ASSESSING VALIDITY OF SALZMANN INDEX AND HANDICAPPING LABIOLINGUAL DEVIATION INDEX IN DETERMINING TREATMENT PRIORITY FOR ORTHODONTIC PATIENTS

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ABSTRACT

Objectives: More than 30 states use the Salzmann Index or the Handicapping Labiolingual Deviation Index to determine which patients receive tax-supported orthodontic treatment. The indexes use a criterion which produces a numerical value reflective of the severity of the malocclusion. The aim of the study is to evaluate the validity of these indexes by comparing subjective evaluations of orthodontic treatment need to objective scores produced by indexes of malocclusion.

Methods: 20 orthodontic faculty and residents (VAS Group) were asked to evaluate the severity of malocclusion of 20 patients, prior to beginning orthodontic treatment, using a subjective scale, a Visual Analog Scale (from "No need for treatment" to "Severe need for treatment"). The 20 patients consisted of a variety of malocclusions including Class I, Class II, Class III, anterior crossbite, posterior crossbite, impaction. A separate group of 3 residents (IS Group) evaluated the same patient malocclusions using the aforementioned indexes of malocclusion. The results were analyzed to identify a correlation between the subjective scale (VAS) and objective scales (IS).

Results: In total, 20 residents and faculty evaluated the severity of malocclusions. There was a weak correlation between the Salzmann scores and the Visual Analog Scale scores (Correlation Coefficient, R^2=0.2359). There was a moderate correlation between the Handicapped Labiolingual Deviation index scores and the Visual Analog Scale scores (Correlation Coefficient, R^2=0.4486). When comparing the faculty versus the residents in the VAS Group there was a strong correlation between them (Correlation Coefficient, R^2=0.7901). Although, there was a strong correlation, on average the faculty scored the malocclusions with 15% more severe need for treatment than did the residents.

Conclusion: Overall, there was a weak correlation for the Salzmann Index and a moderate correlation for the Handicapped Labiolingual Deviation Index, indicating neither indexes are optimal for evaluation of malocclusions. More emphasis has to be placed on identifying an objective method to evaluating the severity of malocclusions.

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CHAPTER 1

INTRODUCTION

Unique to dentistry is the use of indexes to measure the deviation from the norm of oral health. Some examples are indexes regarding plaque, caries, tooth wear and periodontal disease. An objective assessment of malocclusion has been difficult to construct since malocclusion is a developmental condition and is not an acute condition. The main justification for orthodontic treatment are 1) to improve function 2) to improve dentofacial appearance and 3) to improve oral health (Borzabadi-Forhani, 2011).

Beginning in the mid 19th century, a drive to establish an objective means to evaluate malocclusion was initiated. The goal was to devise an index that could evaluate the occlusion and need for treatment. The index should produce a numerical value as an objective means to evaluate the malocclusion corresponding to its severity in need for treatment. Those with the highest scores will be the patients that have the highest priority for treatment. These indexes could be used by insurance companies to facilitate the disbursement of government finances to cover treatment for orthodontic malocclusions. By creating a cut-off score, an objective means for insurance companies to evaluate malocclusions was produced.

In 1960, Draker developed an occlusion index to assist the state of New York in identifying qualifying patients to admit to its state dental rehabilitative program. He dubbed the occlusion index the Handicapping Labiolingual Deviation Index (HLD). Draker thought to determine eligibility for Medicaid-funded treatment should be based on a physical handicap due to the malocclusion (Theis, 2005).

Following suite, in 1967, Salzmann created the Handicapping Malocclusions Assessment Record, also known as the Salzmann Index. The Salzmann Index measures the severity of the malocclusions by providing certain point values to intra-arch or inter-arch deviations. This results in a clear and concise way to evaluate a malocclusion without using millimetric readings or angular measurements. This index was widely accepted for its ease of use and simplicity.

The most widely used indexes of malocclusion to determine eligibility and distribution of government funded orthodontic treatment are the Handicapped Labiolingual Deviation Index and the Salzmann Index. It is essential that these resources are not maldistributed and that the patients that have the greatest severity of malocclusion be the ones to receive treatment. The aim of this study is to investigate the validity of the of the Salzmann Index and the Handicapped Labio-Lingual Deviation Index in determining treatment priority for orthodontic patients. The participating faculty and residents (VAS Group) were asked to evaluate severity of malocclusion of 20 patients from pre treatment records, prior to beginning orthodontic treatment, using a subjective scale, a Visual Analog Scale (from “No need for treatment” to “Severe need for treatment”). The 20 patients consisted of a variety of malocclusions including Class I, Class II, Class III, anterior crossbite, posterior crossbite, and impaction. A separate group of 3 residents (IS Group) evaluated the same patient malocclusions using the indexes of malocclusion. The results were analyzed to identify a correlation between the subjective scale (VAS) and objective scales (IS).

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Defining Broad Medical Necessity

Is orthodontic treatment medically necessary? In order to answer this question, one must look at the meaning of medical necessity. Does this refer to matters of life or death, or do matters of quality of life apply? Ghafari discusses medical necessity in terms of two concepts: one in which insurance coverage excludes procedures unrelated to critical health improvement, albeit an augmentation of one's well-being, such as overall appearance; the other in terms of oral health as an essential component of total health. In the former, orthodontics possesses few procedures that may qualify medical necessity in comparison to other medical fields. Dentistry is a discipline of medicine that aims mostly at improving the quality of life. Many considerations beyond a life-threatening impairment are brought into light.

Medically guided treatment aims to apply orthodontic procedures to correct a systemic problem related or unrelated to local orofacial problems. Mouth-breathing and respiration-related disorders ranging from snoring to obstructive sleep apnea can have consequences on oral health and craniofacial morphology. Mouth-breathing due to obstruction of the nasal passage can have deleterious skeletal effects causing a change of orientation (inferior and posterior tip) of the maxilla and the development of Class II, open bite, crossbites, and maxillary arch constriction. Obstructive sleep apnea can lead to serious clinic consequences such as failure to thrive, behavioral problems, enuresis, and *cor pulmonale*.

Orofacial-guided treatment targets orofacial health in its relationship of function and growth of the body. The vital functions of speech and mastication may be affected by craniofacial anomalies or by pain associated with temporomandibular joint dysfunction. In these instances, treatment is surely deemed medically necessary (Ghafari, 2016).

On the other hand, the development of a constitutional assay by Moorrees attempted to diagnose the structural and functional harmony and well-being of the total person. He synthesized three separate but interrelated panels as a mean to diagnose total health: anatomical, physiological, and psychobiological. This was a striking concept that not only included the physiologic but also the psychobiologic aspects of the individual patient. The assay aimed to assess the psychosocial impact of dentofacial disfigurement in addition to the physiologic impact between malocclusion, lip function, tongue posture, and breathing (Moorrees, 1993). He argued that by removing the stigma of "being ugly", thus bolstering self-image and social adjustments, orthodontics represents an important health service for adolescents and adults (Ghafari, 2016).

Malocclusion is not a life-threatening disease or condition, but there has been a significant demand for orthodontic treatment. Many of the indexes created to evaluate severity of malocclusion do so based on possible future destruction if left untreated. However, many people seek orthodontic treatment not for the functional health of the oral cavity but for the esthetic impairment as a result of malocclusion. Thus, orthodontic treatment and malocclusion becomes an issue of quality-of-life.

