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# METHODS OF ASSESSING AND GRADING MALOCCLUSION: A REVIEW

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**Methods of assessing and grading malocclusion are reviewed under the headings: Diagnostic, Epidemiological, Treatment need, Treatment success and Treatment complexity. Historic and current usage, together with an appraisal of some of their advantages and weaknesses, are presented. The multifactorial and multivariate nature of malocclusion makes any single classification not only difficult but also of limited value in dentofacial assessment. Angle's classification, which is widely used, was originally devised as a prescription for orthodontic treatment planning: not as an epidemiological tool. Many of the indices developed to assess treatment need may be criticised for lack of objectivity. Most of the current indices of treatment standards show low intra- and inter-examiner variability when compared with those used for diagnostic or epidemiological purposes. To date, no suitable index has been developed to measure treatment complexity.**

**Key words: Assessing, grading, malocclusion, review.**

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## Introduction

The development of a uniform method of epidemiological assessment and grading of malocclusion has been of interest for several decades. Due to the multiplicity of measurement methods and the difficulty in standardising criteria, Baume[1] expressed concerns about the lack of suitable methods of recording malocclusion. Jago[2], in a review of 45 studies of malocclusion in 18 countries, reported similar difficulties when comparing his findings. The inability to develop a universal occlusal index can be traced to an ever-increasing understanding of the multifactorial nature of malocclusion. McLain and Proffit[3] reported that occlusal problems cannot be judged solely in physical terms. The negative social stereotyping of malocclusion because of unacceptable dental aesthetics may exceed the biological problems.[4,5]

With increasing accountability of health care services, a reproducible and valid malocclusion index would be advantageous for service planning and evaluation. Shaw *et al.*[6] outlined the advantages of a standardised method of assessment which included uniformity in treatment prescription, safeguards for patients and the monitoring and promotion of standards.

In view of the increasing numbers of orthodontic indices gaining popularity in different parts of the world, this paper aims to provide a review of different methods of assessing and grading malocclusion and highlights some of their advantages and shortcomings. Indices are considered under five main headings; Diagnostic, Epidemiological, Treatment need, Treatment success and Treatment complexity.

## 1 Diagnostic classifications.

Diagnostic classifications are descriptive and enable malocclusion to be categorized. They tend to be qualitative rather than quantitative, which makes them of limited value as research tools.

The most widely used classification is that proposed by Angle[7]; it is based upon the positional relations of the first permanent molars and is known for its relative simplicity. Although it was originally devised as a prescription for orthodontic treatment planning and not as an epidemiological tool,[2,8] Angle's classification has been widely criticized. Criticisms have included: the lack of a quantitative meaning;[9,10] an inability to express other characteristics of malocclusion, particularly the relation of the teeth within the face;[11] and failure to express malocclusion in three dimensions.[12] In addition, Angle's classification ignores the dento-alveolar and skeletal contributions to malocclusion,[13,14] and has been shown to have poor intra- and inter-examiner reliability.[15,16] A number of modifications have been suggested, including the addition of the categories of 'normal occlusion'[17] and 'Class II uncertain'[15] together with the use of a premolar-derived classification.[18] Katz,[19] on the other hand, evaluated eight popular indices, including Angle's classification, in terms of their ability to measure the level of the patient's satisfaction with his or her oral self-image. He was surprised to find that Angle's classification demonstrated the strongest and the most consistent correlation with the patient's own satisfaction. Despite many criticisms, Angle's classification has proven to be the most widely used indicator of the prevalence of individual

malocclusion types in different populations.[20]

The incisor classification first described by Ballard and Wayman[21] is based on the positional relations of the incisor teeth: rather than the first molars. This avoids the problems associated with drifted molars in a crowded arch. It is mainly descriptive, although, probably more reliable than Angle's classification and has now become the British Standards Institute's[22] classification of malocclusion. Recently, Williams and Stephens[23] suggested that the classification be modified to include a 'Class II intermediate' group.

Ackerman and Proffit[14] proposed a system of classification based on a minimum of five characteristics which should be considered in a complete diagnostic evaluation. This approach was designed to overcome those major weaknesses of Angle's classification which failed to demonstrate the relation of tooth and jaw factors with facial appearance. The classification included an evaluation of facial proportions and aesthetics, alignment and symmetry within the dental arches and skeletal and dental relations in the transverse, anteroposterior and vertical planes of space. Using a modified Venn diagram and computer analysis, cases were classified into nine diagnostic categories. The relative complexity of this classification has limited its widespread application.

