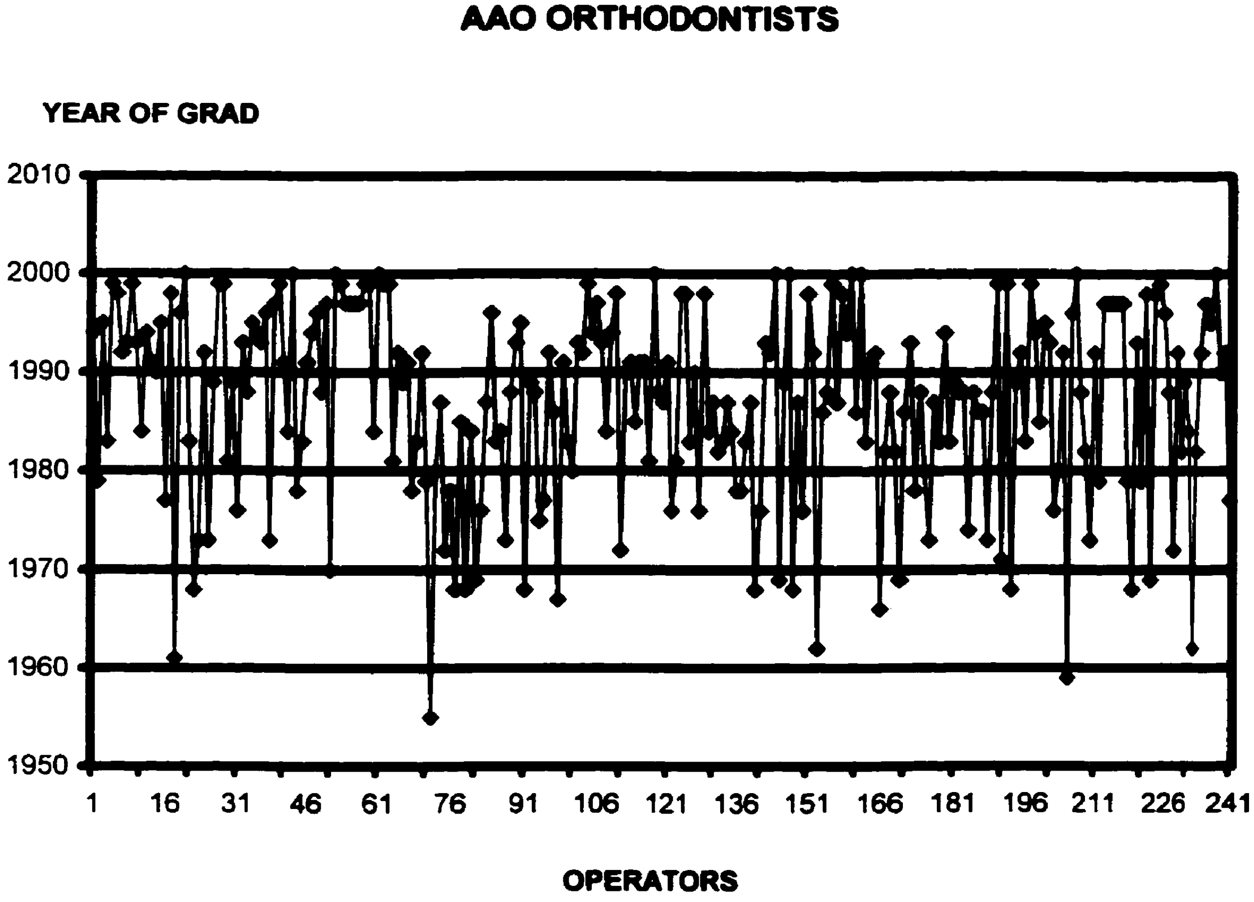


**Fig. 3.21:** The above graph indicates the Year of Graduation of the orthodontists attending the American Association of Orthodontists Conference.

**Figure 3.22**

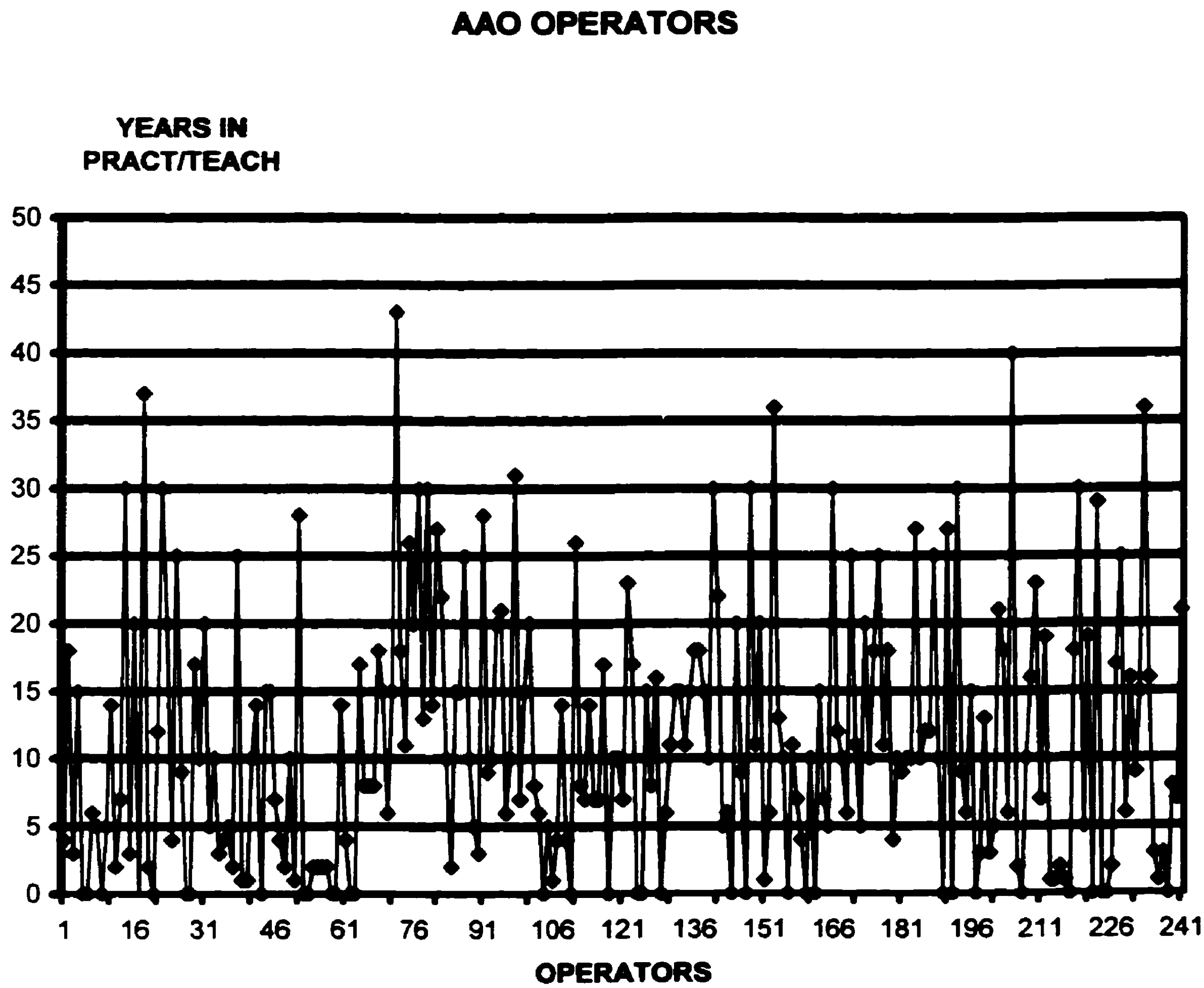


Fig. 3.22: The above graph indicates the number of Years in Private Practice/Teaching of the orthodontists attending the American Association of Orthodontists Conference.

## 3.9 CalMod Index

The CalMod Index does appear to have advantages over the DAI and Likert (V-A) scale as it was able to distinguish between Case No. 3 and Case No.4, that Case No. 4 was the more complicated case and was given the highest score of 55 (See Fig. 3.6). Case No. 4 according to the CalMod index is considered to be a severe handicapping malocclusion according to the large overjet of 9mm, and would automatically qualify for orthodontic treatment in California.

## 3.10 Cephalometric Records

The cephalometric tracings of "A" and "B" cephs and their superimposition and the Manitoba analysis ( the four cases were all children who were from Manitoba and lived here most of their lives) can be found in Appendix 5.

## 3.11 Summary

The results of this study therefore conclusively indicate that the DAI & Likert scores cannot assure consistent assessments of the treatment difficulty. Furthermore, CalMod scores offer little additional benefits, as illustrated in Figure 4, CalMod case scores.

These conclusions may therefore be summarized by the following; the DAI, Likert and CalMod indices cannot assure consistent assessments of treatment difficulty

# DISCUSSION

## CONTENTS

# DISCUSSION

## 4.0 Categorization of Treatment Difficulty

Quantitative descriptors are more appropriate to define biological phenomena (including individuals' healthcare service needs), than the potentially biased subjective assessments of health care administrators and health care specialists . Although such descriptors are particularly relevant to the assessment of orthodontic services required to resolve a malocclusion, where progress to date has been slow relative to many other healthcare services, e.g. services for hypertension (Moser, 1998). For instance, various indices have been developed to:

- describe malocclusions (e.g. Angle, 1899; Ballard & Wayman, 1964);
- collect epidemiological data on malocclusion prevalence between populations (Elsasser, 1953; Van Kirk & Pennell, 1959; Poulton & Aaronson, 1961);
- priorize individuals' orthodontic service needs (Draker, 1960; Grainger, 1967; Brook & Shaw, 1989);
- evaluate orthodontic service outcomes (Richmond *et al.*, 1992).

Unfortunately, assays to assess the complexity of orthodontic services required to resolve specific malocclusions have so far proved elusive, although their potential advantages are clearly apparent:

- the objective discrimination of orthodontic services that should be preferentially provided by specialists rather than non-specialists;
- the reduction of contentious variations in orthodontic service types and timing (often patient driven) for apparently similar occlusal discrepancies;
- the provision of objective measures to differentiate the orthodontic service fees for different types of malocclusion, (i.e. professional fees that are functions of the required service complexity).

The urgent need for a quantitative approach was underscored by the current investigation, where the categorization of service complexity (treatment difficulty) for four Class II cases by different specialists proved unacceptably inconsistent (even though case appraisals based on the DAI proved more consistent than their subjective visual assessments). This also raised another common problem for many other aspects of dentistry: the lack of accepted clinical guidelines relative to the more than 1800 clinical guidelines catalogued for other healthcare services (Citrome, 1998).