2.2 Insurance and Medical Necessity

Title XIX of the Social Security, also known as Medicaid, was signed in 1965 to provide medical treatment to the medically indigent population (Salzmann, 1966). With significant funding provided to support the orthodontic treatment of patients, it becomes necessary to determine which patients qualify for coverage. The American Association of Orthodontists defines medically necessary as "the *treatment of a malocclusion (including craniofacial abnormalities/anomalies) that compromise the patient's physical, emotional or dental health."* (AAO, 2016). The American Association of Orthodontists originally selected the Salzmann Index, also known as the Handicapping Malocclusion Assessment Record, to evaluate medical necessity; However, in 1985, they reversed this selection avoiding the recommendation of any index of malocclusion or criterion for assessment of treatment need (Parker, 1998). This placed the onus on individual states to select the criterion to determine the eligibility of individuals based on need of treatment. In 1960, Harry L. Draker proposed the Handicapped Labio-Lingual Deviation Index to help the state of New York identify an eligibility and qualifying criteria for acceptance into its state dental rehabilitation program (Draker, 1960). The Handicapped Labio-Lingual Deviation Index, now adopted by 15 states, along with the Salzmann Index, adopted by an additional 15 states, are used by more than 50% of the United States to determine the qualifying criterion of medical necessity for orthodontic treatment (Minick, 2017). These indexes are widely used to distribute government funds to eligible individuals. It is essential to ensure that these indexes correctly identify the individuals that need treatment most.

2.3 Review of Occlusal Indexes

Orthodontic treatment diagnosis is generally a qualitative process, a naturally descriptive process that makes it difficult to quantify the extent of the malocclusion. When third party payers such as insurance companies or state funds are responsible for paying for treatment, an objective method to identify handicapping malocclusion that constitutes medical necessities is needed. Occlusal indexes attempt to objectively determine the severity of the malocclusion, summarizing the characteristics of dentition, returning a numeric value to describe the malocclusion (Beglin, 2001). The indexes must be simple and concise but also accurately reflect the medical necessity of treatment. Two methods of measuring and recording malocclusions are qualitative and quantitative. Qualitative method describes the occlusal features and provides descriptive classification of the dentition, while quantitative methods quantify the complexity and severity of the problem rated in a scale or proportion (Gupta, 2015). Qualitative methods are more subjective, whereas quantitative methods are more objective. The earliest methods of recording malocclusion were qualitative ones. Among the qualitative methods of recording malocclusion, Angle's method of classifying malocclusion has been the most widely used system since it was first published in 1899 (Tang, 1993). Following Angle, many indexes for measuring malocclusion severity were developed in the 1950s and 1960s. The Handicapping Labiolingual Deviation Index (HLDI) was developed by Draker in 1960. Then, in 1968, Salzmann developed the handicapping malocclusion assessment record now known as the Salzmann Index. As quantitative methods, they decrease the subjectivity in determining the diagnosis, outcome, and complexity of treatment.

In 1966, the World Health Organization Report summarized the requirements for an occlusal index (Grippaudo, 2008). From the report, item 5 says that the classification must be reproducible, and item 10 says that the index should be valid. According to Beglin, the most important criteria for a diagnostic index are reliability and validity. Validity is the ability of an index to accurately measure what it is intended to measure. Reliability is the ability of an index to consistently achieve similar results time and again. A high degree of both measures is ideal for an index to be widely accepted.

Many studies have been conducted to evaluate the reliability and validity of indexes of malocclusions commonly used by states to provide funding for coverage of treatment. Our research will focus on validity and reliability of malocclusion indexes.

Dr. William Shaw and co-workers divided occlusal indexes into five different categories (Shaw, 1995). These are the diagnostic, epidemiologic, orthodontic treatment need, treatment outcome, and orthodontic treatment complexity indexes. Orthodontic treatment need indexes classify malocclusions on the basis of treatment need. It is estimated that one third of the population has a need for orthodontic treatment; however, this estimation varies from country to country and even region to region depending on that location's public perception of need of treatment in that specific population. An orthodontic treatment need index identifies patients in need of orthodontic treatment and prioritizes their treatment needs. There is usually a cut-off point for each index and the lowest index score that allows treatment determines the cut-off point. These cut-off points are adjustable depending on available resources and the perception of need in the area where the index is used (Borzabadi-Farahani, 2011). The Handicapping Malocclusion Assessment Record (HMAR), also known as the Salzmann index, and the

Handicapping Labio-Lingual Deviation Index are the orthodontic treatment need indexes evaluated in this study.

2.4 Scoring the Salzmann Index

In 1967, J.A. Salzmann developed the Handicapping Malocclusion Assessment Record as means for establishing priority for treatment of handicapping malocclusion in the individual child according to severity as shown by the magnitude of the score obtained in assessing the malocclusion from dental casts or directly in the oral cavity. Salzmann defined handicapping malocclusion and handicapping dentofacial deformity as conditions that constitute a hazard to the maintenance of oral health and interfere with the well-being of the child by adversely affecting dentofacial esthetics, mandibular function, or speech. Salzmann provided specific guidelines to define the categories of the index and weighted values to more accurately reflect the malocclusion. The following is a summary of the instructions on how to score the Salzmann Index (Salzmann, 1966):

A. *Intra-Arch Deviations*:

Score: 2 points for each maxillary anterior tooth affected

Score: 1 point for each mandibular incisor and all posterior teeth affected

1. *Missing teeth*. Count the teeth; remaining roots of teeth are scored as missing.
2. *Crowding*. Not sufficient space to align a tooth without moving other teeth in the same arch.
3. *Rotation*. One or both proximal surfaces are to be seen in anterior teeth. All or part of the buccal or lingual surface in posterior teeth turned to a proximal surface of an adjacent tooth. The space for tooth alignment is sufficient in rotated teeth for their alignment.

4. *Spacing*. Score teeth, not spacing.
    a. *Open spacing*. One or both interproximal tooth surfaces and adjacent papillae are visible in an anterior tooth; both interproximal surfaces and papillae are visible in a posterior tooth.
    b. *Closed spacing*. Space is not sufficient to permit eruption of a tooth that is partially erupted.

B. ***Inter-Arch Deviations***

1. *Overjet*. The mandibular incisors occlude on or over the maxillary mucosa in back of the maxillary incisors. The incisor crowns show labial axial inclination.
2. *Overbite*. Maxillary incisors occlude on or opposite labial gingival mucosa of the mandibular incisor teeth.
3. *Cross-bite*. Maxillary incisors occlude lingual to mandibular incisors. Posterior teeth occlude entirely out of occlusal contact.
4. *Open-bite*. Teeth occlude above opposing incisal edges and above opposing surfaces of posterior teeth.
5. *Mesiodistal deviations*. Relate mandibular to opposing maxillary teeth by full cusp for molars; buccal cusps of premolars and canines occlude mesial or distal to accepted normal interdental area of maxillary premolars.

2.5 Scoring the Handicapping Labio-Lingual Deviation Index

In 1960, Draker developed the handicapping labio-lingual deviation index (HLD Index) to assist New York State's Dental Rehabilitation Program in regard to patients' qualification and acceptance into its program. Prior indexes focused on the malocclusion, which are diagnosed by the dentist or orthodontic specialist. Focus is lost defining and classifying the malocclusion, instead of approaching it from a public health perspective to identify and help those who need it most. A "handicapping malocclusion" is easier to detect because it is disfiguring. The presence of a demonstrable handicap is the main public health interest. The index was devised to determine how far from the norm the deviation is so as to constitute a handicap. The following is a summary of the instructions on how to score the handicapping labio-lingual deviation index:

All measurements are made with a Boley gauge in millimeters. Round all measurements to the nearest whole millimeter. Absence of any conditions is recorded with a zero. Presence of conditions 1-6 automatically qualify for orthodontic treatment and it is no longer necessary to continue scoring. If no automatic qualifier present, an aggregate score of 26 or more qualifies for orthodontic treatment.

A. Conditions Observed

1. *Cleft Palate Deformity*. Structural deformities related to the growth and development and the maxilla and/or mandible.
2. *Cranio-facial Anomaly*. Structural deformities related to the growth and development and the maxilla and/or mandible.
3. *Deep Impinging Overbite*. Lower incisors are destroying soft tissue of the palate and tissue laceration and/or clinical attachment loss are present.