## 2 Epidemiological indices.

These indices are useful tools to determine the prevalence of occlusal anomalies in populations and are also valuable for research and manpower planning. The most important requirement of any index used in this way is that it is reliable (intra- and inter-examiner reproducibility).

The 'Dento-facial index' (DFI) was developed primarily as an epidemiological tool.[24,25] It measures the dentofacial morphology using facial landmarks and certain features of malocclusion. The facial orthometer, which is a dedicated instrument, was developed to facilitate measurement. This index has been found to be of greater value for anthropological studies than for epidemiological research.

An 'Index of Tooth Position' was proposed by Massler and Frankel[26] as a quantitative method of evaluating malocclusion in a large group for epidemiological purposes. The method of assessment was based on individual teeth as units of occlusion rather than on arch segments. Tooth displacement, rotation, infra-occlusion and supra-occlusion were recorded and the number of maloccluded teeth summed to give an overall measure of malocclusion. Unfortunately, it was not reliable because of the difficulties encountered in judging the conformity of each tooth to an ideal position in all planes of space. Furthermore, because each tooth was recorded as either 'maloccluded' or 'aligned', a mildly displaced tooth scored the same as a severely displaced tooth, thereby giving no indication of relative severity.

The 'Malalignment Index'[27] (MI) examined the arches in isolation, with each arch divided into three segments: two posterior and one anterior. For each tooth present, two malocclusion traits were considered: rotation and displacement. A score of '0' was awarded for ideal alignment, '1' for minor malalignment and '2' for major malalignment. The scores were then summed to give a full-mouth index. Unfortunately, this method of scoring did not reflect the true severity of malocclusion because no account was taken of the relation between upper and lower teeth in occlusion.

The 'Occlusal Feature Index'[28] (OFI) was developed to measure malocclusion in population studies. This index was based on four primary features of occlusion which were considered to be of importance in an orthodontic examination. These were: lower anterior crowding, cuspal interdigitation, vertical overbite and horizontal overjet. Scores were allocated for specific deviations from normal for each of these criteria and summed to give an overall index within the range 0-9; with zero denoting 'normal' occlusion. In a validation exercise the OFI was found to have reasonable inter-examiner reliability and good correlation with treatment need.

Björk *et al.*[29] introduced a system of registration of malocclusion for epidemiological purposes. This system used an objective registration procedure based on detailed definitions of recorded symptoms which makes it possible to analyse the data directly by computer. The registration was based on three main features: anomalies in the dentition, occlusion and deviation in space conditions. It also included a subjective assessment of treatment need. Unfortunately, the registration is rather complex and simplification of the examination procedure is necessary as the total number of recorded features on the score sheet is 567.

The 'FDI' system[30] was developed by a group assessing dento-facial anomalies for the FDI Commission on Classification and Statistics for Oral Conditions (COCSTOC), and was designed for the clinical examination of patients with a full complement of permanent teeth (excluding third molars). The system set out to measure and record, in a simple manner, three categories of occlusal features: dental, intra-arch and inter-arch relations. Designated traits were recorded using codings for aspects of malocclusion, together with the FDI system of tooth identification to localise individual tooth malrelations.

In 1981, Kinaan and Burke[31] proposed a simple, reproducible and quantitative method of assessing occlusion for epidemiological studies. Five main features of occlusion were considered: overjet, overbite, posterior crossbite, buccal segment crowding and incisor segment alignment. Each arch was divided into three segments: one anterior and two posterior, and was assessed in terms of alignment and inter-arch relations. Four instruments were developed to facilitate direct intra-oral measurement.

## 3 Indices of treatment need

Some indices has been developed in an attempt to categorize the treatment of malocclusion into groups according to urgency and need for treatment. These indices are valuable when allocating limited resources to priority groups or as guides in an orthodontic risk/benefit analysis.

The 'Handicapping Labio-lingual Deviation Index'[32] was proposed to complement ñ and perhaps as a substitute for ñ clinical judgment when screening subjects with handicapping anomalies. One advantage was that special equipment was unnecessary. The presence or absence of specified criteria was noted and scored. These criteria were: cleft palate, trauma-related malocclusions, overjet,

mandibular protrusion, open bite and labiolingual spread (severe displacement of teeth). The sum total derived from these scores permitted differentiation between handicapping and non-handicapping malocclusions.