A conceptually most useful index would be one that defined orthodontic service complexity. There are many potential advantages of such an index, including the following:

- target the most appropriate skills to provide the most appropriate service(s) for individual patients
- set an appropriate third-party service fee for specific patients
- inform and obtain more valid consent from specific patients

Inconsistent assays for service complexity (difficulty) required to resolve specific Class II malocclusion cases also illustrate why,

- the "art" of orthodontics has yet to progress to a "science" (Baumrind, 1998);
- the inability to predict service outcomes disappoints even experienced specialists;
- the frequent need to institute unanticipated mid-course corrections to achieve the intended clinical objective;
- the provision of orthodontic services by non-specialists that fall short of the "specialists" standards (Woodside, 1998).

These are issues that clearly need further discussion.

## 4.1 Imprecise Craniofacial growth predictions

Accurate assays of the services to resolve a particular malocclusion are principally constrained by the inability to predict craniofacial growth changes. For instance, mandibular growth generally grows in a downward and forward direction via posterior growth and anterior displacement (Enlow & Harris, 1964), although the rotational component is more difficult to predict (Baumrind, Korn & West, 1984; Skieller, Bjork & Linde-Hensen, 1984; Leslie *et al.*, 1998). For example, a Class II dental case in the mixed dentition progressing to a Class I dental molar relationship on Class II skeletal base with minimal overjet, and moderate crowding in the mandible, long LAFH. There could be a number of growth scenarios,

a) if the mandible has a vertical growth pattern the patient may end up with an openbite and more severe Class II skeletal, requiring extraction of two lower first bicuspids, a one piece maxillary impaction, mandibular advancement with a vertical reduction advancement genioplasty, or
b) if the mandible has a more horizontal growth pattern, the patient may end up with a Class III molar and incisor relationship which would require extraction of two lower first bicuspids, a one piece maxillary impaction and a mandibular setback, and a vertical reduction sliding genioplasty

Therefore, depending on the direction of growth, the mandible would be treated surgically in the exact opposite direction, either

a) mandible moved forward or
b) mandible moved backward.

If on the other hand growth is entirely favourable, a High Pull Headgear (HPHG) is worn sufficiently (compliance issue), and the mandible grows in a more horizontal than vertical direction, just enough to decrease the overjet, but not too much where the incisors become Class III, then the case may be treated simply with the extraction of two lower bicuspids and HPHG, and an vertical reduction advancement genioplasty, without the need for complicated two jaw surgery.

Of course it would require very thoughtful treatment planning by an orthodontist to be able to treat such a case and even then it is impossible to predict the final treatment plan and outcome of such a case due to the vagaries of growth. The treatment plan of choice, and also the possibility of either of the other two treatment plans which included complicated surgery would need to be discussed with the patient and the parents prior to the start of treatment.

Growth prediction for the craniofacial skeleton as a whole elicits similar concerns, since the magnitude and direction of growth directly impacts on the stability of the final orthodontic service outcome (Ricketts, 1957). For example, a Class II Division 1 crowded case in a 11 year 6 month old female in mixed dentition. The planned treatment is the extraction of upper first bicuspids and lower second bicuspids. At the end of 30 months of full multi-banded orthodontic treatment with Class II elastics, the malocclusion is corrected and everything appears fine. Years later, when the young lady is in her late 20's, her right upper jaw begins to grow asymmetrically causing a skewing of the upper dentition, the midlines are no longer coincident with the maxillary midline shifted 3mm to the left, and a large buccal and anterior overjet involving the upper right first molar (tooth #16) to the upper left incisor (tooth #21). Now the case needs to be reevaluated and assessed to ensure no further growth will occur prior to a second phase of orthodontic treatment.

Despite numerous models to improve growth prediction, including mesh diagrams (Moorrees & Lebret, 1962), grids (Johnston, 1975), arcial growth evaluations (Ricketts, 1972), templates (Popovich & Thompson, 1977), multivariate regression methods (Bhatia, Wright & Leighton, 1979), mathematical formulae (Todd & Leonard, 1981), craniofacial growth remains difficult to predict. For example, it is generally thought that the growth of the mandible in females stops just prior to their pre-pubertal growth spurt. In a Class II division 2 malocclusion in a 12 year 4 month old female with a large overjet (overjet = 8 mm), and an obtuse nasolabial angle. In order to improve the upper lip profile it is not recommended to extract maxillary first bicuspids to correct the maxillary crowding or to decrease the overjet. Yet it is unlikely that growth of the mandible will occur to help decrease the overjet at this late stage of growth, however, if the patient is a late grower, the mandible may after the proclination of the maxillary incisors, may correct its position sufficiently that with the help of Class II elastics and some remaining growth of the mandible, the overjet can be corrected without the need for a mandibular advancement.

Even the more recent methods based on the Bayes theorem (Iverson, 1984), using statistical inference to estimate the likelihood that a particular feature observed in a sample population will occur in the total population, have limited applications as illustrated by craniofacial growth in Class II children aged 6-12 years with favorable and unfavorable growth patterns (Rudolph, White & Sinclair, 1998), where this method incorrectly identified 17.8% of patients as "poor growers" (a child in which growth is no longer expected) and 5 % as good growers (a child in which a significant amount of growth is still remaining).

Few studies have centered on craniofacial growth in untreated Class II children, however, although their highly variable patterns (Bjork, 1969) are clearly different from "normal" subjects (Buschang *et al.*, 1988). Moreover, imprecise craniofacial growth predictions are mainly responsible for the difficulties in assaying the service complexities required to resolve Class II malocclusions (Tulloch, Proffit & Phillips, 1997). A more recent clinical trial on the services required to treat Class II malocclusions underscores such dilemmas, since the severity of the malocclusion or the time required to resolve the malocclusion, proved less important to the final outcome than the variable skeletal growth patterns (Tulloch, Phillips & Proffit, 1998). Tulloch reported on data from 107 severe Class II patients who participated in a randomized clinical trial and who had completed phase 2 treatment at the time of publication of the article. The trial was conducted in order to answer two questions: "Can you change growth?" and "Does early growth modification make a long-term difference?" Their conclusions were ..."Variability in skeletal growth pattern appears to be a major contributor to variability in treatment response." Other parameters may also be important determinants of service complexity, including patient compliance (Egolf, BeGole & Upshaw, 1990) and clinician proficiency (Tulloch, Phillips & Proffit, 1998), although the assessment of service complexity required to resolve a particular malocclusion is primarily constrained by the imprecision of craniofacial growth prediction.

### 4.2 Consequences of Inaccurate Predictors of orthodontic service complexity (difficulty)

The inability to accurately predict craniofacial growth changes is important when viewed in the context of the recent economic success of North American (including Canadian) dentistry. Since this success may be largely attributed to the increased availability of insurance benefits, dental insurers have gained an enormous potential to control dental (including orthodontic) markets. For instance, by providing insurance payments for orthodontic services from both specialists and generalists, insurers have contributed to the relative demise of the specialty, i.e. the majority of orthodontic services are provided by non-specialists rather than specialists (Waldman, 1998). An increase of 3.7 million youngsters (between the ages of 5 and 19 years in 30 states between the years 1987-1995, and a decrease in the number of orthodontists during this time would also support the idea that an increasing percentage of insurance payments are made to non-specialists (Waldman, 1998). Futhermore, whereas the opinion of orthodontic specialists (in common with those of physicians) was rarely challenged by insurers in the past, the recent introduction of market-driven healthcare reforms (e.g. health maintenance organizations, preferred provider options, etc.) now threatens to further erode their autonomy. This concern is particularly relevant to managed care plans, whose fiscal restraint strategies increasingly tend to restrict service provisions to generalists rather than specialists.

Professional standards of care for all but the wealthiest patients are therefore increasingly defined by insurers rather than the profession, as illustrated by the view that contemporary orthodontics has become inundated in a world of managed care organizations, insurance reporting, peer review, malpractice insurance, "..competition from non-specialists in orthodontics, risk management, and changes in the patient-doctor relation" (Miner & Moorrees, 1993). These concerns would, however, be reduced by the development of rigorous assays to discriminate between "mild" and "severe" malocclusions. From the perspective of the condyle, up and forward growers tend to have counter-clockwise changes in the chin point and the dentition, and the correction of a Class II malocclusion can be more easily achieved. Up and backward growers have more clockwise changes in the position of the chin point, due to the influence of the teeth which have erupted vertically. In the case of a child with leptoprosopia, the influence of the weak musculature has a significant influence on growth, causing the development of dolichocephalia or a long face.

### 4.3 The need for "gold standards"

There is an inherent dichotomy between the provision of insurance benefits for orthodontic services and the lack of specified ("gold") standards for their outcomes. Consequently, when faced with patient dissatisfaction with their orthodontic services, insurers typically rely on clinically derived professional service standards defined by dental records and their consultants' opinions. This is a two-edged sword:

- the opinions of insurers "expert's regarding service outcomes are not only difficult to challenge due to the lack of peer-review standards;
- orthodontic service standards therefore depend on those defined by good clinical practice rather than rigorous scientific (meta-analysis) reviews.

As there are no "gold" standards to differentiate between:

- necessary/unnecessary orthodontic services
- simple/complicated orthodontic services

  (simple = removeable appliances, complicated – multi-banded fixed appliances)
- satisfactory/unsatisfactory orthodontic service outcome

  (measured by the PAR score of pre-treatment and post-treatment study models)

They are currently based on "accepted principles of professional orthodontic practice", without delineating whether such standards relate to those for specialists or generalists. The inconsistent orthodontic case assessments between specialists on the differentiation between simple (removeable appliances) or difficult services (multi-banded fixed appliances) required to resolve particular Class II malocclusions established by the present investigation then served to underscore this dilemma.

This dilemma is further compounded by the American Association of Orthodontists failure to endorse an index to define either needs or to priorize their urgency. Other dilemmas arise from this deficiency, including the development of guidelines to delineate the most appropriate appliance (this may be impossible to achieve) or timing (early mixed dentition or adult dentition) to resolve specific malocclusions. Such deficiencies are unfortunate, since the American Association of Orthodontists has, by inference, opted out of the development of service standards, i.e. the distinction between services that should be preferentially provided by specialists rather than non-specialists. The resultant "the inexorable unfavorable patient response from excessive use by inadequately trained orthodontists and non-orthodontically trained paediatric dentists and general practitioners, has produced a wave of frustration and backlash to functional (orthodontic) appliances in many quarters" (Graber, Rakosi & Petrovic, 1997). Clearly further research is required if the "art" of orthodontics is to be replaced by scientific principles.

### 4.4 Areas requiring further research

Although the current study showed that the DAI provides a consistent pattern of case assessment by 42 orthodontists with varying degrees of experience, the American Association of Orthodontists (1990) stated that it "does not recognize any index, rating classification or coding system as scientifically valid measures of the need for orthodontic treatment". There is still a concern that an index cannot encompass all of the factors regarding service need.