4. *Crossbite of Individual Anterior Teeth.* Clinical attachment loss and recession of the gingival margin is present.
5. *Severe Traumatic Deviation*. Refers to gross pathology such as missing premaxilla due to a burn or accident or resection due to osteomyelitis.
6. *Overjet greater than 9mm with incompetent lips or mandibular protrusion (reverse overjet) greater than 3.5mm with masticatory and speech difficulties.* Measure the greatest value between upper central incisor and its corresponding lower central or lateral incisor.
7. *Overjet equal to or less than 9mm*. The measurement applies to a single tooth or the entire arch, in millimeters.
8. *Overbite*. A pencil mark indicating the extent of overlap should be used to facilitate measurement, in millimeters.
9. *Mandibular Protrusion*. Measured from labial of lower incisor to labial of upper incisor, in millimeters.
10. *Open Bite*. Measured in the anterior from edge to edge, in millimeters. In cases of severe protrusion, an exact measurement is not possible, and an approximation is acceptable.
11. *Ectopic Eruption.* Count each tooth, excluding 3rd molars. Tooth must be blocked out more than 50%. When two teeth block each other out only count one. Count number of qualifying teeth and multiply by 3.
12. *Anterior Crowding.* Arch length insufficiency exceeding 3.5mm. Count 1 for maxillary arch and 1 for mandibular arch and multiply by 5 for score. If ectopic eruption present in anterior, count the greatest condition.

13. *Labio-Lingual Spread*. This measures the deviation from the normal arch and requires a Boley gauge. Measure from the incisal edge of the left cuspid to the incisal edge of the left lateral incisor, as in figure 6. Only the most severe individual measurement will be recorded.
14. *Posterior Unilateral Crossbite.* Two or more adject teeth in crossbite, one of which has to be a molar. Do not count if bilateral crossbite. Presence is indicated by a score of 4 points.

The following illustrations were included to allow a better visualization of the guidelines and more accurate scoring (Draker, 1960):

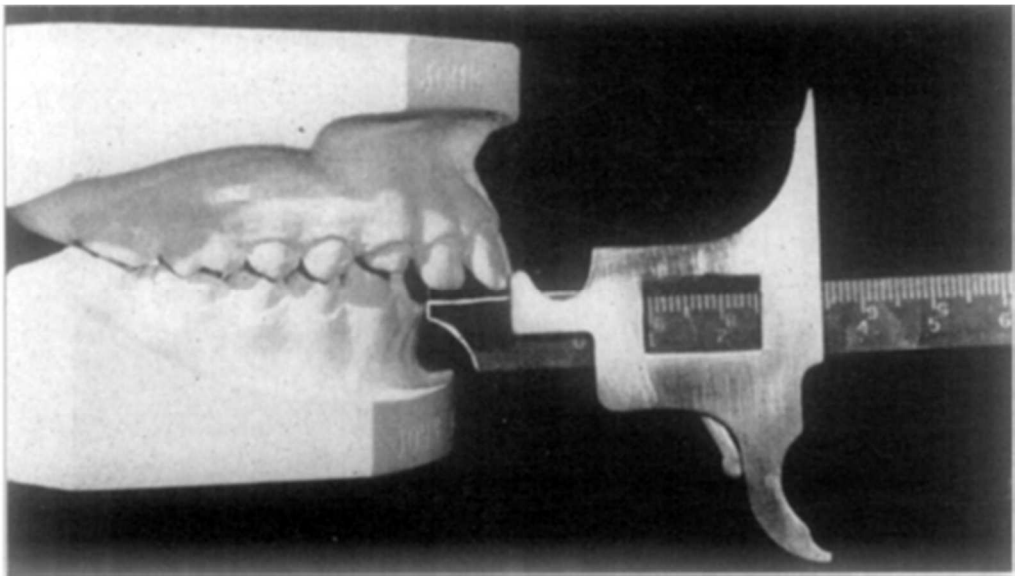


Figure 1. Overjet. Measure the greatest value between upper central incisor and its corresponding lower central or lateral incisor.

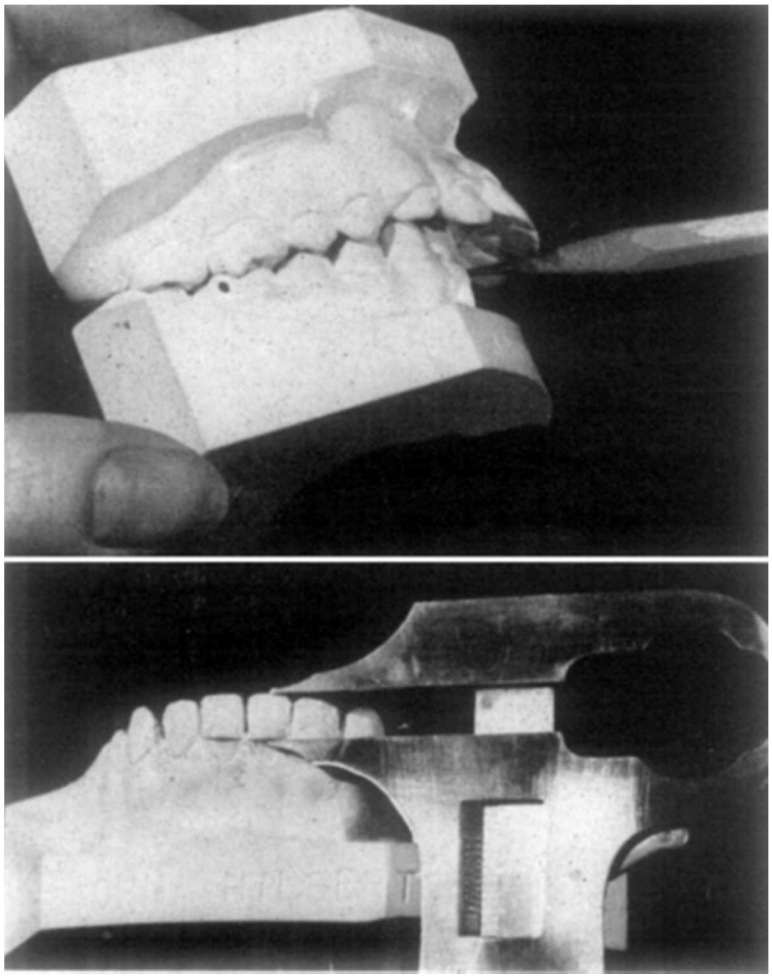


Figure 2. Overbite. A pencil mark indicating the extent of overlap should be used to facilitate measurement, in millimeters.

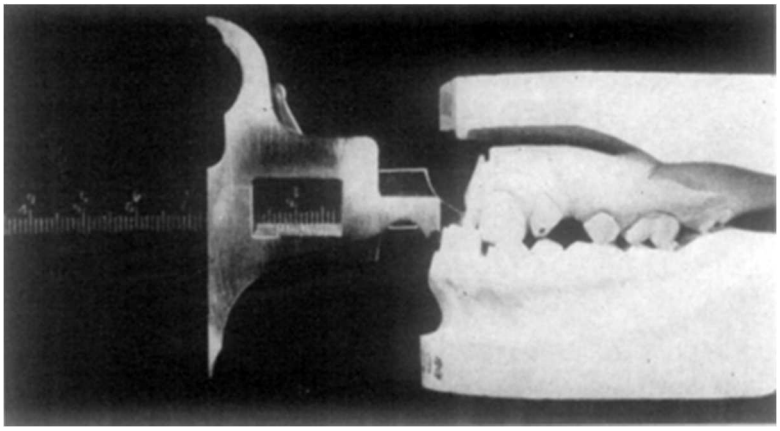


Figure 3. Mandibular Protrusion. Measured from labial of lower incisor to labial of upper incisor, in millimeters.

