ASSESSING RELIABILITY OF SALZMANN INDEX SCORING AMONGST ORTHODONTIC PRACTITIONERS IN PENNSYLVANIA

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Submitted to
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MASTER OF SCIENCE in ORAL BIOLOGY

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by
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ABSTRACT

Objectives: The state of Pennsylvania uses the Salzmann Index as a qualifying criterion for patients to be covered for tax-supported orthodontic care. The Salzmann Index measures the severity of a malocclusion by giving different point values to certain intra-arch and inter-arch deviations, and produces a numeric score for each patient examined. The aim of this study was to assess the reliability of Salzmann Index scores amongst orthodontic practitioners in Pennsylvania.

Methods: 20 participating orthodontists were asked to complete Salzmann Indices for three sets of pre-treatment dental study models which included: (a) A Class I malocclusion (b) A Class II malocclusion (c) A Class III malocclusion. The variability in examiner scoring was analyzed to determine the reliability of the Salzmann Index. This was then correlated with responses to survey questions to evaluate factors that may influence the practitioners' scoring of the indices.

Results: In total, 20 orthodontists completed the indices and survey. The Class II malocclusion had an average total score closest to the 25 point cut-off and the largest variability in scoring (M=27.15, SD=8.51), compared to the Class I malocclusion (M=18.6, SD=5.86) and Class III malocclusion (M=31.15, SD=4.11). Inter-rater reliability (IRR) for the index scores as measured by $ICC_{(3)}$ were 87.9% ($F_{(2,38)}$= 226.50, p<.000) for the Class I malocclusion, 40.9% ($F_{(2,38)}$=15.90, p<.000) for the Class II malocclusion, and 67.3% ($F_{(2,38)}$=45.87, p<.000) for the Class III malocclusion. No significant correlation was found between the number of years in practice or percentage of patients covered under Medicaid plans and the index scoring.

Conclusions: Overall, there was moderate reliability in the Salzmann Index scores amongst the participating orthodontists, with the Class II malocclusion scores having the poorest reliability. For the Class II case, the anterior segment inter-arch deviation score (overbite/overjet) showed the most variability, indicating orthodontists' difficulty in scoring this relationship.

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CHAPTER 1

INTRODUCTION

The ability to evaluate malocclusion is essential in establishing the diagnosis and treatment need of an orthodontic patient. Since the 1950's and 1960's, various indices of malocclusion have been devised to provide an objective means for both assessing severity of malocclusion and for estimating priorities of orthodontic treatment (Beglin et al. 2001; Tang and Wei 1993). Each of these indices allows for the measurement of different occlusal features and returns a numeric score or grade (Grippaudo et al. 2008). These scores are then used to distinguish patients with the highest priority of treatment from those with less urgent need for treatment. Often times, a cut-off score is established for an index which facilitates disbursement of insurance and governmental funds for orthodontic treatment (Borzabadi-Farahani 2011). Although many indices have been developed, none have been universally accepted. In fact, the American Association of Orthodontics declared in 1990 that it opposed the use of any index in measuring malocclusion to identify treatment needs of patients, and would not endorse any specific index (Järvinen 2001; El-Gheriani et al. 2008). Despite this proclamation by the AAO, most states still use an index as a qualifying criterion for patients to be covered for tax-supported orthodontic care. In 2015, eight states, including the state of Pennsylvania, were using the Handicapping Malocclusion Assessment Record, also known as the Salzmann Index (Minick and Shellhart et al. 2017).

The Salzmann Index was developed in 1968 and measures the severity of a malocclusion by giving different point values (1 or 2) to certain intra-arch and inter-arch

deviations (Salzmann 1968). The index provides a concise, clear-cut and finite score for each patient examined, and it does not use millimetric readings or angular measurements often found in other evaluation techniques (Allen 1970; Caveney 1976). The index is widely accepted as it is simple and easy to use. The Pennsylvania Department of Human Services states under code 1149.55 that certain conditions and requirements need to be met to qualify for orthodontic services under the state Medicaid program. The final criterion listed to qualify for these services is that "The recipient scored 25 or higher on the Salzmann Evaluation Index upon examination and evaluation by the orthodontist" (Pennsylvania Department of Human Services 2018). Since the Salzmann index is being used to establish treatment priority for patients in the state of Pennsylvania, it must be scrutinized and tested for its validity and reliability.

The aim of this study is to assess the reliability, or reproducibility, of Salzmann index scores amongst orthodontic practitioners in Pennsylvania. Pre-treatment models from the Department of Orthodontics at Temple University Kornberg School of Dentistry were used in this study. The participating orthodontists were asked to complete Salzmann indices for three cases: (a) A Class I malocclusion (b) A Class II malocclusion (c) A Class III malocclusion. The variability in examiner scoring was analyzed to determine the reliability of the Salzmann index. This was then correlated with responses to survey questions to evaluate factors that may influence the practitioners' scoring of the indices.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Defining an Occlusal Index

Occlusal indices provide an objective method for assessing severity of malocclusions and recording traits of malocclusion in a numerical or categorical format. The methods of recording and measuring malocclusion can be divided into two types: qualitative and quantitative. Qualitative methods describe the occlusal features and provide descriptive classification of the dentition, while quantitative methods quantify the complexity and severity of the problem in a scale or proportion. Indices based on qualitative methods have a high risk of bias, while quantitative methods are more reliable (Gupta et al. 2015). 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 and Wei 1993). Since then, a large number of occlusal indices have been developed, with many appearing in the 1950s. The most popular of the older indices, the Occlusal Index (OI) by Summers, the Treatment Priority Index (TPI) developed by Grainger, and the Handicapping Malocclusion Assessment Record (HMAR) developed by Salzmann were introduced in the 1960s (Grippaudo et al. 2008).

The requirements of an index of occlusion were summarized in a World Health Organization Report in 1966, as seen in Figure 1 (Tang and Wei 1993). From this list, criteria number 5 states that the index must be reproducible (reliable), and number 10

states that the index must be valid. A well-developed occlusal index *must* be both valid and reliable. Validity is the ability of an index to accurately measure what it purports to measure. Reliability is the ability of an index to yield the same score or result when one or more examiners measure the same clinical case at the same or at different times (Beglin et al. 2001; Tang and Wei 1993). Our study aims to assess the reliability of a particular index.