Although the CalMod index has been tested twice in the courts in California and offers some benefits over the DAI and the Likert indices. Accurate assays of treatment difficulty are constrained by the inability to predict craniofacial growth changes.

No index can replace an objective assessment by an orthodontist doing a complete examination and thorough cephalometric analyses to determine the exact treatment required for each patient. Neither can any growth prediction graph, hand wrist radiograph, or racial statistical norms give the orthodontist an accurate indication of when growth will occur and to what extent it will correct an A-P discrepancy, or worsen the malocclusion by excess vertical growth of the maxilla, causing downward an backward growth of the mandible and a worsening of a Class II profile.

Despite these limitations orthodontists are generally able to predict using the knowledge in the published literature and their experience and subtle hints from familial comparisons, the way in which a particular patient will grow and the appropriate treatment plan for each patient. There will always be the exception to the rule, and the odd patient which will either not grow at all, or will continue to grow far beyond the expected period of growth. These cases must continually be reassessed and followed up with annual growth measurements and cephalometric radiographs (which is unethical by today's health guidelines) until the orthodontist feels confident that growth has slowed or stopped, particularly in a Class III case (in females 98 % of growth is complete by age 15, and 100% complete by age 18; in males - 98% of growth is complete by age 18, and 100% of growth is complete by age 25), and can then proceed with treatment including surgery. According to the work of Beherents (1985) growth continues throughout life, although the yearly increments are small, the overall change through the years is large. This further compounds the problem. Indeed, orthodontics is an "Art" struggling to become a "Science". The determinants may not be measurable in precise terms for years to come.

Therefore, any index is just another adjunct to add to the armamentarium of the orthodontist/researcher who is trying to determine trends in populations and predict into the future using actuarial tables to estimate what the numbers of patients requiring orthodontic treatment will be in the future.

### 4.5 Why the data from this investigation must be interpreted carefully (with a pinch of salt)

In order for the orthodontist/researcher to determine which index will be best suited to his/her needs, each index must be tested, evaluated and validated in comparison to the other indices in order to choose an existing index, or if there are no existing indices which will do the job, to develop a new index which will fulfill the needs of the orthodontist/researcher.

# SUMMARY AND FUTURE INVESTIGATIONS

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# SUMMARY AND FUTURE INVESTIGATIONS

## 5.0 Conclusions

It seems that we can determine the relative severity of a malocclusion using various indices such as the DAI or the Likert Visual Analog (V-A) scale with some consistency, with little variation occurring between orthodontists from different educational backgrounds, country of origin, and years of experience.

Canadian orthodontists using the DAI Index and the Likert Visual Analog (V-A) scale, chose Case 3 as the most difficult case, which coincided with the same case the AAO orthodontists attendees chose (from the same 4-case sample) using the Likert Visual Analog scale.

Therefore we can conclude that;

1. The DAI index offers no advantages over the Likert (Visual-Analog Scale) and are therefore equivalent in determining treatment difficulty
2. The CalMod index is superior to the DAI and VAS in determining treatment difficulty and since it has also been tested in the courts twice in California, it can be relied upon for improved validity.

## 5.1 Future Research

1). A study of a group of native children from an isolated northern community can be done to determine the prevalence of malocclusion amongst young adolescent and teenage children using the both the DAI and the CalMod indices. A comparison of the validity of the indices and their ability to predict the need for orthodontic treatment in the community can then be assessed. This can then be utilized to predict the need for orthodontic treatment in the Native population and other subgroups of the population in Manitoba.

2). An ideal index can be developed using all the best features of both the CALMOD and the Manitoba-Modified DAI indices (See Appendix 6). This proposed Manitoba-Modified Index will consist of two parts initially and can be tested in a pilot study in order to determine the elements for the future index. Once validated, the Manitoba-Modified Index can be used to determine treatment need in future studies.

**Part I – will be exactly the same as the CALMOD Index.**

The CALMOD index is simple to use with various dental anomalies automatically qualifying the orthodontic malocclusion as requiring treatment. It has been tested in the courts in California twice and has stood the test of legal scrutiny.

**Part II – will consist of the Manitoba-Modified DAI.**

The original DAI combines occlusal, esthetic and physical parameters as a single score. It has been tested extensively and has been shown to be both valid and reliable when testing North American Caucasian populations as well as sup-population samples, such Native Americans. It has been adopted by both the United States of America Indian Health Service and the World Health Organization for individual and epidemiological assessments of orthodontic treatment-need.

3). Studies of "A, B, C, D" records of patients who have been treated in the graduate orthodontic clinic can be studied using the new Manitoba index, comparing the need for treatment, the difficulty of treatment, and the final outcome of treatment.

4). The new Manitoba index can be used when entering existing patients into the computer using the new scanner and Ortho Vision Computer Program and a Manitoba Index score can be assigned to each case which could then be utilized for future comparisons of treatment need, treatment difficulty and treatment outcome. It can also be used to compare trends in the level of difficulty of cases selected for treatment in the University of Manitoba graduate clinic, undergraduate clinic, the private practices of orthodontists, and other dental care providers in Manitoba .

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# APPENDICES

## Contents

# Appendix 1

## Superimposition of the 4 pre-treatment cephs

Case 1 10y 5m Female

Case 2 13y 2m Male

Case 3 15y 10m Female

Case 4 13y 6m Female

# Appendix 2

## INITIAL ASSESSMENT OF STUDY MODELS

## UTILIZING THE

## DENTAL AESTHETIC INDEX (DAI)

**Case # __________**

| | value | | |
|---|---|---|---|
| 1) Missing incisor, canine and premolar<br>Maxillary and Mandibular Enter total # | | 6 | |
| 2) Crowding in the incisal segments 0= no crowding<br>1= 1 segment crowded<br>2= 2 segments crowded | | 1 | |
| 3) Spacing in the incisal segments 0= no spacing<br>1= 1 segment spaced<br>2= 2 segments spaced | | 1 | |
| 4) Diastema in mm. | | 3 | |
| 5) Largest anterior irregularity... Maxilla in mm. | | 1 | |
| 6) Largest anterior irregularity... Mandible in mm. | | 1 | |
| 7) Anterior Maxillary overjet in mm. | | 2 | |
| 8) Anterior Mandibular overjet in mm. | | 4 | |
| 9) Vertical anterior openbite in mm. | | 4 | |
| 10) Antero-posterior molar relation Normal= 0<br>1/2 cusp= 1<br>Full cusp= 2 | | 3 | |
| 11) CONSTANT | ////////// | 13 | 13 |
| 12) TOTAL SCORE | ////////// | ////////// | |

## The Dental Aesthetic Index: Protocol of Usage

### Missing Visible Teeth: Incisors, Canines and Premolar

Count the number of missing permanent incisors, canine and premolar teeth on the upper and lower arches Counting the teeth present starting at the right second premolar and moving forward to the left second premolar. There should be 10 teeth present in each arch. If there are less than 10 the difference is the number missing, record that number.

If the spaces are close, do no count the teeth as missing. If a primary tooth is still in position and its successor has not yet erupted, do not count the teeth as missing.

### Crowding in the Incisal Segments of the Arch

Examine both upper and lower incisal segments for crowding from lateral to lateral. Teeth may be rotated or displaced out of alignment in the arch. The number of incisal segments (each incisal segment consists of four incisors in either the upper or lower arch) with crowding recorded as 0, 1, or 2 ( 0 = no segments crowded, 1 = 1 segment crowded, 2 = 2 segments crowded) When in doubt, assign the lower score.

Do not mark the incisal segment crowded if four incisors are in proper alignment but either or both canines are displaced.

### Spacing in the Incisal Segment

Examine both the upper and lower incisal segments for spacing from lateral to lateral. If one or more incisor teeth have proximal surfaces without any interdental contact the

**Anterior Maxillary Overjet**

Measurement of the horizontal relation of the incisors is made with the teeth in centric occlusion. Record only the largest maxillary overjet with a metric ruler to the nearest whole millimetre from the labio-incisal edge of the most prominent upper incisor to the labial surface of the corresponding lower incisor holding the instrument parallel to the occlusal plane. This trait is not recorded if all upper incisors are missing or in lingual crossbite.

**Anterior Mandibular Overjet (mandibular protrusion)**

Record this trait when any lower incisor protrudes anteriorly, or labially, to the opposing upper incisor, i.e. it is in crossbite. Record the largest mandibular overjet (mandibular protrusion) or crossbite of any of the incisors in the lower arch to the nearest whole millimetre. Measure in the same manner as described for anterior maxillary overjet. Do not mark the tooth as a mandibular overjet if a lower incisor is rotated so that one part of the incisal edge is in crossbite.

**Vertical Anterior Openbite**

If there is a lack of vertical overlap between any of the opposing pairs of incisors (openbite) the amount of openbite is measured with a metric ruler to the nearest whole millimetre.

**Anterior-posterior Molar Relation**

This assessment is most often based on the relation of the permanent upper and lower first molars. If the assessment cannot be based on the first molars because one or both are segment is recorded as having space. The number of incisal segments in both arches with spacing is recorded as either 1, 1 or 2 ( 0 = no segments crowded; 1 = 1 segment crowded; 2 = 2 segments crowded). When in doubt assign the lower score.

## Diastema

A midline diastema is defined as the space, in millimetres, between the two permanent maxillary incisors. This measurement can be made at any level between the mesial surfaces of the central incisors and should be recorded to the nearest whole millimetre.

## Largest Anterior Irregularity on the Upper (maxillary) Arch

Irregularities may be either rotations out of, or displacement from, normal alignment. Measure the site of the greatest irregularity between adjacent teeth using the ruler provided. It is placed into contact with the labial surface of the most lingually displaced or rotated incisor while it is held parallel to the occlusal plane and at right angles to the normal arch line. The irregularity in millimetres can then be recorded to the nearest whole millimetre. If there is sufficient space for all four incisors in the normal alignment but some are rotated or displaced do not mark that segment as crowded but record the largest irregularity. Irregularities at the distal of the lateral incisors should also be considered, if present.

## Largest Anterior Irregularity on the Lower (mandibular) Arch

Measurement is the same as on the upper arch except that it is made on the lower (mandibular) arch. The greatest irregularity between adjacent teeth on the lower arch is located and measured as described above for the upper teeth.

absent, not fully erupted, or misshaped because of extensive decay or fillings, the relations of the permanent canines and premolar are assessed.

The right and left sides with the teeth in occlusion and only the largest deviation from the normal molar relation is recorded. Score as follows:

0 = normal molar relation

1 = lower first molar on either side is 1/2 cusp either mesial or distal to the upper first molar

2 = lower first molar on either side is one full cusp or more either mesial or distal to the upper first molar. When in doubt assign the lower score.