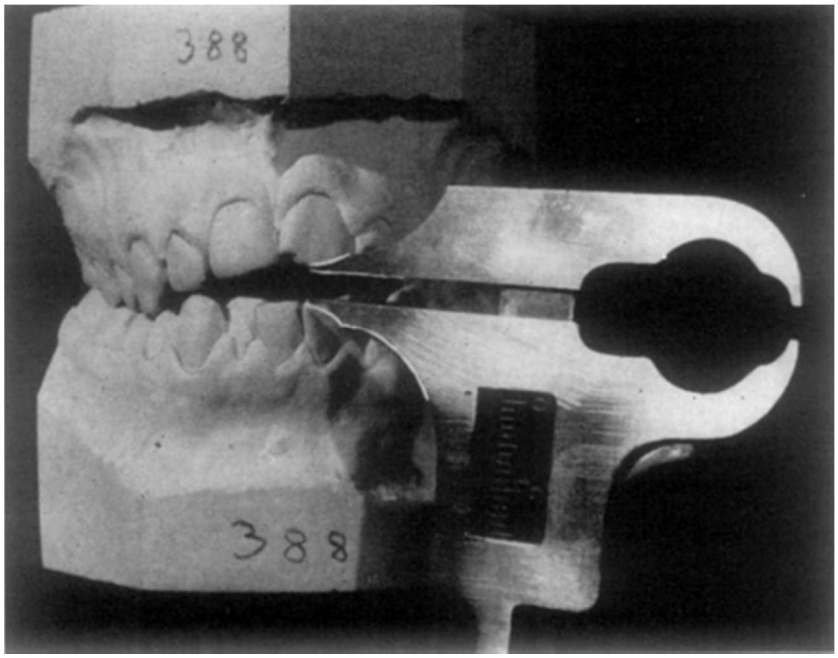


Figure 4. Open Bite. Measured in the anterior from edge to edge, in millimeters. In cases of severe protrusion, an exact measurement is not possible, and an approximation is acceptable.

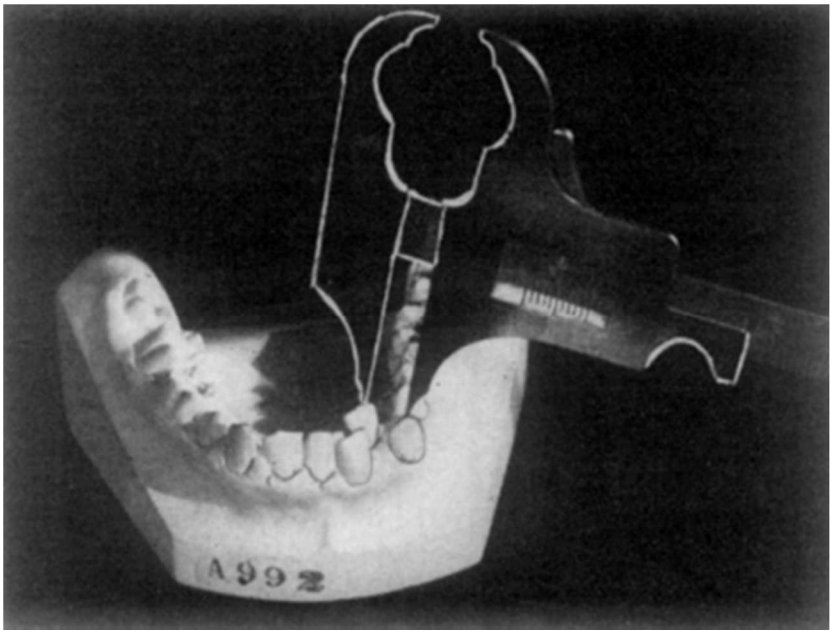


Figure 5. Labio-lingual Spread. This measures the deviation from the normal arch and requires a Boley gauge. Measure from the incisal edge of the left cuspid to the incisal edge of the left lateral incisor. Only the most severe individual measurement will be recorded.

2.6 Validity of Salzmann and HLD: Past studies

The most important criteria for a diagnostic index are reliability and validity. Validity is the ability of an index to accurately measure what it is intended to measure. Reliability is the ability of an index to consistently achieve similar results time and again. A high degree of both measure is ideal for an index to be widely accepted (Beglin, 2001).

Many studies have focused on evaluating the reliability of indexes of malocclusions, but not many studies have investigated the validity of the indexes of malocclusion. Beglin evaluates the reliability and validity of 3 occlusal indexes of orthodontic treatment need – the Dental Aesthetic Index (DAI), the Handicapping Labiolingual Deviation Index with the California Modification (HLD[CalMod]), and the Index of Orthodontic Treatment Need (IOTN). One hundred seventy pairs of untreated and treated study casts from the University of Pittsburgh Orthodontic Department were scored by 15 orthodontists using the 3 indexes. The results showed that the 3 indexes are reliable and valid. Although the overall accuracy of the indexes in distinguishing patients for whom treatment is indicated from those for whom it is not, is very high, the cutoff points were too stringent and making it more lenient increased the agreement.

CHAPTER 3

AIMS OF THE INVESTIGATION

Purpose/Specific aims: The aim of this study is to investigate the validity of the Salzmann Index and the Handicapped Labio-Lingual Deviation Index in determining treatment priority for orthodontic patients.

Hypothesis: We hypothesize that there will be a no correlation between malocclusion indexes and treatment priority.

CHAPTER 4

MATERIALS AND METHODS

Pre-treatment orthodontic patient records from the Department of Orthodontics at Temple University Kornberg School of Dentistry will be used in this study. This includes a panoramic radiograph, a lateral cephalogram, intraoral photographs (right buccal, left buccal, front center, mandibular occlusal, maxillary occlusal), and extraoral photos (frontal, frontal smiling, profile, three quarters smiling). The study will utilize 20 patients' pre-treatments records that were previously sent to insurances for approval in addition to 3-D printed models of the malocclusions. All patient records used for the study will be current or past patients. All records will be de-identified and no medical/dental history or contact information will be used. All records will be evaluated to ensure quality and consistency. All the patients had signed informed consent during initial visit to allow permission to use their diagnostic records for research purposes.

A. Inclusion and Exclusion Criteria

The patient records will cover a range of malocclusions including: Class I malocclusions, Class II crowding, Class II spacing, Class III crowding, Class III spacing, anterior crossbite, posterior crossbite, impacted teeth, missing teeth. The study will only include those records with:

- Permanent dentition
- Previously submitted to Medicaid insurance programs for approval

