

QUANTITATIVE ASSESSMENT OF THE SEVERITY OF MALOCCLUSION. A PRELIMINARY STUDY OF FIVE INDICES *

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Introduction.

Malocclusion is a non-specific anomaly. Accurate assessment of its prevalence and severity in different population groups has proven particularly difficult. The complexity of variables involved in the development of occlusion has been responsible for our poor understanding of its aetiology. This complexity has also impeded precise definition of the different types of malocclusion, and to some extent precise measurement. The term 'malocclusion' is relatively vague and ill-defined. The differences between the results of various investigations of the prevalence and severity of malocclusion have in part been due to variations of definition. It is not intended to imply that there is any single satisfactory definition of malocclusion, however, it is important to remember that differences may exist when comparing the results of various studies.

In trying to develop a simple standardised method of assessment of malocclusion an Expert Committee of the World Health Organisation (1962) proposed substitution of the term 'handicapping dentofacial anomaly.' This was defined as an anomaly which caused disfigurement or impeded function. A method of assessment dependent on the subjective judgment of the examining dentist was devised. This method has been used in field surveys in Singapore, Fiji, Tahiti, New Zealand and Australia. (World Health Organisation, 1965 a, 1965 b; Baume, 1968; McCann, 1967; Davies, Kruger and Homan, 1969). The results of these surveys are interesting for comparative and therefore possibly aetiological reasons. They are however of limited value to the administrators and planners of public dental health schemes. In such schemes a more detailed and less subjective method would be required. The immediate requirement is a method of assessment which is capable of discriminating between those individuals eligible for orthodontic treatment and those not eligible for orthodontic treatment. The point of discrimination between these two categories would vary with the aims of the particular programme and the availability of resources and personnel.

Previous Studies of Malocclusion.

Studies of the prevalence of malocclusion are numerous. The features or attributes chosen for study have been diverse. Many studies have simply estimated the prevalence of one or more of these features in a given population and in some cases, a subjective appraisal of the overall severity of the malocclusion has been included. (Huber and Reynolds, 1946). The variations in definition and recording have made the comparison of results difficult and sometimes unwarranted. Gardiner (1956) drew attention to this problem when he pointed out that in his sample, if all cases with exactly one half a cusp width distocclusion were called Angle's Class II rather than Angle's Class I, the percentage of Class II cases rose from 10.9 per cent to 25.0 per cent.

Investigations concerned with the measurement of specific occlusal features do not give a useful indication of the number of individuals in any given sample requiring treatment. Neither are these features, by themselves, able to indicate the overall severity of the individual malocclusion. An example of this point may be made of Angle's classification, the classes of which are not related to overall severity. For other very good reasons however, Angle's classification endures as a descriptive method.

Some of the previous studies concerned with the prevalence of malocclusion are summarised in Table 1. The following possible conclusions might be drawn from these studies and demonstrate the immediate need for objective quantitative methods of assessment of malocclusion.

1. The prevalence of malocclusion increases with age during the period of development of the occlusion. Whether such differences, if real, are due to hereditary developmental influences or to environmental factors acting during the period of development, is of obvious importance in the practice of preventive orthodontics.

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* This investigation was supported by grants from the University of Queensland, Brisbane and the Australian Universities Commission, Canberra.

2. The prevalence and percentage distributions of different types of malocclusion vary in different ethnic groups. Davies (1949, 1956) found considerably less malocclusion in samples from Fiji and Pukapuka compared with most white civilised populations. Dockrell (1958) also suggested from a survey of published reports that there were significant differences in the prevalence of malocclusion between different races.
3. Preventive measures such as fluoridation of drinking water may reduce not only the prevalence but also the severity of malocclusion. The figures given by Hill, Blayney and Wolf (1959) are not conclusive on this point, but those of Ast, Allaway and Draker (1962) would support this view more strongly.
4. The reported prevalence and severity of malocclusion depends on the aims of the individual investigator and these may reflect the socio-economic environment in which he is working. It is interesting to compare estimates of the percentage of individuals with a malocclusion in studies from the United Kingdom with more recent studies from North America.
5. Some types of malocclusion may be considered as more of an impediment by the patient than by the orthodontist. Conversely, the orthodontist may advise treatment of a malocclusion to improve facial appearance when the patient is unconcerned. Fisk (1960) found that 55.8 per cent. of Canadian patients seeking orthodontic treatment had an Angle's Class II malocclusion. This is similar to the percentage of Miller and Hobson (1961) in the United Kingdom but much higher than has been found in comparable samples from other countries.