## Appendix 3

# INITIAL ASSESSMENT OF STUDY MODELS UTILIZING THE

# LIKERT (VISUAL-ANALOG) SCALE

Please evaluate cases 1-4, using the following scale from 1 to 10 to evaluate the difficulty of treatment. Circle one number per case.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Case 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Case 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Case 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Case 4 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

(Bagozzi & Phillips, 1982)

# ASSESSMENT OF ORTHODONTIC TREATMENT MODALITIES
# IN
# NORTH AMERICA

The purpose of this survey is to gather data concerning current trends in orthodontic treatment in North America.

Your **name is not required** All of your answers will be tabulated **anonymously**.

Your time and cooperation in filling out this survey is greatly appreciated.

**Demographic Data**

Province/State/Country in which you practice ________________________

Year of Orthodontic specialty graduation ________________________

School of graduation ________________________

Number of years in private orthodontic practice and/or teaching ____________________

Number of days per week in orthodontic practice

6 ____
5 ____
4 ____
3 ____
2 ____
1 ____

# Appendix 4

**(CALMOD) - Handicapping Labiolingual Deviation (HLD) Index***
(You will need this scoresheet and a Boley Guage or a disposable ruler)

Provider | Patient
**Name:**______________________________ **Name:**______________________________
**Number:**______________________________ **SSAN:**______________________________

**Procedure:**

- Position the patient's teeth in centric occlusion
- Record all measurements in the order given and round off to the nearest millimeter (mm).
- ENTER SCORE '0' IF CONDITION IS ABSENT
- If anterior crowding and an ectopic eruption are present in the anterior portion of the mouth, score only the most severe condition
- The use of a recorder (assistant) is recommended

**Conditions:** **HLD Score**

1. **CLEFT PALATE DEFORMITIES**
(Indicate an "X" if present and score no further .......................... __________
2. **DEEP IMPINGING OVERBITE** when LOWER INCISORS are destroying the SOFT TISSUE OF THE PALATE.
(Indicate an "X" if present and score no further).......................... __________
3. **CROSSBITE OF INDIVIDUAL ANTERIOR TEETH** when destruction of SOFT TISSUE IS PRESENT
(Indicate an "X" if present and score no further) .......................... __________
4. **SEVERE TRAUMATIC DEVIATIONS**(E.g. loss of a premaxilla segment by burns or by accident; the result of osteomyelitis; or other gross pathology. ATTACH DESCRIPTION OF CONDITION)
(Indicate an "X" if present and score no further) .......................... __________

5A. **OVERJET GREATER THAN 9MM**
With INCOMPETENT LIPS or REVERSE OVERJET greater than 3.5mm with reported MASTICATORY AND SPEECH DIFFICULTIES
(Indicate an "X" if present and score no further).......................... __________

5B. **OVERJET** in mm.......................... __________

6. **OVERBITE** in mm.......................... __________
7. **MANDIBULAR PROTUSION** in mm.......................... ________ x 5 = __________
8. **OPEN BITE** in mm.......................... ________ x 4 = __________

**IF BOTH ANTERIOR CROWDING AND ECTOPIC ERUPTION ARE PRESENT IN THE ANTERIOR PORTION OF THE MOUTH, SCORE ONLY THE MOST SEVERE CONDITION.**
**<u>DO NOT SCORE BOTH CONDITIONS</u>.**

9. **ECTOPIC ERUPTION**
COUNT EACH TOOTH, EXCEPT 3RD MOLARS.......................... ________ x 3 = __________

10. **ANTERIOR CROWDING**
Score one point for MAXILLA and/or one point for MANDIBLE;
TWO POINTS maximum for anterior crowding.......................... ________ x 5 = __________

11. **LABIOLINGUAL SPREAD** in mm.......................... __________

12. **POSTERIOR UNILATERAL CROSSBITE** (must involve TWO or MORE ADJACENT TEETH, one of which MUST BE A MOLAR....... **Score 4** __________

**TOTAL SCORE:** __________

**IF A BENEFICIARY DOES NOT SCORE 26 OR ABOVE, HE/SHE MAY BE ELIGIBLE UNDER MSB, IF MEDICAL NECESSITY IS DOCUMENTED (ATTACH INFORMATION).**
***(Parker, 1998)**

## HANDICAPPING LABIOLINUAL DEVIATION INDEX (HLD) - SCORING INSTRUCTIONS

The intent of the HLD Index is to measure the presence or absence, and the degree, of the handicap caused by the components of the Index, and not to diagnose "malocclusion". All measurements are made with a Boley Guage (or a disposable ruler) scaled in millimeters. Absence of any conditions must be recorded by entering "0" (refer to attached scoresheet).
The following information should help clarify the categories on the HLD Index:

1. **Cleft Palate Deformities:** Indicate an "X" on the scoresheet. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

2. **Deep Impinging Overbite:** Indicate an "X" on the scoresheet when lower incisors are destroying the soft tissue of the palate. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

3. **Crossbite of Individual Anterior Teeth:** Indicate an "X" on the scoresheet when destruction of soft tissue is present. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

4. **Severe Traumatic Deviations:** Traumatic deviations are, for example, loss of a premaxilla segment by burns or by accident; the result of osteomyelitis; or other gross pathology. Indicate an "X" on the scoresheet and attach documentation and description of condition. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

5A. **Overjet greater than 9 mm:** If the overjet is greater than 9 mm with incompetent lips or the reverse overjet (mandibular protrusion) is greater than 3.5 mm with reported masticatory and speech difficulties, indicate an "X" and score no further. If the reverse overjet is not greater than 3.5 mm, score under #7.

5B. **Overjet in Millimeters:** This is recorded with the patient's teeth in centric occlusion and measured from the labial portion of the lower incisors to the labial of the upper incisors. The measurement may apply to a protruding single tooth as well as to the whole arch. The measurement is read and rounded off to the nearest millimeter and entered on the scoresheet.

6. **Overbite in Millimeters:** A pencil mark on the tooth indicating the extent of overlap facilitates this measurement. It is measured by rounding off to the nearest millimeter and entered on the scoresheet. "Reverse" overbite may exist in certain conditions and should be measured and recorded.

7. **Mandibular Protrusion in Millimeters:** Score exactly as measured from the labial of the lower incisor to the labial of the upper incisor. The measurement in millimeters is entered on the scoresheet and multiplied by five (5). A reverse overbite, if present, should be shown under "overbite."

8. **Open Bite in Millimeters:** This condition is defined as the absence of occlusal contact in the anterior region. It is measured from edge to edge, in millimeters. The measurement is entered on the scoresheet and multiplied by four (4). In cases of pronounced protrusion associated with open bite, measurement of the open bite is not always possible. In those cases, a close approximation can usually be estimated.

9. **Ectopic Eruption:** Count each tooth, excluding third molars. Enter the number of teeth on the scoresheet and multiply by three (3). If condition No. 10, anterior crowding, is also present with an ectopic eruption in the anterior portion of the mouth, score only the most severe condition. DO NOT SCORE BOTH CONDITIONS.

10. **Anterior Crowding:** Arch length insufficiency must exceed 3.5 mm. Mild rotations that may react favorably to stripping or mild expansion procedures are not to be scored as crowded. Enter five (5) points each for maxillary and mandibular anterior crowding. If condition No. 9, ectopic eruption, is also present in the anterior portion of the mouth, score the most severe condition. DO NOT SCORE BOTH CONDITIONS.

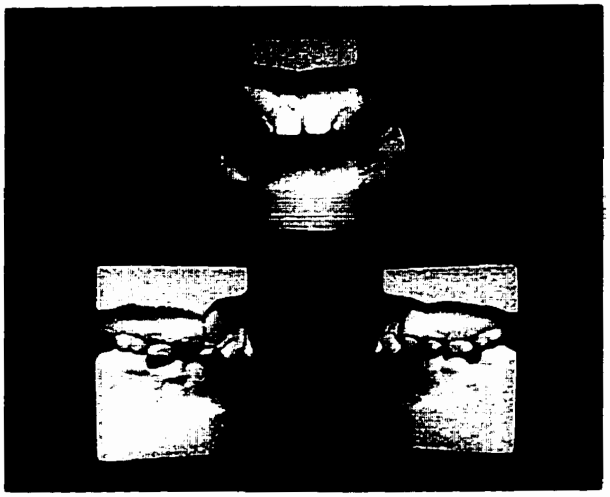
11. **Labiolingual Spread:** A Boley Guage (or a disposable ruler) is used to determine the extent of deviation from a normal arch. Where there is only a protruded or lingually displaced anterior tooth, the measurement should be made from the incisal edge of that tooth to the normal arch line. Otherwise, the total distance between the most protruded tooth and the lingually displaced anterior tooth is measured. The labiolingual spread probably comes close to a measurement of overall deviation from what would have been a normal arch. In the event that multiple anterior crowding of teeth is observed, all deviations from the normal arch should be measured for labiolingual spread, but only the most severe individual measurement should be entered on the index.

12. **Posterior Unilateral Crossbite:** This condition involves two or more adjacent teeth, one of which must be a molar. The crossbite must be one in which the maxillary posterior teeth involved may either be both palatal or both completely buccal in relation to the mandibular posterior teeth. The presence of posterior unilateral crossbite is indicated by a score of four (4) on the scoresheet.