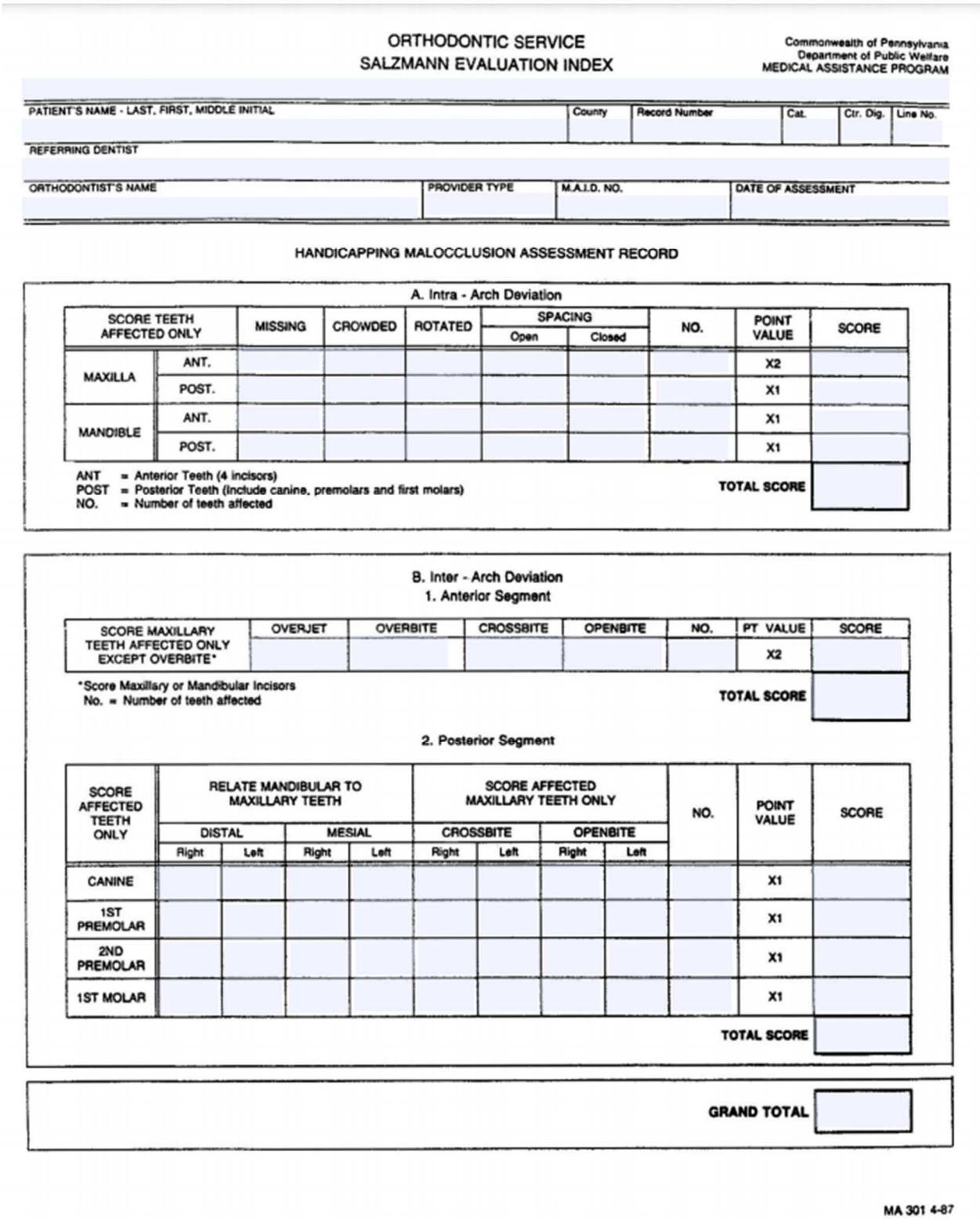
The diagnostic records will be evaluated for quality of images, scans, and radiographs. Records that fail to meet generally accepted standards will not be included.

This includes incomplete records, and records that are non-diagnostic due to errors of projection or artifacts. The study will prepare 20 pre-treatment patient records that qualify the criteria.

The subjects for the study are residents and faculty at the Department of Orthodontics at Temple University Kornberg School of Dentistry. The Visual Analog Scale group (VAS group), consisting of 15 participating faculty and residents, will score the pre-treatment records along a visual analog scale from least need to most need of treatment. The VAS scores were chosen as gold standard for the severity of malocclusion for each set of patient records. A separate cohort of three residents, the Index Scoring group (IS group), calibrated in the Salzmann Index and Handicapped Labio-Lingual Deviation Index, will score each case using both indexes, Figures 6 and Figures 7, respectively. The gold standard will be compared with the indexes of malocclusion. No compensation will be provided for participation in the study. The IS group and VAS group assessment of the malocclusions will be anonymous. The VAS group assessment of treatment need will be assessed for variability with the scores provided by the indexes.

The VAS group will use a visual analog scale shown below to assess the orthodontic patients' treatment priority:

Figure 6. Visual Analog Scale



ORTHODONTIC SERVICE
SALZMANN EVALUATION INDEX

Commonwealth of Pennsylvania
Department of Public Welfare
MEDICAL ASSISTANCE PROGRAM

PATIENT'S NAME - LAST, FIRST, MIDDLE INITIAL	County	Record Number	Cat.	Ctr. Dig.	Line No.

REFERRING DENTIST

ORTHODONTIST'S NAME	PROVIDER TYPE	M.A.I.D. NO.	DATE OF ASSESSMENT

HANDICAPPING MALOCCLUSION ASSESSMENT RECORD

A. Intra - Arch Deviation

SCORE TEETH AFFECTED ONLY		MISSING	CROWDED	ROTATED	SPACING		NO.	POINT VALUE	SCORE
					Open	Closed			
MAXILLA	ANT.							X2	
	POST.							X1	
MANDIBLE	ANT.							X1	
	POST.							X1	

ANT = Anterior Teeth (4 incisors)
POST = Posterior Teeth (Include canine, premolars and first molars)
NO. = Number of teeth affected

TOTAL SCORE

B. Inter - Arch Deviation
1. Anterior Segment

SCORE MAXILLARY TEETH AFFECTED ONLY EXCEPT OVERBITE*	OVERJET	OVERBITE	CROSSBITE	OPENBITE	NO.	PT VALUE	SCORE
						X2	

*Score Maxillary or Mandibular Incisors
No. = Number of teeth affected

TOTAL SCORE

2. Posterior Segment

SCORE AFFECTED TEETH ONLY	RELATE MANDIBULAR TO MAXILLARY TEETH				SCORE AFFECTED MAXILLARY TEETH ONLY				NO.	POINT VALUE	SCORE
	DISTAL		MESIAL		CROSSBITE		OPENBITE				
	Right	Left	Right	Left	Right	Left	Right	Left			
CANINE										X1	
1ST PREMOLAR										X1	
2ND PREMOLAR										X1	
1ST MOLAR										X1	

TOTAL SCORE

GRAND TOTAL

MA 301 4-87

Figure 7. Salzmann Evaluation Index form.

Handicapping Labio-Lingual Deviation (HLD) Index Report

(New York State Medicaid Program)

Provider Name: _____ NPI: _____

Recipient Name: _____ CIN: _____ Age: _____

Instructions: *(Assistance from a recorder/hygienist is recommended.)*

1. Position the patient's teeth in centric occlusion;
2. Record all measurements in the order given and round off to the nearest millimeter (mm);
3. Enter a score of "0" if the condition is absent;
4. Enter the requested provider and patient information above. Provider must sign and date at the bottom;
5. Use the accompanying "HLD Index Scoring Instructions" for guidance in completion of the assessment;
6. Submit pages 1 and 2 along with a prior approval request and all necessary diagnostic and supporting documentation (refer to the "Dental Policy and Procedure Code Manual").

Condition	HLD Score
The Conditions In This Section Automatically Qualify For Treatment	
Cleft palate deformity or cranio-facial anomaly. *Indicate an "X" if present and score no further.*	
Deep impinging overbite with severe soft tissue damage. *Indicate an "X" if present and score no further.*	
Crossbite of individual anterior teeth when clinical attachment loss and recession of the gingival margin are present. *Indicate an "X" if present and score no further.*	
Severe traumatic deviations. *Indicate an "X" if present and score no further.*	
Impacted permanent anteriors where extraction is not indicated. *Indicate an "X" if present and score no further.*	
Overjet greater than 9mm with incompetent lips or reverse overjet greater than 3.5mm with reported masticatory/speech difficulties. *Indicate an "X" if present and score no further.*	
The Conditions In This Section Must Total 26 Or More To Qualify For Treatment	
Overjet equal to or less than 9mm	
Overbite in mm	
Mandibular protrusion (reverse overjet) in mm equal to or less than 3.5mm	_____ x 5 = _____
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. Do not score both conditions.	
Ectopic eruption: Count each tooth, excluding 3rd molar.	_____ x 3 = _____
Anterior crowding: Score one point for MAXILLA, and/or one point for MANDIBLE; two (2) points maximum. Multiply by five (5).	_____ x 5 = _____
Labio-Lingual spread (in mm)	
Posterior unilateral crossbite (involving at least one molar): Score 4 if present.	
Total Score	_____

Effective Date: September 1, 2012 *Page 1*

Figure 8. Handicapping Labiolingual Deviation Index Form

4.1 Data Collection Protocol

The data was collected at the Albright Conference Room at the Department of Orthodontics at Temple University Kornberg School of Dentistry. The records used consisted of panoramic radiographs, lateral cephalograms, intraoral photographs (center, right lateral, left lateral, maxilla occlusal, mandible occlusal), extraoral photographs (profile, frontal, frontal smiling, ¾ smiling), and a printed model. The panoramic radiograph, lateral cephalogram, and the photographs were printed on a separate 8.5”x11” sheet of paper. The printed models were printed using an EnvisionTEC 3-D printer, from scans sent for insurance approval. The models were processed as per directions by the manufacturer. Each set of records were marked with a randomly assigned identifier. The three sheets of papers (panoramic radiograph, lateral cephalogram, photographs) along with the printed models were placed on the table in front of a chair situated at the table. Each chair was considered a station. There was one set of records at each station. After each subject passed through the 20 stations, the records at the stations were scrambled to randomize the order in which the records were viewed.