Dr. William Shaw (1995) divided occlusal indices into five different categories: Diagnostic, Epidemiologic, Orthodontic Treatment Need, Treatment Outcome and Orthodontic Treatment Complexity indices (Borzabadi-Farahani 2011). Among these, orthodontic treatment need indices have been widely used to establish priorities for receiving treatment and for disbursing insurance and governmental funds for orthodontic treatment. A list of orthodontic treatment need indices can be found in Table 1 (Grippaudo et al. 2008). There is usually a cut-off score for these indices and the lowest point value that allows treatment determines the cut-off score. These cut-off scores are often times 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, is the orthodontic treatment need index evaluated in this study.

1. Status of the group is expressed by a single number which corresponds to a relative position on a finite scale with definite upper and lower limits; running by progressive graduations from zero, i.e., absence of disease, to the ultimate point, i.e., disease in its terminal stage.
2. The index should be equally sensitive throughout the scale.
3. Index value should correspond closely with the clinical importance of the disease stage it represents.
4. Index value should be amendable to statistical analysis.
5. Reproducible.
6. Requisite equipment and instruments should be practicable in actual field situation.
7. Examination procedure should require a minimum of judgement.
8. The index, should be facile enough to permit the study of a large population without undue cost in time or energy.
9. The index would permit the prompt detection of a shift in group conditions, for better or worse.
10. The index should be valid during time.

Figure 1. Requirements for an Occlusal Index, reproduced from Tang and Wei (1993)

Table 1. *Orthodontic Treatment Need Indices*

INDEX	AUTHOR	YEAR	METHOD
Handicapping Labiolingual Deviation Index (HLDI)	Draker HL	1960	quantitative
Grade Index Scale For Assessment of Treatment Need (GISATN)	Salonen L, Mohlin B, Gotzlinger B	1966	qualitative
Dental Aestetic Index (DAI)	Cons NC, Jenny J	1966	quantitative
Treatment Priority Index (TPI)	Grainger RM	1967	quantitative
Handicapping Malocclusion Assessment Record (HMAR)	Salzmann JA	1968	quantitative
Occlusal index (OI)	Summers CJ	1971	quantitative
Eismann index	Eismann D.	1974	quantitative
Index of Orthodontic Treatment Need (IOTN)	Brook PH, Shaw WC	1989	quantitative
Risk of Malocclusion Assessment Index (ROMA index)	Grippaudo C, Russo E, Marchionni P, Deli R,	1998	quantitative
Memorandum of Orthodontic Screening and Indications for Orthodontic Treatment	Danish National Board of Health	1990	qualitative
Need for Orthodontic Treatment Index (NOTI)	Espeland LV, Ivarson K, Stenvik	1992	quantitative

From Grippaudo et al. (2008)

2.2 Scoring the Salzmann Index

In 1967, Salzmann first introduced the Handicapping Malocclusion Assessment Record (Figure 7), providing specific guidelines and weights for the assessment of the severity of malocclusion. The following is a summary of the instructions on how to score the Salzmann Index from the original article (Salzmann 1967):

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.
5. *Overjet*. The mandibular incisors occlude on or over the maxillary mucosa in back of the maxillary incisors. The incisor crowns show labial axial inclination.

6. *Overbite*. Maxillary incisors occlude on or opposite labial gingival mucosa of the mandibular incisor teeth.
7. *Cross-bite*. Maxillary incisors occlude lingual to mandibular incisors. Posterior teeth occlude entirely out of occlusal contact.
8. *Open-bite*. Teeth occlude above opposing incisal edges and above opposing surfaces of posterior teeth.
9. *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.

Additionally, the following schematics (Figures 2-6) were included in the article to help the clinician visualize the guidelines and score the assessment more accurately (Salzmann 1967):