Indices of Malocclusion.

In order to overcome some of the difficulties already discussed concerning the assessment of malocclusion several workers have constructed indices of malocclusion. An index is essentially a type of classification. Most previous indices have been devised as generalised indicators of the severity of the individual malocclusion and samples studied have been partitioned on the basis of the numerical index scores. It has also been implied in some instances, that the index should be capable of discriminating between handicapping and non-

handicapping malocclusions. The efficiency of these indices has mostly been assessed by reference to additional subjective clinical ratings of severity, made by orthodontists.

The first attempt to construct a simple objective quantitative index of malocclusion was made by Massler and Frankel (1951). The index score was simply the summation of the number of malaligned teeth excluding third molars. Each tooth was assessed in three planes in relation to both the opposing and adjacent teeth. The index of Jamison and McMillan (1957) was intended to distinguish between handicapping and non-handicapping malocclusions, a handicapping malocclusion being defined as any deviation from ideal occlusion which presents a serious potential threat to masticatory function, health of the supporting structures, or the emotional stability of the patient. The basis of this index was the unit of occlusion consisting of one maxillary tooth and its two mandibular antagonists. Any detectable deviation from ideal was recorded, with anterior units being given a score of 1 and posterior units being given a score of 2. The index of Van Kirk and Pennell (1959) was dependent on weighted scores (0, 1, 2) of the severity of malalignment of each tooth.

Each of these three indices is based on a form of measurement (overall tooth malalignment) whose relationship to other features of the occlusion is not adequately understood. It is not clear if the index scores are significantly correlated with measurements of specific features of the occlusion such as overjet. Neither has the effectiveness of each index in separating case types or showing up differences between individuals been fully investigated.

The Dentofacial Index (D.F.I.) was based on both intraoral and extraoral features (Elsasser, 1951, 1953; Pelton, 1954; Pelton and Elsasser, 1953, 1955). The basis and aims of the D.F.I. are difficult to interpret in terms which are meaningful to the clinician. The relationship between the D.F.I. score and the severity of malocclusion in the individual is obscure.

A number of indices which are dependent on specific measurable features of the occlusion have also been devised. Draker (1960) proposed the index of Handicapping Labiolingual Deviations (H.L.D. index) as a screening device for applicants for orthodontic treatment. The index was intended to measure the extent of the handicap caused by the individual's

malocclusion. A preliminary check of the accuracy of the H.L.D. index showed approximately "80 per cent correlation" between the total index score and a clinical severity assessment. This assessment classified each case as 'approved' or 'non-approved' for orthodontic treatment. Presumably therefore, 20 per cent. of cases were misclassified. Carlos and Ast (1966) further studied the relationships between H.L.D. index scores and subjective assessments of severity. Even the use of weighted index component scores, based on a discriminant function analysis, did not significantly improve separation of the sample into the approved and non-approved groups.

The Occlusion Feature Index (O.F.I.) of Poulton and Aaronson (1961) was similar to the H.L.D. index. Four components of the O.F.I. were selected because "of importance in an orthodontic examination." The authors do not give any clear evidence of the value of the O.F.I. and the misclassification rate would appear to be of the same order as that produced by the H.L.D. index. (Draker, 1960).