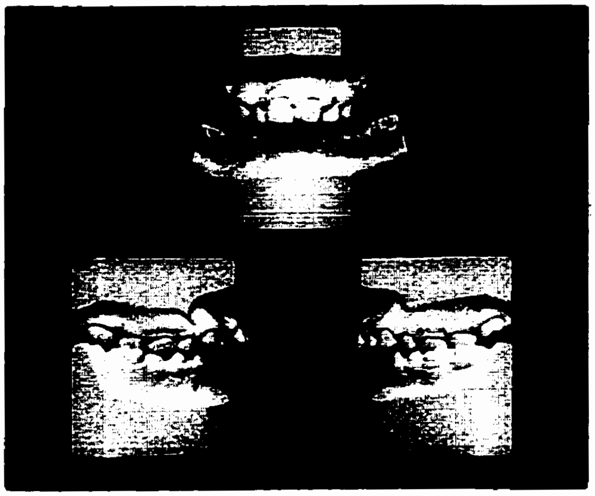
# Appendix 5

## Pre-treatment study models are shown below

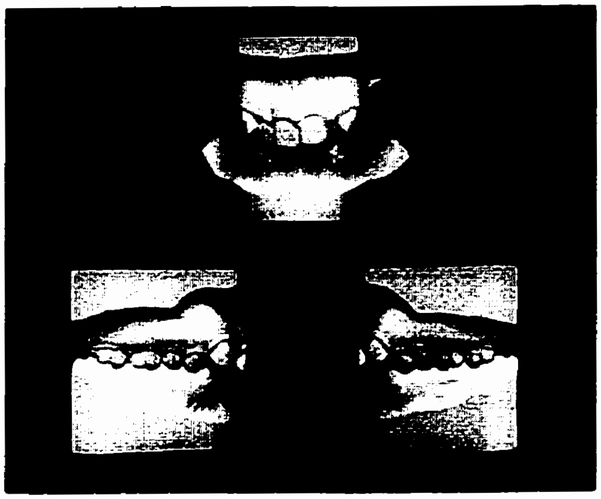
1



2



3



4

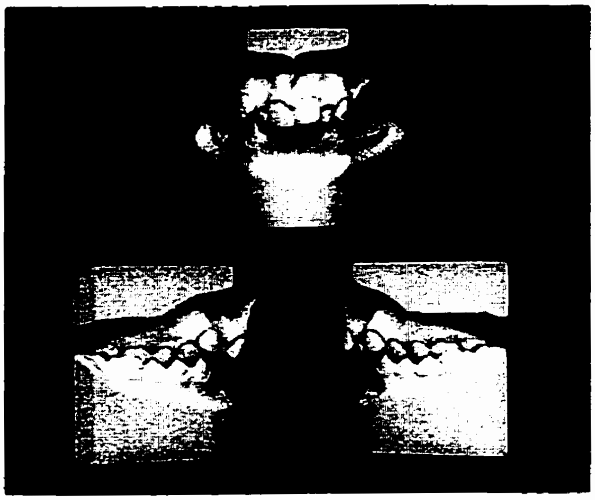


**Table Appendix 5.1: Parameters Indicating Increased Difficulty of Treatment**

| PARAMETER | CASE 1 | CASE 2 | CASE 3 | CASE 4 |
|---|---|---|---|---|
| Non/Grower | - | - | ++ | ++ |
| Overjet (> 5mm) | + | + | ++ | ++ |
| Overbite (Deep - Palatally Impinging) | + | + | ++ | + |
| Dental Relationship (Class II) | - | + | + | + |
| ANB | - | + | + | ++ |
| Nasolabial Angle | + | + | - | + |
| Lower Anterior Face Height | - | - | ++ | + |
| Post crossbite | - | ++ | - | ++ |
| Maxillary Anterior Crowding | - | + | ++ | ++ |
| Mandibular Anterior Crowding | - | - | ++ | + |
| Gingival Display (High smile) | - | - | ++ | + |
| Wits | - | - | + | - |
| Mandibular Plane-Sella-Nasion | - | - | + | - |
| **TOTAL SCORE:** | 3 (+) | 8 (+) | 18 (+) | 16 (+) |

(Note: The 'TOTAL SCORE' is the total number of '+' in each column, where each '+' is given a score of '1'. If each of the 4 cases had an equivalent number of '+' for a specific parameter, then that parameter was not included. For example 'Class II Skeletal' or 'Incompetent Lips' were not included as all the cases were scored equivalently for this parameter.)

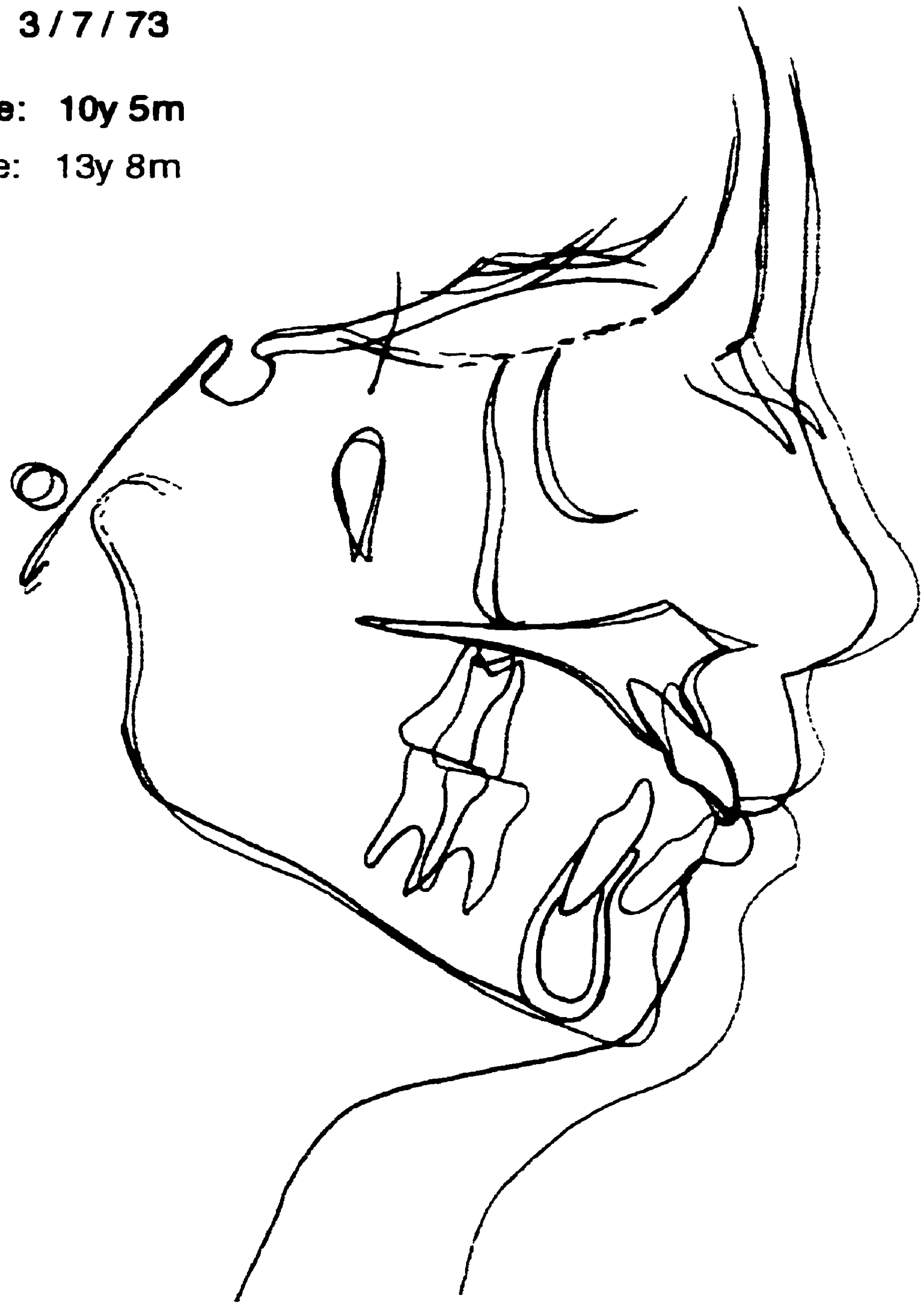
## Case 1
## Overall Superimposition

**Female**

D.O.B: 3 / 7 / 73

**(A) Age: 10y 5m**

(B) Age: 13y 8m



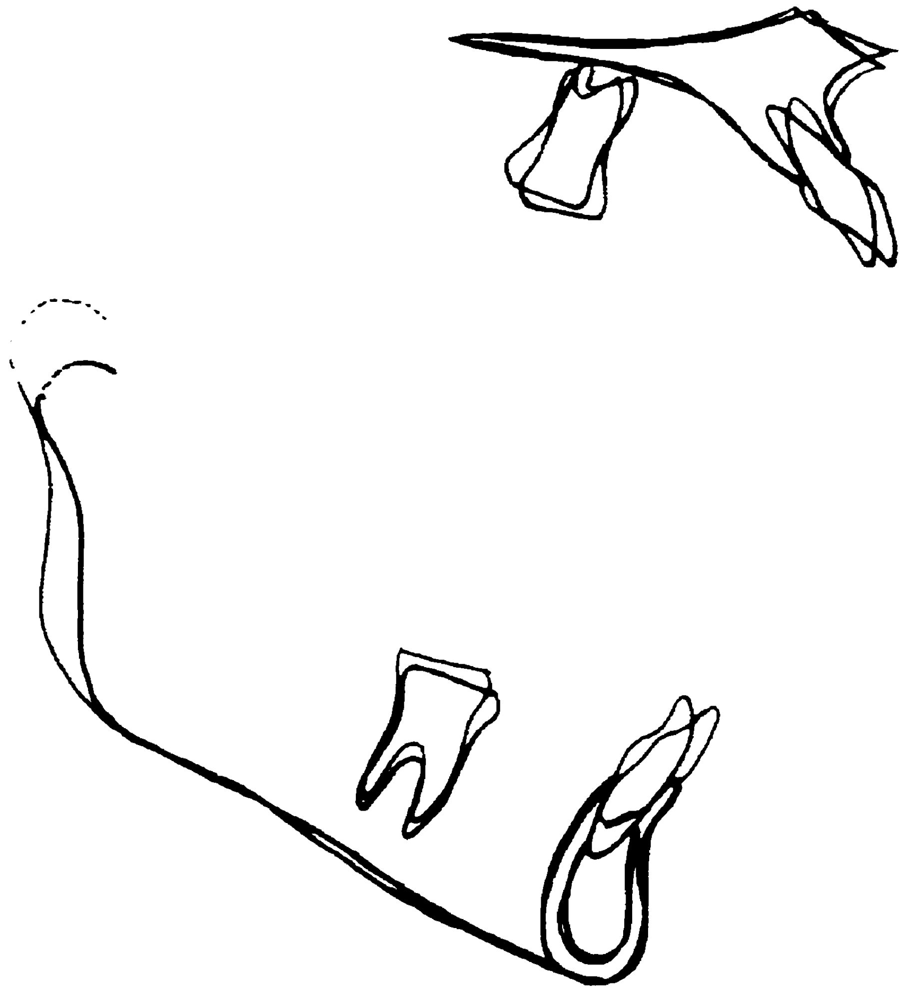
## Case 1
## Regional Superimposition

Female

D.O.B: 3 / 7 / 73

**(A) Age: 10y 5m**

(B) Age: 13y 8m



**CEPHALOMETRIC ANALYSIS**
**MANITOBA II**

PATIENT'S NAME CASE 1 BIRTHDATE 3 - 7 - 73

| DATE | 16 – 12 - 83 | 11 – 3 - 86 |
|---|---|---|
| AGE | 10y 5m | 13y 8m |
| CODE | A<br>PRE-TREATMENT | B<br>POST-TREATMENT |

| SKELETAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| NP-FH [°] | 81 | 89 | 85.9 ± 3.5 |
| NAP [°] | 4 | - 3 | 5.1 ± 4.5 |
| SNA [°] | 77 | 76 | 82.0 ± 3.3 |
| SNB [°] | 74 | 77 | 79.0 ± 3.4 |
| ANB [°] | 3 | - 1 | 2.9 ± 1.6 |
| MP-SN [°] | 35 | 36 | 32.0 ± 5.5 |
| MP-FH [°] | 29.5 | 25 | 25.3 ± 4.7 |
| ANS-Me [mm] | 59 | 65 | 65.0 ± 5.0 |
| ANS-Me / N-Me [%] | 59 | 59 | 56.57 ± 0.31 |
| NLA [°] | 104 | 104 | 102.0 ± 8.0 |

| DENTAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| UI-SN [°] | 113 | 107 | 103.8 ± 5.6 |
| UI-AP [mm] | 12.5 | 9.5 | 5.9 ± 1.7 |
| UI-NA [°] | 43 | 31 | 26.6 ± 3.97 |
| UI-NA [mm] | 10 | 9.5 | 4.0 ± 2.0 |
| UI-LI [°] | 118 | 124 | 126.7 ± 9.0 |
| LI-MP [°] | 88 | 96 | 97.6 ± 7.2 |
| LI-AP [mm] | 0.5 | 6 | 2.6 ± 1.6 |
| LI-NB [°] | 17 | 32 | 28.3 ± 2.8 |
| LI-NB [mm] | 2.5 | 7 | 4.8 ± 2.0 |
| P-NB [mm] | 2 | 3 | 1.0 ± 1.3 |