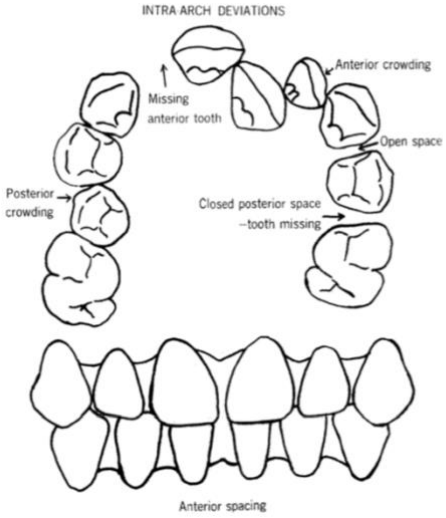


Figure 2. Intra-Arch Deviations

Figure 3. Anterior Inter-Arch Deviations

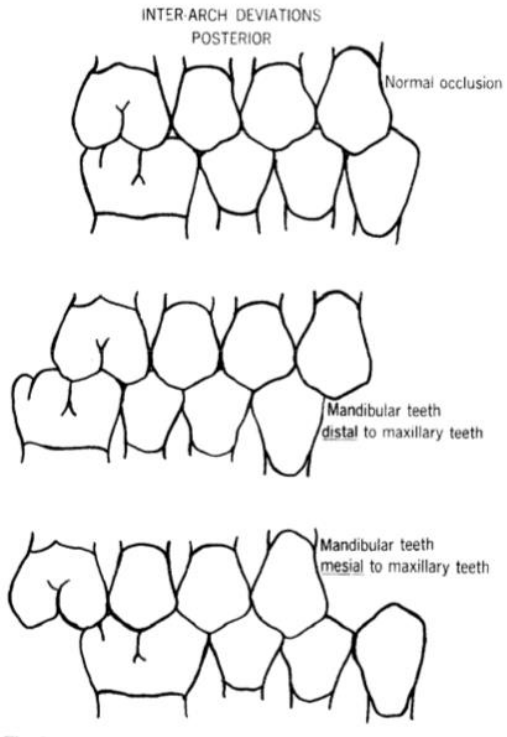


Figure 4. Posterior Inter-Arch Deviations

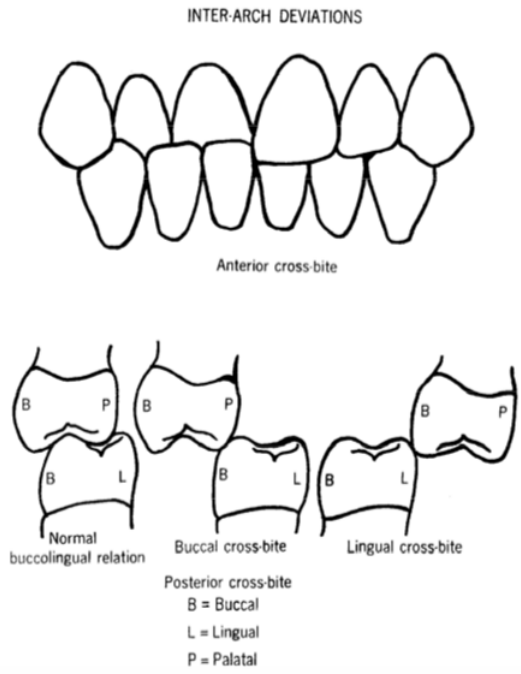


Figure 5. Anterior and Posterior Crossbites

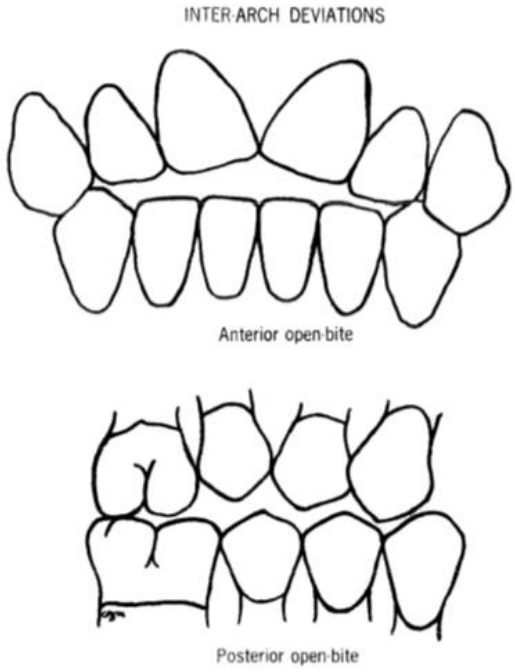


Figure 6. Anterior and Posterior Openbites

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. The Handicapping Malocclusion Assessment Record (Salzmann Index)

2.3 Reliability of the Salzmann Index: Past Studies

Many studies have been conducted to assess the reliability of malocclusion indices, including several studies evaluating the Salzmann Index. Our study focuses on the specific demographic of orthodontists in the Philadelphia area that accept Medicaid and fill out Salzmann indices for patients in their practice. Additionally, the study examines factors that may influence the practitioners' scoring of the indices.

Hermanson and Grewe (1970) tested the reliability and bias of five malocclusion indices including the Handicapping Malocclusion Assessment Record (Salzmann Index), the Occlusal Index (OI), the Treatment Priority Index (TPI) and two other indices. Fourteen pre-orthodontic casts were examined by orthodontic graduate students using each index, and inter-examiner variability was determined for the five indices tested. An analysis of variance test was undertaken for each index. Results showed that only the OI and TPI demonstrated non-significant inter-examiner variability at the one percent level, and that the most reproducible and unbiased index would be the OI or TPI. Examiner disagreement for the Salzmann index was significant at the one percent level.

Grewe and Hagan (1972) compared the Handicapping Malocclusion Assessment Record (Salzmann Index), the Occlusal Index (OI) and the Treatment Priority Index (TPI) for reproducibility and validity when used in the same population. One hundred thirty dental casts taken from pretreatment records at the University of Iowa Orthodontics clinic were scored by three objective examiners for each of the three indices. For all three indices, inter-examiner variability was found not to be significant at the 0.05 level as indicated by the Pearson product-moment coefficients. However, when analysis of

variance was used to check the level of scoring between examiners, significant inter-examiner variability was found for all three indices, indicating lack of precision, or reliability. Overall, of the three indices tested in the study, no one index could be selected over the other with regard to reproducibility, but the OI would be the index of choice with regard to having the least amount of bias.

Gray and Demirjian (1977) evaluated the reproducibility and accuracy of four indices – the Handicapping Labio-lingual Deviation (HLD) Index, the Treatment Priority Index (TPI), the Occlusal Index (OI) and the Handicapping Malocclusion Assessment Record (HMAR or Salzmann index). Eighty-two pre-orthodontic models of children being seen at the University of Montreal Research Centre on Growth and Development, Faculty of Dentistry were assessed quantitatively utilizing each of the four indices. The results showed that all the methods were highly precise and demonstrated an acceptable margin for error. The OI had the best correlation with the clinical standard, which was determined by subjective assessment of orthodontists. The Salzmann index was found to be highly reproducible and sensitive over the entire range of occlusions.

Otuyemi and Noar (1996) studied three malocclusion treatment need indices for reliability and inter-index correlation: The Handicapping Malocclusion Assessment Record (HMAR or Salzmann index), the Occlusal Index (OI), and the Dental Aesthetic Index (DAI). Pretreatment study models of thirty cases representing a wide range of malocclusion severity were assessed using the guidelines for each index. Excellent levels of reliability were achieved for all three indices, with DAI demonstrating the highest level of reliability (r=0.96) and the Salzmann index demonstrating the lowest (r=0.91).

CHAPTER 3

AIMS OF THE INVESTIGATION

Purpose/Specific aims: The aim of this study is to assess the reliability, or reproducibility, of Salzmann index scores amongst orthodontic practitioners in Pennsylvania.

Hypothesis: We hypothesize that there will be significant variability in the grading of Salzmann indices for the selected cases and that higher scores will correlate with orthodontists treating higher percentages of Medicaid patients in their offices.