The 'Treatment Priority Index' (TPI)[33] was designed to assess the severity of the most common types of malocclusion and to provide a mean for ranking individuals according to the severity of the malocclusion, degree of handicap or priority for treatment. This index defined seven natural groupings of manifestations of malocclusion which tended to occur jointly and which were referred to as 'syndromes'. Five grades of treatment need were developed based on ten interrelated features of occlusion as they occurred in 375 twelve-year-old children from three Ontario communities. An eleventh feature was included for gross dento-facial defect.

The 'Handicapping Malocclusion Assessment Record' (HMAR)[34] was endorsed and accepted as a standard by the Council of Orthodontic Health Care, the Board of Directors of the American Association of Orthodontics and by the Council of Dental Health of the American Dental Association. Assessment can be made from study casts, although an additional oral supplementary record permits recording and scoring during clinical examination. One advantage of the HMAR system is the ability to record treatment need without the need for a millimetre gauge, thereby reducing the likelihood of clerical errors.

'Summers' Occlusal Index' (SOI)[35] scored nine characteristics at different stages of dental development. Two divisions and seven syndromes can be described using the Occlusal Index; which also ascribes five subjective classifications of occlusion to its scores. Time has shown the Occlusal Index to be valid[20] and it has been used by a number of investigators[10,36-39] to assess orthodontic treatment outcomes. Unfortunately, the Occlusal Index is time-consuming and cumbersome to use, involving a long, complex procedure of scoring, thereby making research and audit difficult. So and Tang[40] criticized the Occlusal Index for failing to score missing teeth, other than upper incisors, where pre-restorative orthodontics or orthodontic space closure might be needed, suggesting that this tended to underestimate treatment need. The index also penalises cases with a full unit pre-or post-normal molar relation - the presence of which may still be compatible with static and functional occlusion.[10] In a field study, the Occlusal Index may be difficult to compute because it is expressed as a decimal which is more difficult to work with than are integral values.[41] Despite the criticisms of the Occlusal Index, it has been shown to be one of the most reliable and valid indices of treatment need.[41-43]

Freer and co-workers[9,44,45] attempted to develop a system using a similarity analysis technique, whereby a population was divided into groups containing similar malocclusions. Several multivariate techniques were used with 40 attributes measured for individuals whose occlusions varied from 'near perfect' to 'extreme malocclusion'.

In Sweden, a system was devised by the Swedish Dental Society and the Swedish Medical Board[46] for prescription of orthodontic treatment needs. The system concentrated on dental health impairment and gave subjective guidelines for measurement of aesthetic impairment. The criteria for assessment were not well defined. Further criteria were added by Ingervall and Ronnerman[47] who incorporated a morphological index and a functional index.

In 1990, the 'Norwegian Index' (NI) was introduced as a guide for the allocation of refunds of treatment costs by the National Health Insurance System.[48] This index was based on morphological and functional measurements and comprised four categories of treatment-need varying from 'very great need' to 'little or no need'.

In the United Kingdom, an 'Index of Orthodontic Treatment Need' (IOTN)[49] was developed in an attempt to rank malocclusion based on the significance of various occlusal traits for dental health and aesthetic impairment, with the intention of identifying those who would be most likely to benefit from orthodontic treatment. This index incorporated a Dental Health Component (DHC) based on the Index of the Swedish Medical Board and an Aesthetic Component (AC) developed by Evans and Shaw.[50] The DHC comprises five grades which have been combined into three categories: Grades 1 and 2 represent 'No need for treatment'; Grade 3, 'Borderline need for treatment'; and Grades 4 and 5 which represent 'Need for treatment'.[51] The AC was developed from a standardized continuum of aesthetic need and comprises a scale of ten anterior intra-oral photographs showing different levels of dental attractiveness: photographs 1-4 represent 'No need for treatment'; 5-7, 'Borderline need for treatment'; and 8-10 represent 'Need for treatment'. One shortcoming of the aesthetic scale is the poor ability to represent dento-facial imbalance in the antero-posterior plane.[50] Although IOTN was developed for treatment prioritization, before and after treatment scores may be compared as a somewhat crude assessment of outcome.