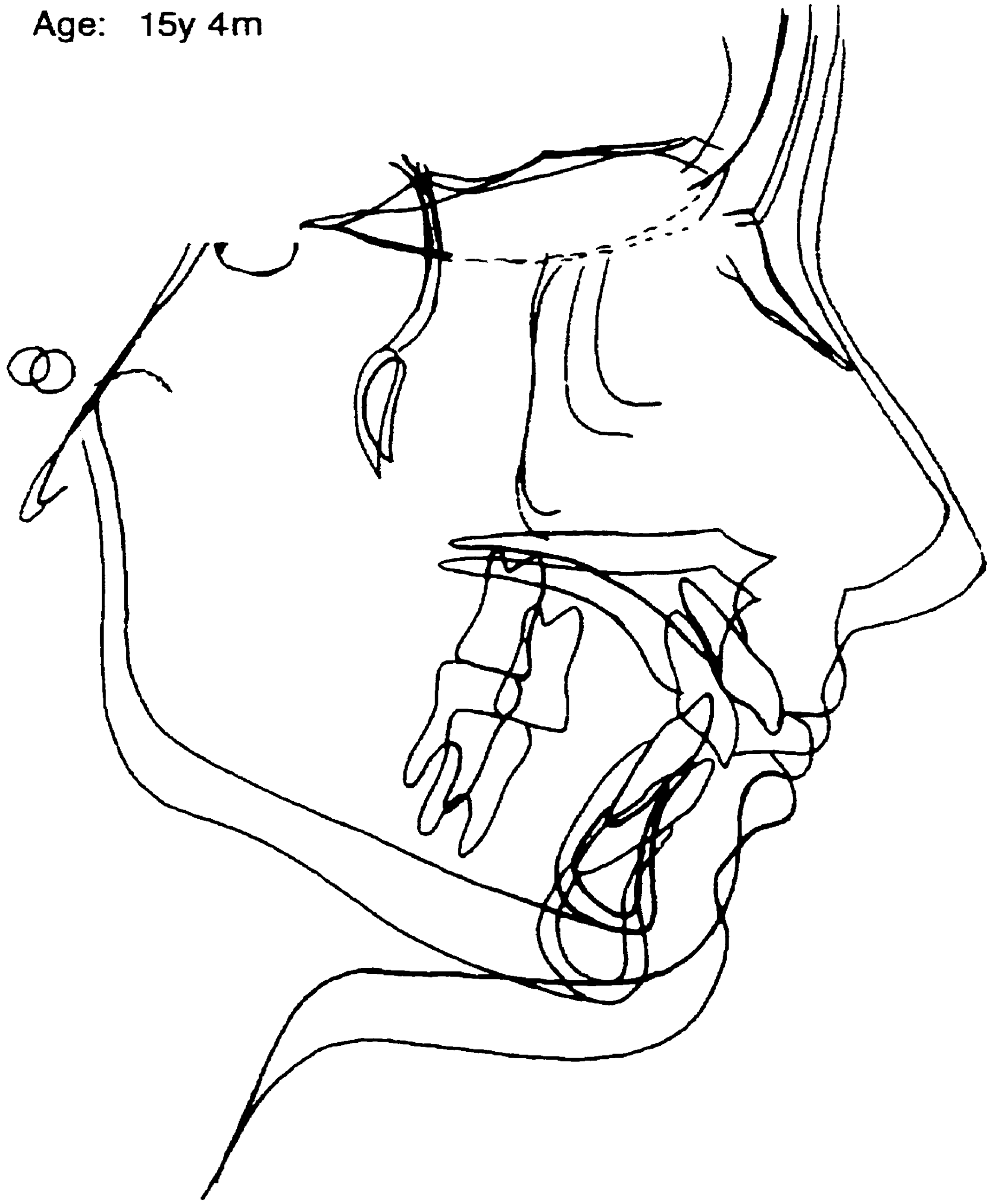
## Case 2
## Overall Superimposition

**Male**

D.O.B: **21 / 6 / 73**

**(A) Age: 13y 2m**

(B) Age: 15y 4m



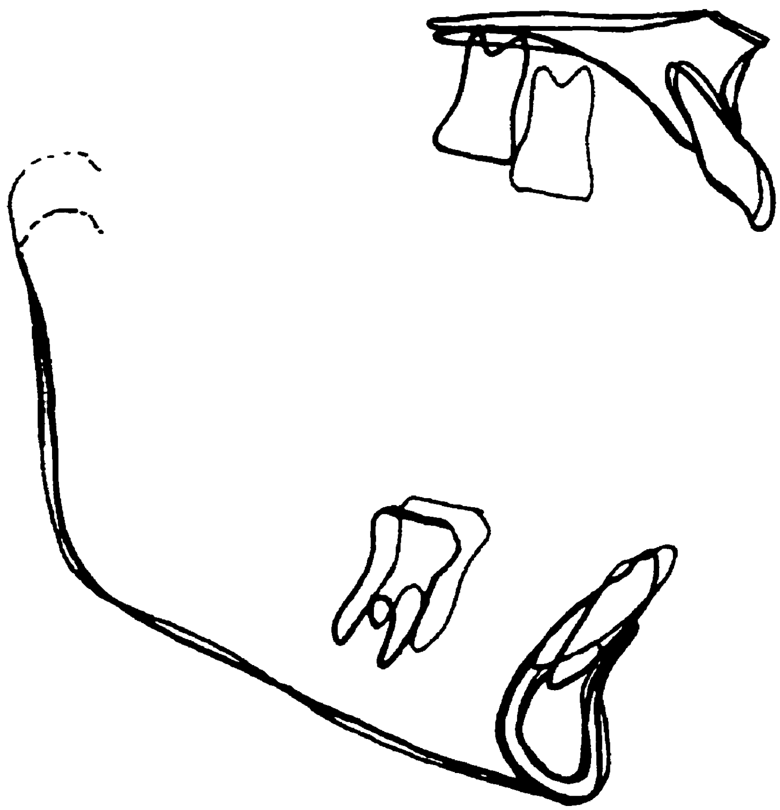
## Case 2
### Regional Superimposition

**Male**

**D.O.B: 21 / 6 / 73**

**(A) Age: 13y 2m**

(B) Age: 15y 4m



**CEPHALOMETRIC ANALYSIS**
**MANITOBA II**

**PATIENT'S NAME** CASE 2 **BIRTHDATE** 21 – 6 - 73

| DATE | 26 – 8 - 86 | 21 – 10 - 88 |
|---|---|---|
| AGE | 13y 2m | 15y 4m |
| CODE | A PRE-TREATMENT | B POST-TREATMENT |

| SKELETAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| NP-FH [°] | 85 | 85 | 85.9 ± 3.5 |
| NAP [°] | 10 | 8 | 5.1 ± 4.5 |
| SNA [°] | 82 | 83 | 82.0 ± 3.3 |
| SNB [°] | 77 | 77 | 79.0 ± 3.4 |
| ANB [°] | 5 | 6 | 2.9 ± 1.6 |
| MP-SN [°] | 34 | 35 | 32.0 ± 5.5 |
| MP-FH [°] | 26 | 27 | 25.3 ± 4.7 |
| ANS-Me [mm] | 62 | 67 | 65.0 ± 5.0 |
| ANS-Me / N-Me [%] | 53 | 53 | 56.57 ± 0.31 |
| NLA [°] | 114 | 121 | 102.0 ± 8.0 |

| DENTAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| UI-SN [°] | 117 | 106 | 103.8 ± 5.6 |
| UI-AP [mm] | 11 | 5 | 5.9 ± 1.7 |
| UI-NA [°] | 35 | 25 | 26.6 ± 3.97 |
| UI-NA [mm] | 8 | 3 | 4.0 ± 2.0 |
| UI-LI [°] | 117 | 110 | 126.7 ± 9.0 |
| LI-MP [°] | 91 | 106 | 97.6 ± 7.2 |
| LI-AP [mm] | 0 | 2 | 2.6 ± 1.6 |
| LI-NB [°] | 24 | 40 | 28.3 ± 2.8 |
| LI-NB [mm] | 5 | 8 | 4.8 ± 2.0 |
| P-NB [mm] | 2 | 4 | 1.0 ± 1.3 |