CHAPTER 4

MATERIALS AND METHODS

Pre-existing pre-treatment models from the Department of Orthodontics at Temple University Kornberg School of Dentistry were utilized for this study. The three cases were selected based on Angle's molar classification (one Class I malocclusion, one Class II malocclusion, and one Class III malocclusion) and were in complete permanent dentition from 1st molar to 1st molar. Each case had been previously submitted to a Medicaid insurance program, and the Salzmann index scores originally reported to insurance were between 25-28. All models were assessed to ensure diagnostic quality, and were printed in accordance with the American Board of Orthodontics' standards for 3D-printed stereolithic study models. The three sets of study models were printed utilizing EnvisionTEC © Envision One cDLM Dental 3D printer, with E1-Model Light DLP printing resin. All three cases included in the study are currently, or had previously been, patients of the Temple University Kornberg School of Dentistry, Department of Orthodontics. All models were de-identified for use in this study. Index and survey completion by participating orthodontists was anonymous. No information on patient health history, medical or dental notes, or contact information was utilized. All patients had signed an informed consent upon their first patient visit to allow the use of diagnostic records for research and teaching purposes. There was no communication with patients in this study. The study obtained approval by the university's institutional review board in June 2019 (Protocal #25814).

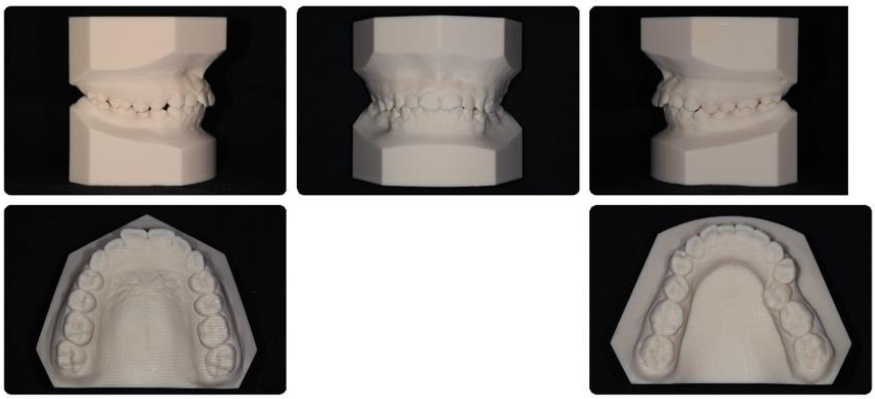
The subjects for the study were orthodontists who met the inclusion criteria and agreed to participate. Approximately 30 orthodontists in the Philadelphia area were contacted for participation. Participating orthodontists were visited at their office where the indices/cases and survey were proctored in-person. The first question of the survey was an acknowledgement of the study terms: “I acknowledge that I choose to participate in this study and that my responses will be recorded and used for research purposes. I understand that all responses will be anonymous.” No payment compensation was made to the participants.

Three cases (diagnostic models) were selected based on malocclusion type: (a) A Class I malocclusion (b) A Class II malocclusion (c) A Class III malocclusion (Figure 8).

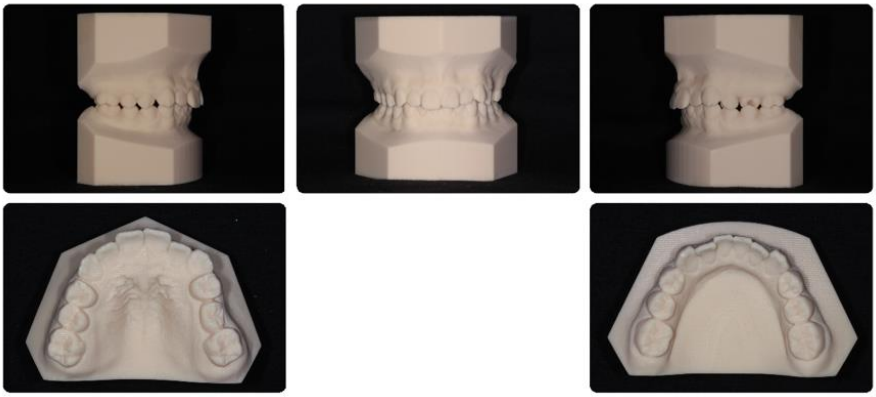
We narrowed the focus so each of the three cases were:

- Permanent dentition (1st molar to 1st molar)
- Previously submitted cases to a Medicaid insurance program
- Salzmann index scores originally reported to insurance between 25-28

Class I malocclusion:



Class II malocclusion:



Class III malocclusion:

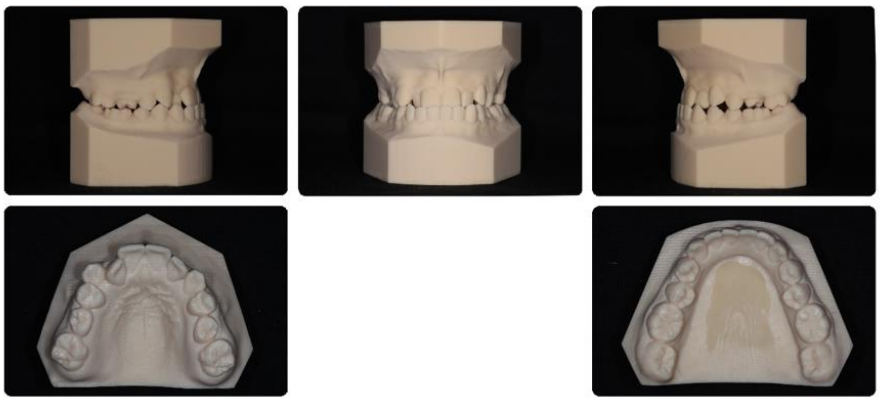


Figure 8. Pre-treatment Dental Study Models

The orthodontists who participated in the study were all practicing orthodontists in the Greater Philadelphia region of Pennsylvania. The participants must accept and treat Medicaid patients at their office. These were the only criteria for subjects in this study. Number of years practicing, educational background, gender, age, etc. were not inclusion/exclusion criteria.

Each orthodontist who agreed to participate was asked to complete Salzmann indices for the three cases.

The prompt for the study read as follows:

"Assume three new patients present to your office seeking orthodontic treatment. The three patients are covered under a Medicaid insurance plan, so you are required to submit a completed Salzmann index for each of these patients. Please fill out and score a Salzmann index for each of the three cases utilizing the models presented to you."

After completing the Salzmann index forms for the three selected cases, the participating orthodontists were asked to complete a series of survey questions (Appendix A):

1) How many years have you been in practice?

   0-10 years 10-20 years >20 years

2) About what percentage of your patients are covered under Medicaid plans?

   0-25% 25-50% 50-75% 75-100%

3) Do you consider the Salzmann Index to be an objective, reproducible assessment of malocclusion severity?