The index of Gupta (1967) was a further attempt to measure the severity of malocclusion in the individual by reference to a limited number of occlusal features or components. Again the efficiency of the index has not been fully reported. A survey of 1273 children aged 13-17 years found that "the severity of malocclusion decreased with age."

The Eastman Esthetic Index (E.E.I.) was designed to measure the degree of 'esthetic handicap' due to malocclusion. (Howitt, Stricker and Henderson, 1967). The results of a study of 120 high school students aged 13-18 years, showed that the index score was significantly correlated with subjective estimates of the degree of esthetic handicap.

The Handicapping Malocclusion Assessment Record (Salzmann, 1967, 1968) was a subjectively scored index based on three broadly defined features — facial appearance, masticatory function and speech. The value of this index in "establishing priority for treatment of handicapping malocclusion" has not been substantiated at this time. However, the index does include a wider range of features than previous indices and may eventually prove to be more efficient than these.

All of the indices discussed so far have one important point in common. They all rely, completely or in part, on features of the occlusion which were selected because of their

supposed importance in measuring the severity of malocclusion or the degree of esthetic handicap. Whilst this assumption may not have been entirely unfounded, in no case has any reported *a priori* evidence been presented to show that the index components selected were appropriate to the purposes of the particular index. Thus it may be, that the components used were not the best available.

Grainger (1967) introduced the orthodontic Treatment Priority Index (T.P.I.) which is the most sophisticated index developed to date. The T.P.I. depends on a multiple regression equation with regression coefficients varying according to the buccal segment relationships of the individual. Testing of this equation on 386 individuals gave a correlation of +0.795 between a subjective severity score observed clinically and a severity score calculated by means of the equation. Comparison of the calculated and observed scores showed approximately 20 per cent. misclassification. Summers (1966) devised the Occlusal Index (O.I.) based on the methods of Grainger (1967). The O.I. proved to be a highly reproducible method of assessment which was well correlated with subjective clinical rankings of severity. However no information was given concerning the ability of the O.I. to determine the eligibility of the individual for orthodontic treatment.

Materials and Methods.

The sample of 76 individuals used has previously been described. (Freer and Adkins, 1968). Components of the indices (Table 4) were measured for each of 76 individuals and total index scores calculated. All measurements were made on study models. The Treatment Priority Index which depended on regression equations was not included here. A subjective evaluation of the overall severity of each malocclusion was made according to the severity scale (1-10) proposed by Grainger (1967).

The reliability of the methods used to measure index scores were tested by means of the differences between duplicate measurements. The work was carried out as part of an investigation of the relationships between many different occlusal features. These included qualitative, multistate and numerical features. (Freer and Adkins, 1968). Because of the impossibility of averaging the duplicate scores for qualitative and multistate features, all analyses were carried out on the first series of measurements for all features. The following

statistical parameters were used to test the reliability of measuring methods:

$$S(\bar{x}) \quad \text{Standard deviation of the differences} \quad \left[\frac{\sum (\alpha - \bar{\alpha})^2}{n-1} \right]^{\frac{1}{2}}$$

$$SE_{\bar{x}} \quad \text{Standard error of the mean difference} \quad [S(\bar{x})^2]^{\frac{1}{2}}$$

$$t \quad \text{students 't' value} \quad \frac{\bar{x}}{SE_{\bar{x}}}$$

In this preliminary investigation, the relationships between the various index components, total index scores and subjective clinical assessment of severity were studied by means of product—moment correlation coefficients.

RESULTS AND DISCUSSION

Reproducibility.

The analyses of the differences between duplicate index scores are shown in Table 2. Both the index of Jamison and McMillan (1957) and the index of Massler and Frankel (1951) show evidence of systematic error and skewness. In both cases 't' tests are significant. In the case of both indices, the absence of any definitive base line against which to measure, led to uncertainty.

Correlations.