A. VAS Group

The VAS Group were provided with a scoring sheet. The scoring sheet consisted of 20 identical questions. There is an underlined blank for the subject to write down the identifier number. The question was posed as such:

“Identifier #____. Please rate the patient’s malocclusion with a mark along the visual analog scale from ‘No need for treatment’ to ‘Severe need for treatment’”

After one subject completes the stations, the records were randomized. Then the following subject proceeded. The subjects were told not to discuss the results of ratings with any of the other subjects.

B. IS Group

The IS Group consisted of three second year orthodontic residents at the Temple University Kornberg School of Dentistry. The three members of the IS group met prior to the assessment of the records to review and standardize the groups assessment of records using the Salzmann Index and the Handicapping-Labiolingual-Deviation Index. The group was presented with 3 sample cases and Salzmann scoring sheets and HLDI scoring sheets. Following the assessment of records, the scoring was reviewed, and they were be asked to justify the individual sections of each scoring sheet. Once each member of the group scored within +/- 2 points of the average score of the three for both malocclusion indexes, then they proceeded to assess and score the 20 records at the stations. The IS group subject was provided with 20 Salzmann Index scoring sheets and 20 HLDI scoring sheets. There was a box at the top right corner of the sheet to insert the identifier of the records. The IS Group proceeded individually rating the records at each station. Once one subject completed the scoring of the records, the records will be randomized. Once randomization was completed the following subject was able to proceed. The subjects margin were told not to discuss the results of the scoring with any of the other subjects.

4.2 Statistical Analysis

The scores of the visual analog scale, Salzmann index, and HLD index, will each be averaged for each record set to provide a single score for each measure. Cohen's Kappa analysis will be used to measure inter-rater reliability. A Pearson Coefficient analysis will be conducted to measure the correlation of the visual analog scale score to the Salzmann index score, the visual analog scale score and the HLD score, and the HLD score and the Salzmann score.

CHAPTER 5

RESULTS

Overall, 20 orthodontic faculty and residents agreed to participate in the study. The VAS Group consisted of 9 orthodontic faculty and 8 orthodontic residents evaluated the malocclusions using a visual analog scale. The IS group consisted of 3 orthodontic residents evaluating the malocclusions using the Salzmann Index and the Handicapping Labiolingual Deviation Index. The results were collected in an Excel spreadsheet. The level of statistical significance for all analyses was set at p-value= 0.05.

The VAS scores collected between the faculty and the residents had statistically different scores in 10 (50%) of the patient records evaluated for the severity of treatment need. Table 1 summarizes the mean VAS score of the faculty and the residents, the standard deviation, and the p-value.

Table 1. *Summary of VAS Group scores*

	VAS Subgroup	Raters	Mean	Std. Deviation	Significance
Patient 1	Resident	9	60.1600	20.46525	0.352
	Faculty	8	69.6775	20.29453	0.352
Patient 2	Resident	9	43.1356	19.51176	0.056
	Faculty	8	64.7425	23.46741	0.056
Patient 3*	Resident	9	40.5244	14.47451	**0.007**
	Faculty	8	68.5025	22.33189	**0.007**
Patient 4*	Resident	9	59.1156	11.21563	**0.011**
	Faculty	8	74.9650	11.22110	**0.011**
Patient 5*	Resident	9	13.5778	8.31662	**0.004**
	Faculty	8	44.5325	21.55239	**0.004**
Patient 6*	Resident	9	39.4800	9.93692	**0.043**
	Faculty	8	58.0450	22.96894	**0.043**
Patient 7	Resident	9	42.7178	23.24059	0.112
	Faculty	8	60.7475	20.35974	0.112

*. Correlation is significant at the 0.05 level

Table 1. (continued)

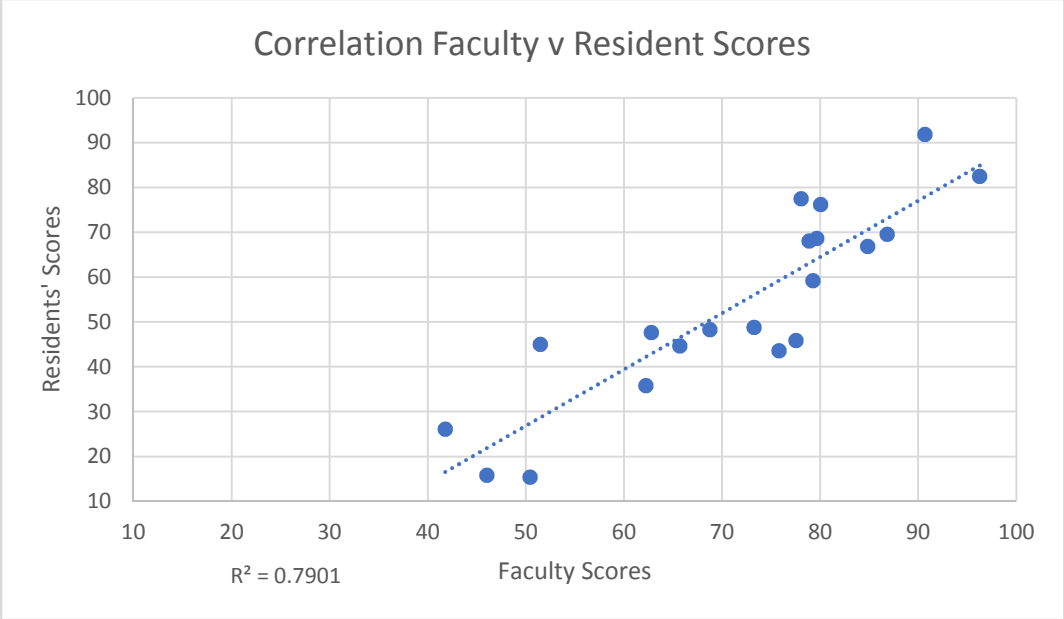
	VAS Subgroup	Raters	Mean	Std. Deviation	Significance
Patient 8	Resident	9	42.0911	17.98189	0.198
	Faculty	8	55.4600	22.94282	0.198
Patient 9*	Resident	9	13.9956	6.27841	**0.019**
	Faculty	8	40.6550	24.98021	**0.019**
Patient 10	Resident	9	39.7933	17.33911	0.615
	Faculty	8	45.4725	27.72573	0.615
Patient 11*	Resident	9	61.5178	13.16932	**0.014**
	Faculty	8	76.7275	8.67274	**0.014**
Patient 12	Resident	9	67.3667	12.48821	0.610
	Faculty	8	70.7350	14.15584	0.610
Patient 13	Resident	9	60.6822	17.47939	0.239
	Faculty	8	70.3825	14.74707	0.239
Patient 14*	Resident	9	38.5400	13.02502	**0.002**
	Faculty	8	66.9750	18.34979	**0.002**
Patient 15	Resident	9	68.5156	8.51783	0.947
	Faculty	8	68.9725	18.10873	0.947
Patient 16*	Resident	9	52.3267	17.84763	**0.044**
	Faculty	8	70.0300	15.01480	**0.044**
Patient 17*	Resident	9	72.9022	12.42713	**0.019**
	Faculty	8	85.0700	3.55287	**0.019**
Patient 18	Resident	9	81.1533	4.99617	0.765
	Faculty	8	80.1350	8.56749	0.765
Patient 20	Resident	9	23.0822	10.39445	0.094
	Faculty	8	36.8950	20.41430	0.094
Patient 21*	Resident	9	31.6467	16.54373	**0.013**
	Faculty	8	54.9900	17.62880	**0.013**
Total*	Resident	9	952.3244	131.49458	**0.006**
	Faculty	8	1263.7125	255.61677	**0.006**