   Yes No

4) Should a cut-off score for the Salzmann index be a criterion for patients to be covered under a Medicaid insurance plan?

Yes No

5) Should orthodontists accepting Medicaid in the state of Pennsylvania be required to go through a training or calibration program to ensure consistency in the scoring?

Yes No

6) Should facial esthetics be included on a priority index for state funding of orthodontic treatment?

Yes No

The variability in examiner scoring was analyzed to determine the reliability of the Salzmann index. Means and standard deviations for the scores in each section, as well as total scores for the indices of each case were calculated. Further, based on the nature of the data, inter-rater reliability for each case was measured utilizing intraclass correlation coefficients ($ICC_{(3)}$). Lastly, total scores for each case were correlated (Pearson correlation) with responses to the survey questions to evaluate factors that may influence the practitioners' scoring of the indices.

CHAPTER 5

RESULTS

In total, 20 orthodontists agreed to participate and completed the indices and survey. The index scores and survey responses were organized into an excel sheet and the survey responses were assigned numerical values in order to be quantified for statistical analysis (Appendix C). The level of statistical significance for all tests was set at $\alpha = 0.05$. Overall, 12 participants had been in practice 0-10 years (60%), 3 participants had been in practice 10-20 years (15%), and 5 participants had been in practice >20 years (25%). In terms of the percentage of patients covered under Medicaid insurance plans, 11 participants have 0-25% of their practice as Medicaid patients (55%), 3 participants have 25-50% of their practice as Medicaid patients (15%), 2 participants have 50-75% of their practice as Medicaid patients (10%), and 4 participants have 75-100% of their practice as Medicaid patients (20%). Table 2 shows the breakdown of these distributions.

Table 2. *Orthodontists' Years in Practice and Percent Medicaid Patients*

	Years in Practice			% Medicaid Patients			
	0-10	10-20	>20	0-25	25-50	50-75	75-100
# Subjects	12	3	5	11	3	2	4
% Participants	60%	15%	25%	55%	15%	10%	20%

The Class II malocclusion had an average total score closest to the 25 point cut-off and the largest variability in scoring (M=27.15, SD=8.51), compared to the Class I malocclusion (M=18.6, SD=5.86) and Class III malocclusion (M=31.15, SD=4.11). When assessing the scores in each section of the index, the anterior segment inter-arch deviation score (overbite/overjet) for the Class II malocclusion showed the most variability (M=6.6, SD=5.73) with a coefficient of variation at 86.9%, compared to the intra-arch deviation score (M=13.6, SD=4.64) and posterior segment inter-arch deviation score (M=6.95, SD=2.98) with coefficients of variation at 34.1% and 42.9%, respectively. Table 3 summarizes the mean, standard deviation, and coefficient of variation for each section and the total scores of the Class I, Class II and Class III cases.

Inter-rater reliability (IRR) for the index scores as measured by intraclass correlation coefficient ($ICC_{(3)}$) were 87.9% ($F_{(2,38)}$=226.50, p<.000) for the Class I malocclusion, 40.9% ($F_{(2,38)}$=15.90, p<.000) for the Class II malocclusion, and 67.3% ($F_{(2,38)}$=45.87, p<.000) for the Class III malocclusion. When all three cases are measured together, the IRR as measured by $ICC_{(3)}$ was 66.5% ($F_{(8,152)}$ =50.47, p<.000). These results are shown in Table 4.

Table 3. *Summary of Index Scoring*

Case/Section	Mean	Standard Deviation	Coefficient of Variation
Case 1 Section 1	14.15	3.33	23.5%
Case 1 Section 2	1.1	2.20	199.8%
Case 1 Section 3	3.35	2.03	60.7%
Case 1 Total Score	**18.6**	**5.86**	**31.5%**
Case 2 Section 1	13.6	4.64	34.1%
Case 2 Section 2	6.6	5.73	86.9%
Case 2 Section 3	6.95	2.98	42.9%
Case 2 Total Score	**27.15**	**8.51**	**31.4%**
Case 3 Section 1	14.05	2.84	20.2%
Case 3 Section 2	8.2	0.89	10.9%
Case 3 Section 3	8.9	2.38	26.8%
Case 3 Total Score	**31.15**	**4.11**	**13.2%**

Table 4. *Intraclass Correlation Coefficients*

All Cases:

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.665[a]	.458	.882	50.467	8	152	.000
Average Measures	.975	.944	.993	50.467	8	152	.000

Case 1:

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.879[a]	.641	.997	226.499	2	38	.000
Average Measures	.993	.973	1.000	226.499	2	38	.000

Case 2:

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.409[a]	.123	.967	15.898	2	38	.000
Average Measures	.933	.738	.998	15.898	2	38	.000

Case 3:

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.673[a]	.328	.988	45.869	2	38	.000
Average Measures	.976	.907	.999	45.869	2	38	.000

Total scores for each case were then correlated (Pearson product-moment correlation) with responses to the survey questions to evaluate factors that may influence the practitioners' scoring of the indices. Specifically, numbers of years in practice and the percentage of patients covered under Medicaid plans were tested. Results showed a non-significant negative correlation between numbers of years in practice and total index scores for Case 1 (r = -.43, p = .059), Case 2 (r = -.28, p= .240), and Case 3 (r = -.23, p = .322). Further, results showed a non-significant positive correlation between percentage of Medicaid patients and total index scores for Case 1 (r = .41, p = .071), Case 2 (r = .19, p = .420), and Case 3 (r = .09, p = .723). A summary of these results are found in Table 5.