Intercorrelations between the subjective clinical severity score and the total index scores for five indices are shown in Table 3. The highest correlation for the subjective score was with the index of Massler and Frankel (+.58). The next highest value was +.56 for the H.L.D. index. It should be noted from the intercorrelations of the various index components and the subjective score (Table 4) that the subjective clinical score is more highly correlated with the buccal component score (+.67) than with the total score of the index of Massler and Frankel (+.58). This suggests that addition of the occlusal and buccal component scores actually decreases the efficiency of the index.

In view of the fact that each of the five indices examined in Table 3 is designed to reflect the severity of the individual malocclusion, inter-correlations of these indices are surprisingly low. Correlations between each index and the subjective score are also low. The selection of significance levels for the assessment of the coefficients in Tables 3 and 4 is of special interest. Consideration of the residual variance/

total variance ratio $(1-r^2/1)$ shows that only coefficients greater than |0.70| account for more than 50 per cent of the covariance. In the present circumstances the use of orthodox levels of significance has little meaning. Only the correlation coefficient between the Occlusion Feature Index and the index of Jamison and McMillan (+0.77) is greater than |0.70|.

Except where components are dependent on common landmarks or definitions, the inter-correlations of Table 4 are also generally low. This suggests a continuously varying data system with little interdependence of components. This conclusion is supported by previously reported analyses. (Freer and Adkins, 1968). The low correlations of the component scores with the subjective clinical score, except for the buccal component of the index of Massler and Frankel (1951), would further suggest that the indices studied could not be efficient predictors of the severity of the individual malocclusion because they lack sufficient information content. The correlation coefficient between the buccal component of the index of Massler and Frankel (1951) and the subjective clinical score should be viewed with circumspection because of the difficulties encountered in measuring this index. Also of interest are the correlations between the same components when measured in slightly different ways.

One further point requires consideration. It may be that the sample used consisted of distinct sub-samples and estimates within these may have improved. It is unlikely that the same components would be relevant to each sub-sample. The main difficulty is to find such sub-samples. Furthermore, if such sub-samples do exist, it is unlikely that the same index would be an efficient predictor within them. It is easy to impose arbitrary sub-divisions such as Angle's classification on a sample, however, Freer and Adkins (1968) using similarity analysis and principal components analysis were unable to demonstrate any natural sub-divisions in the present sample.