*. Correlation is significant at the 0.05 level

The first analysis was the comparison of the VAS scores between residents and the faculty within the VAS Group. There was a statistically significant correlation between the orthodontic faculty and orthodontic residents with a correlation coefficient,

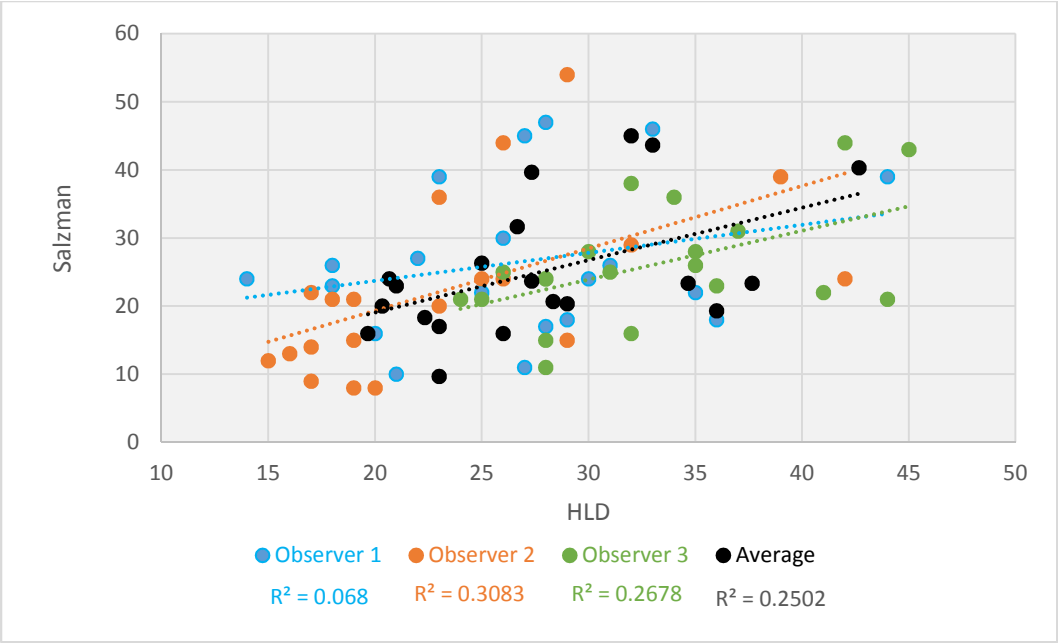
R^2=0.7901 (Table 2), that demonstrates a moderately correlation. Although there was a moderate correlation between the residents and the faculty, the faculty reported VAS scores that were on average 15% higher towards severe need for treatment. Table 2 shows a visual representation of the data.

Table 2. *Correlation of VAS score between Faculty and Residents*



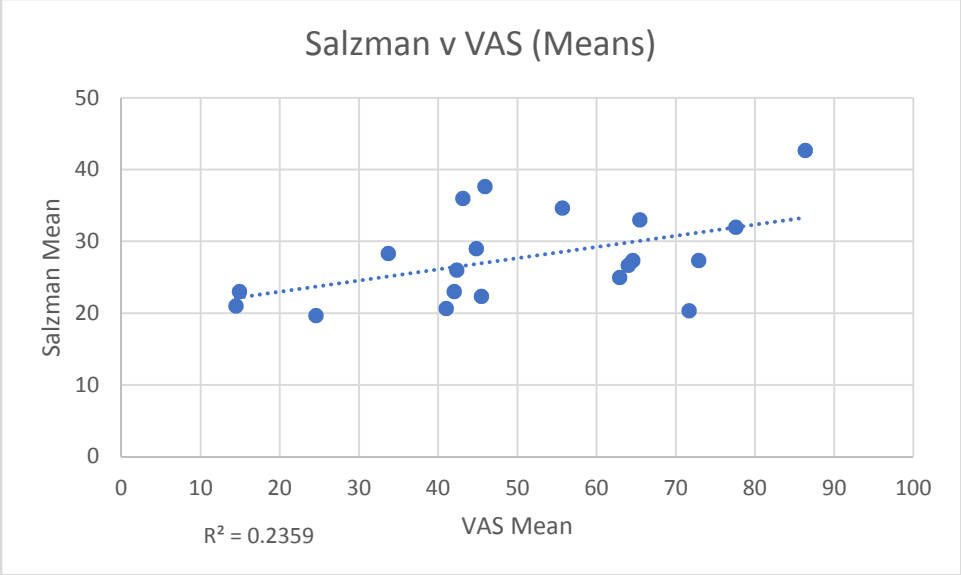
When examining the inter-rater reliability between the IS Group raters, a correlation analysis was used to find an association between the Salzmann scores and the HLD scores (raw data scores in Appendix A and B). There was almost no correlation found between the raters with correlation coefficient, R^2= 0.2503. Although the raters were calibrated prior to the experiment, there was a low number of raters in the IS group. Power analysis estimates acceptable reliability with 20 raters. The results are displayed in Table 3.

Table 3. *Correlation of Salzmann Scores and HLD Scores in IS Group*



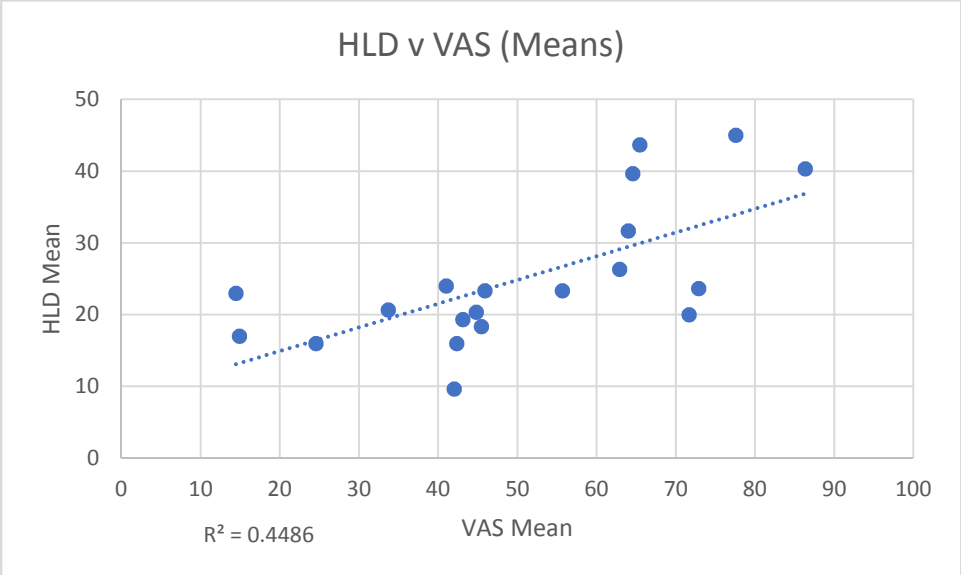
A statistical analysis was performed to find an association between the Salzmann Index scores and the VAS scores, as well as the HLD Index Scores and the VAS scores. A correlational analysis was performed. The weakest association was found between the Salzmann Index scores and the VAS scores with a correlation coefficient of R^2=0.2359 (Table 4). This demonstrates almost no correlation.

Table 4. *Correlation of Salzmann Scores and VAS Scores*



In comparing the HLD Index scores and the VAS scores, a weak correlation was found with a correlation coefficient of R^2=0.4486 (Table 5).

Table 5. *Correlation of HLD Scores and VAS Scores*



The interrater reliability for both Salzmann and HLD assessments (3 residents x 20 records x 2 indexes) grouped together for general comparison was evaluated. Resident 1 and resident 3 had no agreement (Cohen's Kappa, $\kappa = 0.03$ and $\kappa = 0.07$). Resident 2 had a weak agreement ($\kappa = 0.49$). The overall agreement was $\kappa = 0.17$, showing no consistency between the IS scores. The results are summarized in the table below (Table 6).