Table 5. *Pearson Correlations*

		Years	Medicaid_Pct	C1TS	C2TS	C3TS
Years	Pearson Correlation	1	-.456*	-.429	-.275	-.234
	Sig. (2-tailed)		.044	.059	.240	.322
	N	20	20	20	20	20
Medicaid_Pct	Pearson Correlation	-.456*	1	.412	.191	.085
	Sig. (2-tailed)	.044		.071	.420	.723
	N	20	20	20	20	20
C1TS	Pearson Correlation	-.429	.412	1	.668**	.512*
	Sig. (2-tailed)	.059	.071		.001	.021
	N	20	20	20	20	20
C2TS	Pearson Correlation	-.275	.191	.668**	1	.531*
	Sig. (2-tailed)	.240	.420	.001		.016
	N	20	20	20	20	20
C3TS	Pearson Correlation	-.234	.085	.512*	.531*	1
	Sig. (2-tailed)	.322	.723	.021	.016	
	N	20	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Lastly, the 20 orthodontists were asked their opinions on a series of four questions relating to the Salzmann index and its use to establish treatment priority for patients in the state of Pennsylvania. The four questions were as follows:

(1) Do you consider the Salzmann Index to be an objective, reproducible assessment of malocclusion severity?; (2) Should a cut-off score for the Salzmann index be a criterion for patients to be covered under a Medicaid insurance plan?; (3) Should orthodontists accepting Medicaid in the state of Pennsylvania be required to go through a training or calibration program to ensure consistency in the scoring?; (4) Should facial esthetics be included on a priority index for state funding of orthodontic treatment?

For the first question, 10 participants answered 'yes' (50%), and 10 participants answered 'no' (50%) as to whether the Salzmann index is an objective and reproducible assessment of malocclusion severity. For the second question, nine participants answered 'yes' (45%), and 11 participants answered 'no' (55%) as to whether a cut-off score for the Salzmann index should be a criterion for patients to be covered under a Medicaid insurance plan. For the third question, eight participants answered 'yes' (40%), and 12 participants answered 'no' (60%) as to whether orthodontists accepting Medicaid in the state of Pennsylvania should be required to through a training or calibration program to ensure consistency in the scoring. For the fourth question, 17 participants answered 'yes' (85%), and three participants answered 'no' (15%) as to whether facial esthetics should be included on a priority index for state funding of orthodontic treatment. A summary of these survey results is found in Table 6.

Table 6. *Survey Results*

Survey Question	Salzmann objective?		Cut off score?		Training/calibration?		Facial esthetics?	
Survey Response	Yes	No	Yes	No	Yes	No	Yes	No
# Subjects	10	10	9	11	8	12	17	3
% Participants	50%	50%	45%	55%	40%	60%	85%	15%

CHAPTER 6

DISCUSSION

6.1 Evaluation of Methodology and Results

The state of Pennsylvania uses the Salzmann Index as a qualifying criterion for patients to be covered for tax-supported orthodontic care. The objective of this study was to assess the reliability of Salzmann Index scores amongst orthodontic practitioners in Pennsylvania. In total, 20 orthodontists participated in the study, and inter-rater reliability for the index scoring of three cases was measured utilizing intraclass correlation coefficients.

First, it is important to discuss the methodology of assessing intraclass correlation coefficients. There are two common guidelines used for the interpretation of intraclass correlation coefficients: Koo and Li (2016) and Cicchetti and Sparrow (1981). According to Koo and Li (2016), intraclass correlation coefficients should be used to evaluate the level of reliability using the following general guideline: “Values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability.” Cicchetti and Sparrow (1981), in a similar manner, put forth guidelines that state that, “when the reliability coefficient is below 0.40, the level of clinical significance is poor; when it is between 0.40 and 0.59, the level of clinical significance is fair; when it is between 0.60 and 0.74, the level of clinical significance is good; and when it is between 0.75 and 1.00, the level of clinical significance is

excellent." These two guidelines are summarized in Table 7 from Perinetti (2018). Our study utilizes the guidelines by Koo and Li (2016) in our analysis.

Table 7. *Guidelines for Interpreting Intraclass Correlation Coefficients*

Repeatability outcome	Intervals	Further notes
	Ko and Li[8]	Cicchetti and Sparrow[9]
Poor	<0.50	<0.40
Fair	0.50-0.75	0.40-0.60
Good	0.75-0.90	0.60-0.75
Excellent	0.90-1	0.75-1

From G. Perinetti (2018)

Now, looking at the results of our study, inter-rater reliability for the index scores as measured by intraclass correlation coefficient ($ICC_{(3)}$) were 0.879 for the Class I malocclusion, 0.409 for the Class II malocclusion, and 0.673 for the Class III malocclusion. Therefore, according to the guidelines by Koo and Li (2016), there was *good reliability* for the Class I case, *poor reliability* for the Class II case, and *moderate reliability* for the Class III case. When all three cases were measured together, the inter-rater reliability as measured by $ICC_{(3)}$ was 0.665, which means overall, there was *moderate reliability* of the Salzmann index scores in this study.

It is difficult to compare this study's findings with those found in other studies since the methodologies, subjects, and statistical tests in each of the studies differ widely.

The majority of studies on indices were done in the 1960s and 1970s, when the indices were first introduced. No previous reliability study has looked solely at the Salzmann index, and no previous study has assessed inter-rater reliability of the Salzmann index as measured by intraclass correlation coefficients. Moreover, our study is the first to focus on the specific demographic of orthodontists in the Philadelphia area that accept Medicaid and fill out Salzmann indices for patients in their practice.

With that said, results from several previous studies appear to be in disagreement with our findings. In the study by Gray and Demirjian (1977), 82 pre-treatment study models were assessed and scored by three orthodontists to evaluate the reproducibility of the Salzmann index. Results showed the Salzmann index to be highly reproducible and sensitive over the entire range of occlusions as measured by Spearman's ranking correlations. Similarly, in the study by Otuyemi and Noar (1996), pre-treatment study models of 30 cases representing a wide range of malocclusion severity were scored using the Salzmann index. Excellent levels of reliability were achieved for the Salzmann index ($r=0.91$). And lastly, in the study by Grewe and Hagan (1972) , 130 pre-treatment dental casts were scored with the Salzmann index by three examiners (an undergraduate dental student, a graduate orthodontic student, and an orthodontic faculty member). Results showed inter-examiner variability to not to be significant at the 0.05 level as indicated by the Pearson product-moment coefficients. The findings of all three of these studies indicate high levels of reliability of the Salzmann index. Our study, in contrast, indicates only moderate levels of reliability amongst our participating orthodontists.