TABLE 1

The Prevalence of Malocclusion Reported in Previous Studies

Year	Name of Examiner	No. of Examinees	Age Years	Findings	Percentage Distribution of Angle's Classes.*		
					I	II	III
<u>U.S.A.</u>							
1899	Angle		Adult		74.2	21.6	4.2
1928	Korkhaus	568	14	55.4% required treatment	75.2	23.8	1.0
1932	Stallard	1200	5-6	56.0% malocclusion	78.0	14.0	8.0
		600	13-14	68.0% malocclusion	67.0	30.0	3.0
		822	2-12	58.8% malocclusion	74.7	24.8	0.3
1936	Goldstein & Stanton	822	2-12	58.8% malocclusion	74.7	24.8	0.3
1943	Munblatt	1214	6-14	63.3% abnormal	60.3	35.3	2.6
1944	Silver	250	11-15	66.4% malocclusion			
1946	Huber & Reynolds	500	16-32	19.4% had received treatment			
				31.2% required treatment			
				28.9% malocclusion			
1948	Moore	7373	5-17	28.9% malocclusion			
1951	Massier & Frankel	2758	14-18	78.8% required treatment	63.6	24.6	11.8
1951	Krogman	586	6-12	54.1% malocclusion	51.8	45.1	3.1
1952	Barrow & White	51	5	61.0% malocclusion	55.0	30.0	15.0
		51	16	88.0% malocclusion	44.8	41.4	13.8
				(same sample as above)			
1956	Newman	3355	6-14	52.0% required treatment	75.3	25.5	1.0
1959	Hill, Blayney & Wolf	1227	12-14	55.8% malocclusion (Evanston preF)	70.7	25.7	3.6
		706	12-14	46.3% malocclusion (Evanston post F)	70.3	26.3	3.4
		1182	12-14	48.6% malocclusion (Oak Park nonF control, 1956)	71.3	27.3	1.4
1959	Altmanus	3289	12-16	83.6% required treatment (Negroes)	79.3	15.7	6.0
1962	Ast, Allaway & Draker	168	13-14	64.8% malocclusion; 9.4% physical handicap (Newburgh F)	65.9	32.3	1.8
				87.3% malocclusion; 22.5% physical handicap (Kingston nonF)	58.9	37.1	4.0
		142	13-14	87.3% malocclusion; 22.5% physical handicap (Kingston nonF)	58.9	37.1	4.0
1965	Ast, Carlos & Cons	1413	15-18	95.3% malocclusion; 14.4% with 'public Health' severe malocclusion	73.3	25.0	1.7
1966	Mills	1337	8-18	82.5% malocclusion	87.5	8.0	4.5
<u>U.K.</u>							
1945	Stclare	680	8&12	51.5% showed irregularities			
				29.6% required treatment			
1950	Humphreys & Leighton	2711	2-5	25.1% postnormal; 1.5% prenormal			
1956	Gardiner	1000	6-15	74.2% required treatment	88.5	10.9	0.6
1957	Goose, Thompson & Winter	2956	7-15	43.9% malocclusion; 15.0% required treatment	57.0	37.0	6.0
1961	Miller & Hobson	775	12	45.0% malocclusion	46.1	51.2	2.7
<u>CANADA</u>							
1960	Fisk	1000	3-12	100% malocclusion (cases sought treatment)	40.5	55.8	3.7
1963	Stothard & McCombie	1314	7-15	72.5% malocclusion; 39.8% minor, 32.7% severe			
1965	Marsh	32395		16.8% (approx) with gross and unmet treatment requirements			
<u>AUSTRALIA</u>							
1935	Taylor	619	0-15	76.3% malocclusion	76.4	19.8	3.8
<u>DENMARK</u>							
1968	Helm	1240	9-18	77.0% malocclusion			
<u>FIJI</u>							
1949	Davies	772		26.8% malocclusion	83.2	4.9	11.9
<u>GREECE</u>							
1957	Haralabakis	592	19-30	62.1% required treatment	58.5	37.3	4.2
<u>HUNGARY</u>							
1956	Adler	4876	16-18	49.9% malocclusion; 26.6% of malocclusion group was unclassifiable	43.5	27.0	2.9
<u>ITALY</u>							
1913	Chiavaro	1000	3-6	28.9% malocclusion	76.8	14.3	8.9
1955	Hertel	3202	5-14	71.4% malocclusion	72.2	21.8	6.0
<u>NORWAY</u>							
1951	Telle	2349	7-8	58.7% malocclusion	51.3	36.3	12.4
<u>NEW ZEALAND</u>							
1953	Freedlander	398	Adult	85.4% malocclusion	65.3	29.7	5.0
<u>PUKAPUKA</u>							
1965	Davies	427	5-70+	35.6% malocclusion	55.4	10.7	33.9

* In the 'malocclusion' group, not the total sample.

TABLE 2

Analysis of the differences between duplicate index scores of five indices of malocclusion.

INDEX	N	$\bar{x}$	S	S.E. $\bar{x}$	t	p	N Number of duplicate measurements
INDEX OF MASSLER AND FRANKEL (1951)	76	-2.236	3.745	0.430	5.200	.001	$\bar{x}$ Mean difference
INDEX OF JAMISON AND McMILLAN (1957)	76	-1.737	2.862	0.327	5.312	.001	S Standard deviation
INDEX OF VAN KIRK AND PENNELL (1959)	76	0.316	2.417	0.277	1.141	N.S.	S.E. $\bar{x}$ Standard error of the mean
INDEX OF HANDICAPPING LABIOLINGUAL DEVIATIONS (DRAKER, 1960)	76	0.066	0.699	0.080	0.825	N.S.	t Students' 't' value
OCCLUSION FEATURE INDEX (POULTON AND AARONSON, 1961)	76	-0.092	0.636	0.073	1.260	N.S.	p Probability

TABLE 3

Intercorrelations of total index scores of five indices and the subjective clinical score of severity.