**Case 3**

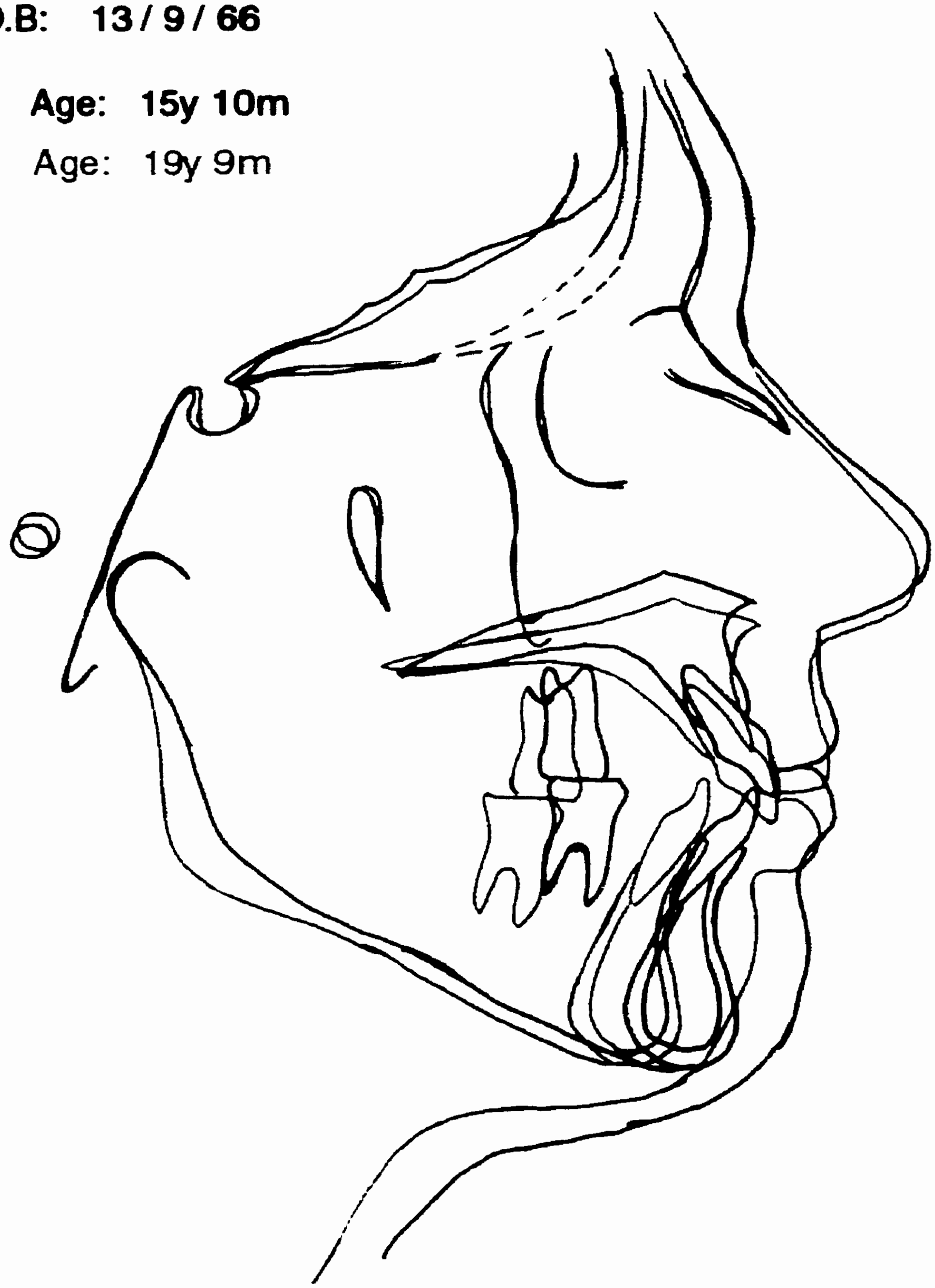
**Overall Superimposition**

## Female

D.O.B: **13 / 9 / 66**

**(A) Age: 15y 10m**

(B) Age: 19y 9m



## Case 3

### Regional Superimposition

Female

D.O.B: 13 / 9 / 66

**(A) Age: 15y 10m**

(B) Age: 19y 9m

**CEPHALOMETRIC ANALYSIS**
**MANITOBA II**

**PATIENT'S NAME** CASE 3 **BIRTHDATE** 13 – 9 - 66

| DATE | 27 – 7 - 82 | 22 – 5 - 86 |
|---|---|---|
| AGE | 15y 10m | 19y 9m |
| CODE | A<br>PRE-<br>TREATMENT | B<br>POST-<br>TREATMENT |

| SKELETAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| NP-FH [°] | 80 | 85 | 85.9 ± 3.5 |
| NAP [°] | 9 | 6.5 | 5.1 ± 4.5 |
| SNA [°] | 80 | 84 | 82.0 ± 3.3 |
| SNB [°] | 75 | 79 | 79.0 ± 3.4 |
| ANB [°] | 5 | 5 | 2.9 ± 1.6 |
| MP-SN [°] | 36.5 | 40 | 32.0 ± 5.5 |
| MP-FH [°] | 33.5 | 38 | 25.3 ± 4.7 |
| ANS-Me [mm] | 75 | 75 | 65.0 ± 5.0 |
| ANS-Me / N-Me [%] | 58.1 | 58.1 | 56.57 ± 0.31 |
| NLA [°] | 107 | 107 | 102.0 ± 8.0 |

| DENTAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| UI-SN [°] | 107 | 109 | 103.8 ± 5.6 |
| UI-AP [mm] | 1.7 | 6.5 | 5.9 ± 1.7 |
| UI-NA [°] | 21 | 27 | 26.6 ± 3.97 |
| UI-NA [mm] | 4 | 4 | 4.0 ± 2.0 |
| UI-LI [°] | 126 | 117 | 126.7 ± 9.0 |
| LI-MP [°] | 93.5 | 94 | 97.6 ± 7.2 |
| LI-AP [mm] | 0 | 3 | 2.6 ± 1.6 |
| LI-NB [°] | 27 | 35 | 28.3 ± 2.8 |
| LI-NB [mm] | 4 | 8 | 4.8 ± 2.0 |
| P-NB [mm] | 2 | 3 | 1.0 ± 1.3 |

**Case 4**

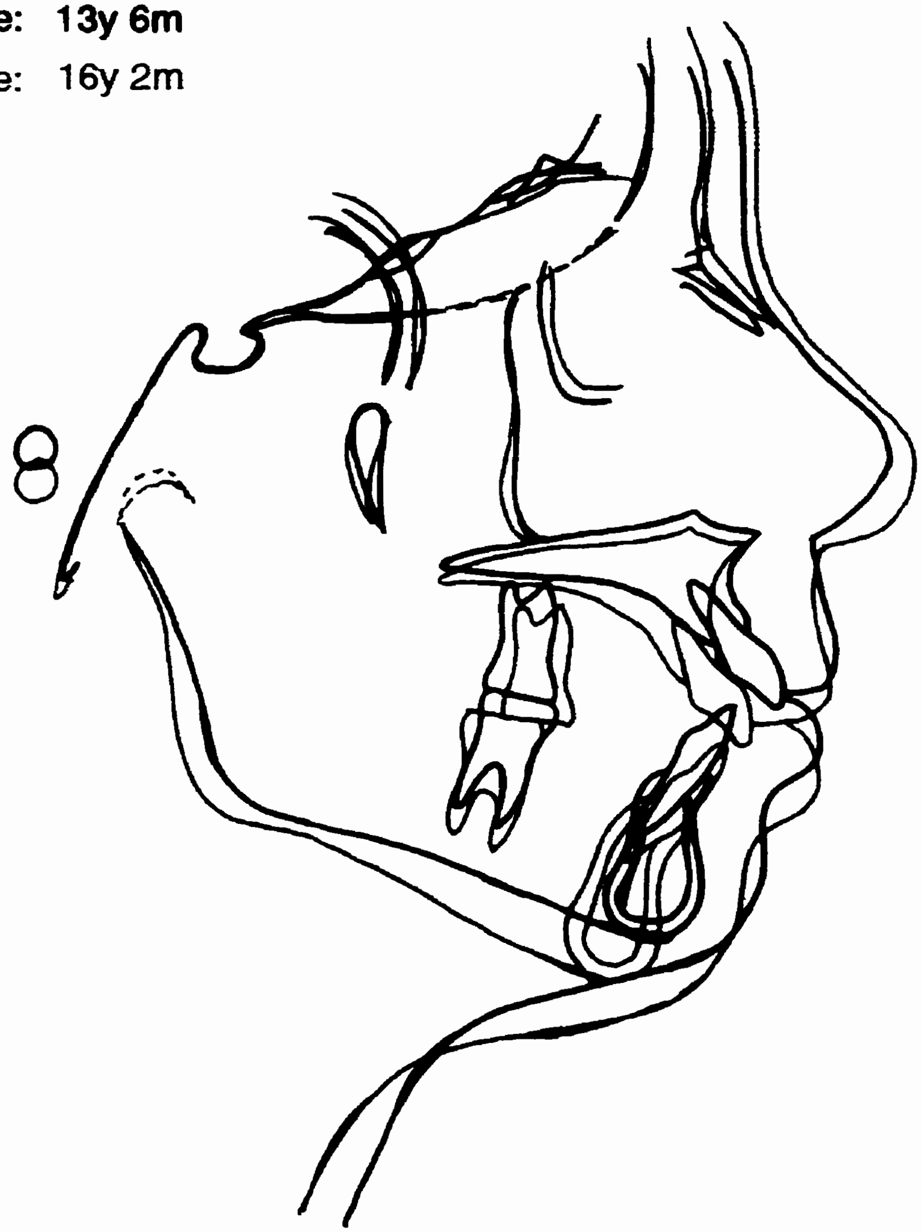
## Overall Superimposition

Female

D.O.B: 27 / 2 / 71

**(A) Age: 13y 6m**

(B) Age: 16y 2m



Case 4

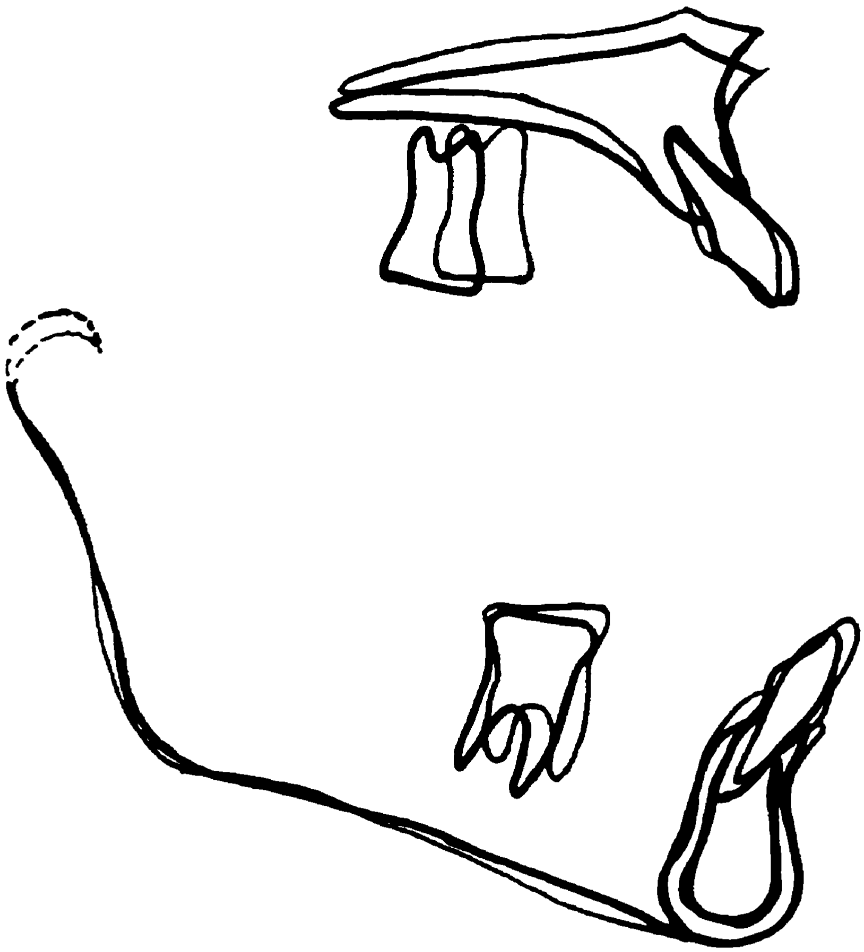
## Regional Superimposition

Female

D.O.B: 27 / 2 / 71

**(A) Age: 13y 6m**

(B) Age: 16y 2m



**CEPHALOMETRIC ANALYSIS**
**MANITOBA II**

PATIENT'S NAME ___CASE 4___ BIRTHDATE ___27 – 2 - 71___

| DATE | 10 – 9 – 84 | 16 – 4 – 87 |
|---|---|---|
| AGE | 13y 6m | 16y 2m |
| CODE | A PRE-TREATMENT | B POST-TREATMENT |

| SKELETAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| NP-FH [°] | 88 | 86 | 85.9 ± 3.5 |
| NAP [°] | 10 | 15 | 5.1 ± 4.5 |
| SNA [°] | 77 | 77 | 82.0 ± 3.3 |
| SNB [°] | 71 | 70 | 79.0 ± 3.4 |
| ANB [°] | 6 | 7 | 2.9 ± 1.6 |
| MP-SN [°] | 36 | 40.5 | 32.0 ± 5.5 |
| MP-FH [°] | 21 | 2.5 | 25.3 ± 4.7 |
| ANS-Me [mm] | 68 | 73 | 65.0 ± 5.0 |
| ANS-Me / N-Me [%] | 56.9 | 57.7 | 56.57 ± 0.31 |
| NLA [°] | 114 | 112 | 102.0 ± 8.0 |

| DENTAL PATTERN | PRE-TX | POST-TX | NORMS |
|---|---|---|---|
| UI-SN [°] | 103 | 102 | 103.8 ± 5.6 |
| UI-AP [mm] | 10 | 8.5 | 5.9 ± 1.7 |
| UI-NA [°] | 26 | 25 | 26.6 ± 3.97 |
| UI-NA [mm] | 7 | 5 | 4.0 ± 2.0 |
| UI-LI [°] | 110 | 113 | 126.7 ± 9.0 |
| LI-MP [°] | 110 | 106 | 97.6 ± 7.2 |
| LI-AP [mm] | 2.5 | 4 | 2.6 ± 1.6 |
| LI-NB [°] | 37 | 36 | 28.3 ± 2.8 |
| LI-NB [mm] | 6.5 | 9 | 4.8 ± 2.0 |
| P-NB [mm] | 1.5 | 0.5 | 1.0 ± 1.3 |

# Appendix 6

## Part I - Manitoba Modified (MANMOD) - Handicapping Labiolingual Deviation (HLD) Index*

(You will need this scoresheet and a Boley Guage or a disposable ruler)

| Provider | | Patient | |
|---|---|---|---|
| **Name:** ______________________ | | **Name:** ______________________ | |
| **Number:** ______________________ | | **SIN:** ______________________ | |

**Procedure:**

- Position the patient' s teeth in centric occlusion
- Record all measurements in the order given and round off to the nearest millimeter (mm).
- ENTER SCORE '0' IF CONDITION IS ABSENT
- If anterior crowding and an ectopic eruption are present in the anterior portion of the mouth, score only the most severe condition
- The use of a recorder (assistant) is recommended

**Conditions:** **HLD Score**

1. **CLEFT PALATE DEFORMITIES**
   (Indicate an "X" if present and score no further ........ .................................. __________
2. **DEEP IMPINGING OVERBITE** when LOWER INCISORS are destroying the SOFT TISSUE OF THE PALATE.
   (Indicate an "X" if present and score no further)......................................... __________
3. **CROSSBITE OF INDIVIDUAL ANTERIOR TEETH** when destruction of SOFT TISSUE IS PRESENT
   (Indicate an "X" if present and score no further) .................................................. __________
4. **SEVERE TRAUMATIC DEVIATIONS**(E.g. loss of a premaxilla segment by burns or by accident; the result of osteomyelitis; or other gross pathology. ATTACH DESCRIPTION OF CONDITION)
   (Indicate an "X" if present and score no further) ........................................ __________

5A. **OVERJET GREATER THAN 9MM**
With INCOMPETENT LIPS or REVERSE OVERJET greater than 3.5mm with reported MASTICATORY AND SPEECH DIFFICULTIES
(Indicate an "X" if present and score no further)............................................ .... __________

5B. **OVERJET** in mm.............................................. .................................. __________

6. **OVERBITE** in mm.............................................. .................................. __________

7. **MANDIBULAR PROTUSION** in mm.................................... ________ x 5 = __________

8. **OPEN BITE** in mm.................................................... .. ________ x 4 = __________

**IF BOTH ANTERIOR CROWDING AND ECTOPIC ERUPTION ARE PRESENT IN THE ANTERIOR PORTION OF THE MOUTH, SCORE ONLY THE MOST SEVERE CONDITION.**
**<u>DO NOT SCORE BOTH CONDITIONS.</u>**

9. **ECTOPIC ERUPTION**
   COUNT EACH TOOTH, EXCEPT 3[RD] MOLARS........................ ________ x 3 = __________

10. **ANTERIOR CROWDING**
    Score one point for MAXILLA and/or one point for MANDIBLE;
    TWO POINTS maximum for anterior crowding.................. ________ x 5 = __________

11. **LABIOLINGUAL SPREAD** in mm............................................ ........... __________

12. **POSTERIOR UNILATERAL CROSSBITE** (must involve TWO or MORE ADJACENT TEETH, one of which MUST BE A MOLAR....... Score 4 __________

**TOTAL SCORE:** __________

**IF A BENEFICIARY DOES NOT SCORE 26 OR ABOVE, HE/SHE MAY BE ELIGIBLE UNDER MSB, IF MEDICAL NECESSITY IS DOCUMENTED (ATTACH INFORMATION).**
***Part I – is the same as the CALMOD Index (Parker, 1998)**

## HANDICAPPING LABIOLINUAL DEVIATION INDEX (HLD) - SCORING INSTRUCTIONS

The intent of the HLD Index is to measure the presence or absence, and the degree, of the handicap caused by the components of the Index, and not to diagnose "malocclusion". All measurements are made with a Boley Guage (or a disposable ruler) scaled in millimeters. Absence of any conditions must be recorded by entering "0" (refer to attached scoresheet).
The following information should help clarify the categories on the HLD Index:

1. **Cleft Palate Deformities:** Indicate an "X" on the scoresheet. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

2. **Deep Impinging Overbite:** Indicate an "X" on the scoresheet when lower incisors are destroying the soft tissue of the palate. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

3. **Crossbite of Individual Anterior Teeth:** Indicate an "X" on the scoresheet when destruction of soft tissue is present. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

4. **Severe Traumatic Deviations:** Traumatic deviations are, for example, loss of a premaxilla segment by burns or by accident; the result of osteomyelitis; or other gross pathology. Indicate an "X" on the scoresheet and attach documentation and description of condition. Do not score any further if present. (This condition is automatically considered to be a handicapping malocclusion without further scoring.)

5A. **Overjet greater than 9 mm:** If the overjet is greater than 9 mm with incompetent lips or the reverse overjet (mandibular protrusion) is greater than 3.5 mm with reported masticatory and speech difficulties, indicate an "X" and score no further. If the reverse overjet is not greater than 3.5 mm, score under #7.

5B. **Overjet in Millimeters:** This is recorded with the patient's teeth in centric occlusion and measured from the labial portion of the lower incisors to the labial of the upper incisors. The measurement may apply to a protruding single tooth as well as to the whole arch. The measurement is read and rounded off to the nearest millimeter and entered on the scoresheet.

6. **Overbite in Millimeters:** A pencil mark on the tooth indicating the extent of overlap facilitates this measurement. It is measured by rounding off to the nearest millimeter and entered on the scoresheet. "Reverse" overbite may exist in certain conditions and should be measured and recorded.

7. **Mandibular Protrusion in Millimeters:** Score exactly as measured from the labial of the lower incisor to the labial of the upper incisor. The measurement in millimeters is entered on the scoresheet and multiplied by five (5). A reverse overbite, if present, should be shown under "overbite."

8. **Open Bite in Millimeters:** This condition is defined as the absence of occlusal contact in the anterior region. It is measured from edge to edge, in millimeters. The measurement is entered on the scoresheet and multiplied by four (4). In cases of pronounced protrusion associated with open bite, measurement of the open bite is not always possible. In those cases, a close approximation can usually be estimated.

9. **Ectopic Eruption:** Count each tooth, excluding third molars. Enter the number of teeth on the scoresheet and multiply by three (3). If condition No. 10, anterior crowding, is also present with an ectopic eruption in the anterior portion of the mouth, score only the most severe condition. DO NOT SCORE BOTH CONDITIONS.

10. **Anterior Crowding:** Arch length insufficiency must exceed 3.5 mm. Mild rotations that may react favorably to stripping or mild expansion procedures are not to be scored as crowded. Enter five (5) points each for maxillary and mandibular anterior crowding. If condition No. 9, ectopic eruption, is also present in the anterior portion of the mouth, score the most severe condition. DO NOT SCORE BOTH CONDITIONS.

11. **Labiolingual Spread:** A Boley Guage (or a disposable ruler) is used to determine the extent of deviation from a normal arch. Where there is only a protruded or lingually displaced anterior tooth, the measurement should be made from the incisal edge of that tooth to the normal arch line. Otherwise, the total distance between the most protruded tooth and the lingually displaced anterior tooth is measured. The labiolingual spread probably comes close to a measurement of overall deviation from what would have been a normal arch. In the event that multiple anterior crowding of teeth is observed, all deviations from the normal arch should be measured for labiolingual spread, but only the most severe individual measurement should be entered on the index.

13. **Posterior Unilateral Crossbite:** This condition involves two or more adjacent teeth, one of which must be a molar. The crossbite must be one in which the maxillary posterior teeth involved may either be both palatal or both completely buccal in relation to the mandibular posterior teeth. The presence of posterior unilateral crossbite is indicated by a score of four (4) on the scoresheet.

## PART II - MANITOBA-MODIFIED DENTAL AESTHETIC INDEX**

Case #__________

| DENTAL COMPPONENT | VALUE | WEIGHTING |
|---|---|---|
| 1) ANTERIOR MAXILLARY OVERJET (in mm) | | 2 |
| 2) ANTERIOR MANDIBULAR OVERJET (in mm) | | 4 |
| 3) VERTICAL ANTERIOR OPENBITE (in mm) | | 4 |
| 4) ANTERO-POSTERIOR MOLAR RELATION<br>NORMAL = 0<br>½ CUSP = 1<br>FULL CUSP = 2 | | 3 |
| 5) CONSTANT | | 7 |
| 6) TOTAL SCORE | | ..............................<br>.............................. |

**Note: The differential weightings and the constant are tentative and would need to be validated in future testing.**

**** Part II – from Dr. K. Danyluk's thesis (Danyluk, 1998)**