Since the most common motive for seeking orthodontic treatment is dissatisfaction with the appearance of the teeth, a number of attempts have been made to measure aesthetic handicap objectively.[50,52-54] One such attempt resulted in the development of the 'Dental Aesthetic Index' (DAI) which is now widely used. In this index the assessment of need for orthodontic treatment is based on an evaluation of aesthetic factors and, therefore, psychosocial handicap.[54] The index has been used as an epidemiological tool to identify orthodontic treatment need in a number of populations.[55,56] Recently, the DAI was integrated into the items of the International Collaboration Study of Oral health Outcomes (ICS II) by the World Health Organisation.[57] Although DAI identifies ten morphological features which constitute aesthetic impairment, it is limited by its failure to assess features which constitute aesthetic impairment like: dental midline discrepancy, traumatic deep overbite, buccal cross-bite and open-bite which, although of limited aesthetic importance, can, undoubtedly, affect the need for orthodontic treatment. The inability to assess treatment need during the mixed dentition stage may further limit its use.

Another commonly used aesthetic index is the 'Standardized Continuum of Aesthetic Need' (SCAN) which was based on the perception of dental aesthetics in the United Kingdom.[50]

Individual dental occlusion is matched for overall dental attractiveness against ten scaled photographs: from 1 (attractive) to 10 (unattractive). In the UK SCAN has been found to be of value in the state-funded hospital service to assess treatment priority.[58] The SCAN index is easy to use with a high level of reliability even when used by non-dental personnel;[50] however, it may be criticized for providing only a two-dimensional guide and an insufficiently extensive spectrum of dental aesthetics. Phillips *et al.*[59] have shown that, on a set of photographs, the perception of dental attractiveness is often affected by the photographic view. In recent studies both the DAI and the SCAN Index have been used to assess treatment outcome[60-62] although they were not developed specifically for such use.

In general, aesthetic handicap is difficult to measure and there seems to be diverse professional and public opinion about the need for orthodontic treatment based on dental appearance. Lay judges seem to be more sensitive than orthodontists to dental aesthetic impairment. It has been suggested that, orthodontists may respond strongly to the physical or functional characteristics of malocclusion; which may influence their judgment of dental aesthetics. This difference has been attributed to training: orthodontists may become less critical in their perception of attractiveness because of the frequency with which they see patients with extreme facial handicaps; on the other hand, they may be more critical in their assessment of treatment need because of their increased knowledge of occlusion and their experience with likely treatment outcomes.[63]

## 4 Indices of Treatment Success.

Orthodontic treatment outcomes are variable, with opinion differing as to what constitutes a good functional and aesthetic result. Various indices have been developed to critically and objectively assess treatment standards.

Eismann[64] described a method of evaluating the efficiency of orthodontic treatment based on fifteen morphological criteria. Points were scored for each condition registered with severe conditions scoring more points. The points scored for each of the criteria were summed to give a total indicating the extent of the morphological abnormality. Unfortunately, the method has been criticised because of the subjective nature of allocation of points.

Gottlieb[65] developed a method of grading orthodontic treatment results based on ten accepted criteria for orthodontic correction. A 'percentage achievement' was obtained which related to the factors requiring correction at the commencement of treatment. This method of grading was biased towards improvement because five points were allotted for full correction of a feature but only a single point was deducted for a worsening of the condition.

Berg[66] produced a method of assessing treatment success based on defined skeletal and dental outcome criteria which included: sagittal, vertical and transverse occlusion, alignment, axial inclination and apical resorption. Cases fulfilling the stated criteria were graded as 'A-cases'; those that did not fulfil the requirements were denoted as 'B-cases'. Although rather crude, one of the strengths of this assessment was the attempt to incorporate iatrogenic tooth damage into an index of treatment outcome.