		1	2	3	4	5	6
INDEX OF MASSLER AND FRANKEL (1951)	1		.67	.45	.42	.35	.58
INDEX OF JAMISON AND McMILLAN (1957)	2	.67		.34	.42	.36	.41
INDEX OF VAN KIRK AND PENNELL (1959)	3	.45	.34		.30	.18	.43
INDEX OF HANDICAPPING LABIOLINGUAL DEVIATIONS (DRAKER, 1960)	4	.42	.42	.30		.77	.56
OCCLUSION FEATURE INDEX (POULTON AND AARONSON, 1961)	5	.35	.36	.18	.77		.36
SEVERITY	6	.58	.41	.43	.56	.36	

TABLE 4

Intercorrelations of index components and the subjective clinical score of severity.

INDEX	COMPONENT		1	2	3	4	5	6	7	8	9	10	11	12	13	14
INDEX OF MASSLER AND FRANKEL (1951)	OCCLUSAL SCORE	1		.28	.79	.45	.16	.16	.04	-.14	.03	.30	.12	-.02	.02	.28
	BUCCAL SCORE	2	.28		.40	.20	.17	.37	.25	.03	.15	.00	.52	.23	.13	.67
INDEX OF VAN KIRK AND PENNELL (1959)	ROTATION	3	.79	.40		.30	.25	.11	.15	-.06	.08	.25	.14	.08	-.01	.31
	DISPLACEMENT	4	.45	.20	.30		.28	.16	.16	.25	-.07	.19	.21	.10	.08	.43
INDEX OF HANDICAPPING LABIOLINGUAL DEVIATIONS (DRAKER, 1960)	LABIOLINGUAL SPREAD	5	.16	.17	.25	.28		.00	.20	.09	.06	.35	.10	.19	-.04	.49
	OVERJET	6	.16	.37	.11	.16	.00		.20	-.32	-.13	.13	.40	.22	.59	.33
	OVERBITE	7	.04	.25	.15	.16	.20	.20		.12	-.10	.04	.46	.85	.37	.24
	Md. PROTRUSION	8	-.14	.03	-.06	.25	.09	-.32	.12		-.03	-.11	-.04	.14	-.11	.35
OCCLUSION FEATURE INDEX (POULTON AND AARONSON, 1961)	OPENBITE	9	.03	.15	.08	-.07	.06	-.13	-.10	-.03		.02	-.01	-.15	-.28	.07
	LOWER ANT. CROWDING	10	.30	.00	.25	.19	.35	.13	.04	-.11	.02		-.06	-.05	-.02	.09
	CUSPAL INTERDIGN.	11	.12	.52	.14	.21	.10	.40	.46	.04	-.01	-.06		.50	.33	.44
	OVERBITE	12	-.02	.23	.08	.10	.19	.22	.85	.14	-.15	-.05	.50		.40	.22
	OVERJET	13	.02	.13	-.01	.08	-.04	.59	.37	-.11	-.28	-.02	.33	.40		.13
	SEVERITY	14	.28	.67	.31	.43	.49	.33	.24	.35	.07	.09	.44	.22	.13	

SUMMARY

Five indices of malocclusion and their components have been studied in relation to each other and to a subjective clinical assessment of severity by means of correlation coefficients. None of the indices was highly correlated with the subjective severity score. The latter appears to be the only practical basis of assessment at the present time, providing the assessment can be made consistently.

Correlation coefficients suggest that these indices do not contain sufficient information to enable them to be used reliably in determining the eligibility of the individual for orthodontic treatment.

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