Table 6. *Cohen's Kappa Analysis of Inter-rater Reliability*

				Approximate Significance	Interpretation
1	Res	Kappa	0.03	0.888	No Agreement
2	Res	Kappa	0.49	0.028	Weak Agreement
3	Res	Kappa	0.07	0.402	No Agreement
	Total	Kappa	0.17	0.141	No Agreement

CHAPTER 6

DISCUSSION

6.1 Evaluation of Methodology and Results

Most of the United States uses the Salzmann Index or the Handicapping Labiolingual Deviation Index as a qualifying criterion to evaluate the severity of malocclusion and need for orthodontic treatments. This allows for a distribution of government sponsored Medicaid insurance funds to patients that are in most need and will benefit the most from orthodontic treatment. The objective of the study is to evaluate the validity and reliability of these indexes to ensure that the indexes are accurately determining patient treatment need priority. In total, 20 orthodontic residents and faculty participated in the study.

To begin, it is important to discuss the methods used to analyze intraclass correlation. The Cohen's Kappa statistical measure was used which accounts for the level agreement that may occur between raters by merely guessing. Cohen suggested the Kappa result be interpreted according to the following guideline: "values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement" (McHugh, 2012). The guideline is summarized in the following table:

Table 7. *Interpretation of Cohen's kappa.*

Value of Kappa	Level of Agreement	% of Data that are Reliable
0–.20	None	0–4%
.21–.39	Minimal	4–15%
.40–.59	Weak	15–35%
.60–.79	Moderate	35–63%
.80–.90	Strong	64–81%
Above.90	Almost Perfect	82–100%

Therefore, looking at the results of our study, the overall Kappa coefficient of inter-rater reliability for the IS group is 0.17. According to the guidelines set forth by Cohen, the overall Kappa coefficient of 0.17 shows that there was no agreement amongst the examiners.

Moreover, the Pearson's correlation coefficient had a inter-rater correlation coefficient of R^2=0.2502 amongst the IS scores of the Salzmann and HLD scores. Although statistically significant, this signifies a weak correlation between the subjects.

To investigate further, the IS group had only 3 subjects. The statistical power of a study is the probability of a hypothesis test finding an effect if there is an effect to be found. A power analysis of the study shows that the study has low statistical power with 3 subjects leading to Type II errors, also known as a false negative. By increasing the number of subjects in the study, the statistical power will increase and the likelihood of identifying an effect when there is an effect to be found will increase (Liebr, 1990).

It is difficult to compare the findings of this study with the findings of other studies as the materials and methods of the other studies differ vastly. Few studies have analyzed the validity of the Salzmann index and the Handicapping Labiolingual Deviation index. Our study correlated the scores of the IS group and the VAS score, the

gold standard in the study, and found statistical significance between the VAS scores and the Salzmann and HLD scores. Our study found there to be a weak correlation between the Salzmann scores and the VAS scores, and a moderate correlation between the HLD scores and the VAS scores

One study by Younis in 1997 that examined the reliability and validity of the HLD and Salzmann index using a 7-point Likert-type scale anchored with "Minimal need" and "Great need" in the evaluation of 160 dental casts disagrees with our study. They found the indexes to be valid, but the results showed that the cutoff points were too high. They found lowering the index cutoff points for Salzmann to 12 and HLD to 13 increased the validity of the indexes to 89% and 92% respectively. The high cutoff points possibly an attempt for public programs to control costs withing the program. (Younis, 1997).

Similarly, a study by Cooke in 2009 evaluated assessed the validity of the Handicapping Labiolingual Deviation index with modification dubbed HLD(CalMod). 13 orthodontic specialists evaluated 153 casts and recorded the need for treatment using an adjective scale; this was considered the gold standard. An additional 2 orthodontic specialist evaluated and scored the same casts using the HLD(CalMod). Analysis of the scores showed that the HLD(CalMod) was correlated with the gold standard, however the cut-off point did not correspond to the gold standard threshold levels of handicapping malocclusion. Thus, specific cases that were deemed necessary for treatment were not approved for treatment by the 26 point cut-off (Cooke, 2009).

In comparing the VAS scores of the faculty and the residents, a moderately strong correlation was found between the VAS scores of the faculty and the VAS scores of the residents. Although the scores correlated well with each other, the faculty scored the severity of the malocclusion as significantly more severe. The average scores of the faculty were 15% higher in severity of malocclusion than that of the residents. A possible

explanation for this is that the faculty with years of more experience are more adept at identifying difficulties in treatment planning and can more proficiently identify future pitfalls that may occur. Another possible explanation is that faculty with years of working at their own private practice may subconsciously attempt to increase patients covered for treatment and rate cases as more difficult in order to increase the likelihood of the case to be accepted for insurance.

6.2 Study Limitations and Suggestions for Further Research

One study limitation was sample size. The IS group research requirements were time intensive and only managed to recruit 3 subjects. This weakened the strength of the study. Increasing the sample size of the IS group will increase the strength of the study and may increase the findings of the study.

Another study limitation is that all the patients' records used are past patients of the Orthodontic Department at the Kornberg School of Dentistry. As all the subjects are either faculty or residents at the same Department of Orthodontics, it is possible the subjects had some previous exposure to the patient records which may introduce bias into the research.

Future studies may focus on increasing the sample size of the study and ensuring the patients records are completely novel patients to all subjects.

CHAPTER 7

CONCLUSIONS

In conclusion, the null hypothesis was rejected. Results showed that there was no correlation between the Salzmann Index score/Handicapping Labiolingual Deviation Index score and the severity of treatment need as judged by the gold standard for this study. Therefore, we conclude that the Salzmann Index and the Handicapping Labiolingual Deviation score should not be used to distribution of government funding for orthodontic treatment. Although, if one had to pick, the Handicapping Labiolingual Deviation had a stronger correlation with the gold standard and is a more valid index of malocclusion.

- Overall, there was a strong correlation between faculty and resident VAS assessment of the malocclusion, but the faculty reported all the malocclusions to have a more severe need for treatment.
- There was a weak correlation found between the Salzmann Index scores and the gold standard of the study, the visual analog scale scores.
- There was a moderate correlation found between the Handicapping Labiolingual Deviation Index scores and the gold standard of the study, the visual analog scale scores.
- There was poor inter-rater reliability and low power of analysis between the 3 subjects in the IS group.
- A larger follow-up study will be required to validate or disprove the findings of the study.

- Identifying malocclusions that may not be well accounted for with current indexes of malocclusion may help improve their validity.
- Evaluation of orthodontic malocclusions for the distribution of government funding is important to ensure an appropriate dispersal of government funds to those patients that need it most.

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APPENDIX A
IS GROUP SALZMANN SCORES

Record Set	Rater C	Rater B	Rater C
Column1	Column2	Column3	Column4
1	23	23	34
2	30	42	41
3	35	29	44
4	26	19	30
5	18	17	28
6	21	20	28
7	20	19	28
8	27	25	35
9	28	16	25
10	29	17	32
11	33	29	37
12	22	15	24
13	27	23	32
14	18	18	26
15	25	26	31
16	36	32	36
17	28	26	42
18	44	39	45
20	14	17	28
21	31	19	35

APPENDIX B
IS GROUP HLD SCORES

Record Set	Rater A	Rater B	Rater C
Column1	Column2	Column3	Column4
1	39	20	36
2	39	24	22
3	39	15	21
4	39	21	28
5	39	22	24
6	39	8	11
7	39	15	24
8	39	24	26
9	39	13	21
10	39	14	16
11	39	54	31
12	39	12	21
13	39	36	38
14	39	21	25
15	39	24	25
16	39	29	23
17	39	44	44
18	39	39	43
20	39	9	15
21	39	8	28