The 'PAR Index' (Peer Assessment Rating) was developed in the United Kingdom to record malocclusion at any stage of treatment.[67-69] This method was based on defined features of the occlusion: upper and lower anterior contact point displacement, right and left buccal occlusion in three planes of space, overjet, overbite and dental centreline relation. It provides an initial estimate of how far a case deviates from normal, and the difference between scores before and after treatment reflecting the degree of improvement; thereby providing a quantitative and reproducible measure of the success of treatment. Improvement can be expressed either: as a 'percentage improvement'; or by use of a nomogram. The percentage PAR score change appears to be more useful and reliable in this respect.[70] In order to accurately reflect contemporary opinion, the PAR Index has been validated and weighted by a panel of 74 dentists. The Index has recently been adopted as a method of internal and regional audit of treated cases.[60,61,70-72] Recent studies[71,72] reported that the PAR Index, although reproducible, demonstrated a number of shortcomings, particularly in failing to consider the axial inclination of anterior teeth at the end of treatment. In common with other indices of treatment outcome, the PAR Index only measures static tooth position, ignoring dynamic occlusion, facial aesthetics and iatrogenic decalcification, root resorption and periodontal breakdown all of which undoubtedly contribute to the quality of treatment outcome. However, one advantage of the PAR Index is that it can easily be used with a high level of reliability by non-dental personnel; this is not only economical of clinical time, but also it could make the application of the PAR to clinical audit even more objective and impartial[73] than other indices.

## 5 Indices of treatment complexity.

In a study of changes in the complexity of orthodontic treatment prescribed for patients seen between 1977 and 1985 at a UK dental teaching hospital, Stephens and Harradine[74] reported that, although there were no changes found in the relative numbers of simple and complex malocclusions referred during the eight-year period, the proportion of patients receiving complex treatment had increased greatly. To date, no specific index has been developed to measure treatment complexity, although such an index would be useful in objectively setting fee levels, particularly in a State-funded structure. O'Brien[75] suggested that orthodontists' opinions of perceived treatment complexity were closely related to the severity of a malocclusion as measured by the PAR Index.

## Validity, reliability and weighting of indices

The primary objective of the validation of indices is to compare a definite measure of malocclusion with mean subjective dental opinion in terms of deviation from normal for a representative sample. At present, few of the developed indices have been evaluated in this manner. The use of clinicians' opinions in evaluating occlusal indices has been criticised by Carlos[76] and Buchanan[77] who felt that the judgment of the clinician is not independent of the index being evaluated; and that the subjective clinical judgment of a handicapping malocclusion, upon which many indices

are based, has not been shown to have any validity. This view was similarly expressed by Jarvinen and Vaataja,[78] who were of the opinion that all indices of need for treatment could be regarded as more or less arbitrary calculations because knowledge of the consequences of untreated malocclusion remains inadequate.

Many indices are weighted, using mathematical models on the basis of clinical experience such that certain features are given a greater priority, thereby reflecting their relative importance. In this way, an index may be given an element of flexibility with changes in weightings reflecting changes in contemporary clinical opinion. Foster and Menezes[79] criticized the inclusion of weightings, suggesting that they were based upon a subjective assessment that certain types of deviation warranted treatment more than the others.

## Conclusions

A wide range of orthodontic indices has been developed for different purposes. Indices may be valuable in diagnostic assessment, epidemiological studies and the assessment of treatment need, outcome and complexity. Draker[32] wrote that an 'ideal' index should be quick, simple, accurate, reliable and reproducible; that it should be objective and yield quantitative data for analysis; that it should be able to differentiate between handicapping and non-handicapping malocclusions; and that it should be able to measure degrees of handicap.

Unfortunately, no index is currently available which fulfils all these criteria. Simple diagnostic indices do not satisfy the detailed requirements of an epidemiological index. Similarly, extensive and detailed epidemiological indices are too complex and time-consuming to be useful diagnostic tools. Although indices of treatment need may objectively assess variation from an accepted occlusal norm, the impact of anatomical severity of malocclusion may not be directly proportional to the psychosocial distress of patients. Further difficulties arise from the problems faced in assessing biological validity in terms of the potential damage that the patient might be expected to suffer if the malocclusion were not treated.

In spite of these shortcomings, occlusal indices are valuable tools in the hands of orthodontists, public health administrators and epidemiologists. Angle's classification remains the most widely used diagnostic classification worldwide, despite its many critics. Summer's Occlusal Index continues to be used extensively to determine orthodontic treatment need, although the Index of Orthodontic Treatment Need (IOTN) is gaining popularity in Europe. The Peer Assessment Rating (PAR Index) has much to commend it as a measure of treatment outcome and is becoming accepted as a research and audit tool. At present, no index of treatment complexity is in existence, and this area remains open for future research; particularly where state-funding is to be directed towards greatest need but with a fee structure related to both severity of malocclusion and therapeutic complexity.

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