When participating orthodontists in our study were asked whether they consider the Salzmann index to be an objective, reproducible assessment of malocclusion severity,

only 50% answered ‘yes’. Considering this survey response, along with the only moderate level of reliability found in the scoring of the indices in our study, the question must be raised whether it is an effective and fair way to determine which patients should receive state funding for orthodontic treatment, and which should not. The Pennsylvania Department of Human Services (2018) states that in order to qualify for orthodontic services, patients must receive a score of 25 or higher on the Salzmann index. This means a patient, hypothetically, could go to one orthodontist and have a scored index under 25, but then go to another orthodontist and have a score over 25. In this situation, the same patient could be covered or not covered based on which office he or she goes to, simply because of the subjectivity and low levels of reliability of the scoring. This example portrays the importance of having an objective, reproducible index when utilizing the score as a criterion for tax-supported orthodontic care. The results of this study indicate that the Salzmann index does not meet these standards, and therefore, should *not* be used for these purposes.

This leads into an important finding in our study: The Class II malocclusion had an average total score closest to the 25 point cut-off and the largest variability in scoring (M=27.15, SD=8.51), compared to the Class I malocclusion (M=18.6, SD=5.86) and Class III malocclusion (M=31.15, SD=4.11). The prompt for the study asked participating orthodontists to fill out the Salzmann indices as if these were patients presenting to their own offices for treatment. Our results suggest that some orthodontists may inflate their scoring when patients are close to the 25 point cut-off score, in order to get more patients in their office qualified for state funding. This may be a possible explanation for why Case 2 had the most variability in the total scores. This notion, along with the fact that

over half (55%) of orthodontists responded that a cut-off score for the Salzmann index should *not* be a criterion for patients to be covered under a Medicaid insurance plan, further supports removing the Salzmann index score as a requirement for coverage of these patients.

An alternative explanation for the Class II malocclusion having the highest variability and poorest reliability is that orthodontists have a difficult time scoring the anterior segment inter-arch deviation section (overbite/overjet), particularly in a Class II Division 1 case with increased overbite and overjet. This was the presentation of the Class II malocclusion case in our study. The anterior segment inter-arch deviation score (overbite/overjet) for the Class II malocclusion showed the most variability (M=6.6, SD = 5.73) with a coefficient of variation at 86.9%, compared to the intra-arch deviation score (M=13.6, SD=4.64) and posterior segment inter-arch deviation score (M=6.95, SD=2.98) with coefficients of variation at 34.1% and 42.9%, respectively. According to the Salzmann index guidelines, overjet is scored when "the mandibular incisors occlude on or over the maxillary mucosa in back of the maxillary incisors", while overbite is scored when "maxillary incisors occlude on or opposite labial gingival mucosa of the mandibular incisor teeth." Two points are scored for each maxillary anterior tooth affected (Salzmann 1967). If all four teeth are scored for both overbite and overjet, 16 points would go towards the score. If none of the four teeth are scored, 0 points would go towards the score. This 16 point discrepancy emphasizes how differences in scoring this section could drastically affect the total score of a case, which is illustrated by the results of our study.

So if orthodontists are having difficulty scoring the anterior segment inter-arch deviation section in cases like the Class II case in our study, or other sections of other cases, is there a way to improve consistency of scoring these sections, and thereby, improve the reliability of the total scores? One possible solution is to have all orthodontists be required to go through a Salzmann index training or calibration program in order to accept Medicaid patients at their office. Orthodontists would have to complete a brief course and show competency scoring indices in accordance with the guidelines. When participants were asked whether orthodontists accepting Medicaid in the state of Pennsylvania should be required to go through a training or calibration program to ensure consistency in the scoring, only 40% responded 'yes'. This could be because orthodontists feel confident that their scoring is accurate, and unknowingly are not adhering to the guidelines. Another possibility is that the participants in this study do not have time in their busy work week to allocate to a training program. Grippaudo et al. (2008) stated, "The correct application of these indexes [treatment need indexes] depends on the capability and the experience of the operator…Moreover, minimal mistakes and millimetric failings in the survey of measurement could compromise reliability and the truth of the final score." With this in mind, if we are to continue using the Salzmann index for Medicaid insurance approvals, training and calibration of orthodontists on the correct application should be more strongly considered.

6.2 Study Limitations and Suggestions for Further Research

One study limitation was the subject size, with only 20 orthodontists agreeing to participate and complete the indices/survey. This raises the question of whether the results are an accurate representation of all orthodontists in Pennsylvania, and whether generalizations can be made about the reliability of the index scoring across the state. However, despite the low subject numbers, the present study was successful in achieving statistically significant results.

Additionally, previous studies utilized significantly more pre-treatment study models in assessing the reliability of the index scoring. In our research, only three sets of pre-treatment study models were evaluated, which may be considered a weakness of this study. Since participating orthodontists were visited at their offices during working hours to complete the indices and survey, time constraints prevented the inclusion of more study models. Ultimately, a larger follow-up study would be needed to confirm our results, with more orthodontists and a larger sample of pre-treatment study models.

Another consideration is the possible influence of being a participant in a study and its effect on the scoring of the indices. The orthodontists were aware that the scores they provided would form part of a research study. This may have influenced the way in which they scored the study models. For example, the subjects may have taken longer or with more attention to detail than they normally would with patients in their office. Thus the scoring of these study models may not accurately reflect their scoring of indices in their everyday practice.

Future research on orthodontic treatment need indices and their use in Medicaid insurance approvals is endless. Interestingly, 85% of participating orthodontists believed that facial esthetics *should* be included on a priority index for state funding of orthodontic treatment. According to Jarvinen (2001), "facial esthetics and the psychosocial consequences of malocclusions...may be the most important indicators for orthodontic treatment." Therefore, by solely utilizing the Salzmann index for Medicaid insurance approvals, we are ignoring a major factor that should be included in evaluating 'treatment need'. The Dental-Facial Attractiveness scale (DEA) and the Dental Aesthetic Index (DAI) use scales to rate dental or facial attractiveness (Järvinen 2001). Incorporation of these evaluations, or similar ones, into the criteria for tax-supported orthodontic treatment should be an area of future study and discussion to ensure the funding is being allocated properly.

Along similar lines, the American Association of Orthodontists (AAO) has recently made efforts to establish and standardize the criteria for orthodontic cases to be covered under state funding. The AAO determined that an index, like the Salzmann index, is not in the best interest of orthodontists or insurance companies, but instead proposed a list of automatic-qualifiers to streamline and standardize the qualifying process across the United States (American Association of Orthodontists 2020). The proposed auto-qualifiers include: overjet equal to or greater than 9 mm; reverse overjet equal to or greater than 3.5 mm; posterior crossbite with no functional occlusal contact; lateral anterior open bite equal to or greater than 4mm; impinging overbite with either palatal trauma or mandibular anterior gingival trauma; one or more impacted teeth with eruption that is impeded (excluding third molars); defects of cleft lip and palate or other

craniofacial anomalies or trauma; congenitally missing teeth (extensive hypodontia) of at least one tooth per quadrant. If these auto-qualifiers are implemented nationwide, this could mean the Salzmann index and other treatment need indices currently being used by individual states could become a thing of the past. In one sense, this could remove the subjectivity of indices and provide a more fair, consistent and standardized means of qualifying cases for tax-supported coverage. On the other hand, the guidelines appear to qualify only very severe cases, which may reduce the number of eligible patients nationwide. Again, more research and scientific discussion needs to be had in order to ensure the funding is being allocated properly.

CHAPTER 7

CONCLUSIONS

In conclusion, the null hypothesis was rejected. Results show that there was statistically significant variability in the grading of the Salzmann indices for the three selected cases amongst the participating orthodontists in Pennsylvania. Therefore, we conclude that the Salzmann index should *not* be used as a criterion to qualify patients for tax-supported orthodontic care.

- Overall, there was only moderate levels of reliability in the Salzmann Index scores amongst the participating orthodontists, with the Class II malocclusion having the poorest reliability.
- For the Class II case, the anterior segment inter-arch deviation score (overbite/overjet) showed the most variability, indicating orthodontists' difficulty in scoring this relationship.
- No significant correlation was found between the number of years in practice or percentage of patients covered under Medicaid plans and the index scoring.
- Training and calibration of orthodontists on the correct application of the Salzmann index should be strongly considered.
- Ultimately, a larger follow-up study would be needed to confirm our results, with more orthodontists and a larger sample of pre-treatment study models.
- Orthodontic treatment need indices and their use in Medicaid insurance approvals is evolving, and the AAO's recent proposal of automatic-qualifiers may make utilization of indices, like the Salzmann index, become a thing of the past.

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APPENDIX A

SURVEY

Salzmann Index Survey

☐ I acknowledge that I choose to participate in this study and that my responses will be recorded and used for research purposes. I understand that all responses will be anonymous.

Please read the following prompt and complete the three attached Salzmann Indices:

Assume three new patients present to your office seeking orthodontic treatment. The three patients are covered under a Medicaid insurance plan, so you are required to submit a completed Salzmann index for each of these patients. Please fill out and score a Salzmann index for each of the three cases utilizing the models presented to you.

After completing the Salzmann Index for each of the three study models, please also answer the following questions by circling your answer choice:

1) How many years have you been in practice?

   0-10 years 10-20 years >20 years

2) About what percentage of your patients are covered under Medicaid plans?

   0-25% 25-50% 50-75% 75-100%

3) Do you consider the Salzmann Index to be an objective, reproducible assessment of malocclusion severity?

   Yes No

4) Should a cut-off score for the Salzmann index be a criterion for patients to be covered under a Medicaid insurance plan?

   Yes No

5) Should orthodontists accepting Medicaid in the state of Pennsylvania be required to go through a training or calibration program to ensure consistency in the scoring?

   Yes No

6) Should facial esthetics be included on a priority index for state funding of orthodontic treatment?

   Yes No

APPENDIX B

The Handicapping Malocclusion Assessment Record (Salzmann Index) form

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

APPENDIX C

INDEX AND SURVEY RESPONSES

Subject	Years in practice	% pts medicaid	Salzmann objective?	Cut off score?	Training?	Facial esthetics included?	C1 S1	C1 S2	C1 S3	C1 TS	C2 S1	C2 S2	C2 S3	C2 TS	C3 S1	C3 S2	C3 S3	C3 TS
1	3	1	1	1	1	0	10	0	0	10	1	0	8	9	12	8	8	28
2	3	1	1	1	0	0	9	0	2	11	7	16	2	25	13	8	5	26
3	1	2	0	0	0	0	12	0	1	13	19	0	1	20	14	8	4	26
4	1	4	1	0	1	0	17	0	5	22	18	8	9	35	17	8	11	36
5	2	1	0	0	1	0	19	4	4	27	14	16	8	38	12	8	12	32
6	2	1	1	1	1	0	13	0	1	14	14	0	1	15	9	8	8	25
7	3	1	1	1	1	0	14	0	4	18	11	4	7	22	12	8	8	28
8	1	4	1	1	0	0	18	8	8	34	15	8	9	32	16	8	10	34
9	1	3	0	0	1	0	13	0	4	17	13	8	8	29	13	8	8	29
10	1	3	1	1	1	0	12	4	5	21	18	14	8	40	14	8	11	33
11	1	2	1	0	0	1	19	0	3	22	15	4	8	27	20	8	10	38
12	3	1	1	1	1	0	11	0	4	15	11	8	9	28	15	8	10	33
13	1	1	0	0	1	1	14	4	6	24	18	16	9	43	14	8	11	33
14	1	2	0	1	0	0	20	0	3	23	21	0	9	30	16	8	10	34
15	1	1	0	1	1	1	16	0	4	20	15	4	8	27	16	8	11	35
16	2	4	0	0	1	0	17	0	4	21	13	8	8	29	13	8	5	26
17	1	4	0	0	1	0	14	0	1	15	16	0	1	17	15	8	7	30
18	1	1	1	1	0	0	13	0	4	17	11	0	9	20	12	8	12	32
19	1	1	0	1	0	0	9	0	4	13	8	8	9	25	9	8	10	27
20	3	1	0	0	0	0	13	2	0	15	14	10	8	32	19	12	7	38

Legend

C = Case #

S = Section (S1 = Intra-Arch Deviation; S2 = Inter-Arch Deviation (Anterior Segment); S3 = Inter-Arch Deviation (Posterior Segment)

TS = Total Score

Years in practice question: 0-10 years (1); 10-20 years (2); >20 years (3)

% pts medicaid question: 0-25% (1); 25-50% (2); 50-75% (3); 75-100% (4)

Survey questions 3-6: Yes (0); No (1)