9

An Overview of Selected Orthodontic Treatment Need Indices[1]

Ali Borzabadi-Farahani
Craniofacial Orthodontics, Children's Hospital Los Angeles, University of Southern California, Los Angeles, CA USA

1. Introduction

Dentistry is unique in utilizing objective indices to measure the deviation of oral health components from ideal. Examples include various plaque, caries experience, tooth wear and periodontal indices (Quigley & Hein, 1962; Silness & Löe, 1964; Acharya, 2006; Hooper et al., 2004; Ainamo et al., 1982; Croxson, 1984). However, objective assessment of malocclusion has been different since malocclusion is a developmental condition and deviation from normal. Malocclusion is not an acute condition, and therefore, treatment of malocclusion has been associated with a great degree of subjectivity and distorted perceptions of treatment need. The main traditional reasons to justify providing orthodontic treatment are (I) improvement in the functioning of the dentition, (II) improvement in oral or dental health and (III) improvement in facial or dental aesthetic. In the era of evidence-based orthodontics; however, it is hard to justify the treatment based on improvement in oral or dental health for the majority of orthodontic patients (Burden, 2007; Bollen, 2008). Occlusal indices were used initially as epidemiological tools to rank or classify the occlusion. A large number of occlusal indices started to appear in the 1950s and 1960s to assist epidemiological studies. The orthodontic treatment need index is a form of occlusal index used to prioritize the need for treatment. Their use minimizes the subjectivity related to the diagnosis, outcome and complexity assessment of orthodontic treatment.

A well-developed occlusal index should be reliable (indicate reproducibility) and valid. Validity means whether an index measures what it claims to measure (e.g. determination of treatment need) (Carlos, 1970). Indices should be able to identify people not needing treatment (specificity) and those in need of treatment (sensitivity). An index should be quick and easy to use, acceptable to cultural norms, and finally be adaptable to available resources. Dr William Shaw and co-workers divided occlusal indices into five different categories (Shaw et al., 1995). These are the diagnostic, epidemiologic, orthodontic treatment need, treatment outcome, and Orthodontic treatment complexity indices (Table 1).

The purpose of this chapter is to provide an overview on the most commonly used American and European orthodontic treatment need indices. The modifications, advantages, and limitations of these orthodontic treatment need indices are discussed briefly.

[1] This chapter is the longer and more detailed version of an article that has previously been published in a peer-reviewed journal: Borzabadi-Farahani A. An insight into four orthodontic treatment need indices, Progress in Orthodontics, 2011;12(2):132-142.

Occlusal indices	
Diagnostic indices	Angle classification system (Angle, 1899) Incisal categories of Ballard and Wayman (Ballard & Wayman, 1964) Five-point system of Ackerman and Proffit (Ackerman & Proffit, 1969)
Epidemiologic indices	Index of Tooth Position (Massler & Frankel, 1951) Mal-alignment Index (Van Kirk & Pennel, 1959) Occlusal Feature Index (Poulton & Aaronson, 1961) The Bjork method (Bjork et al., 1964) Summer's occlusal index (Summers, 1971) The FDI method (Baume et al., 1973) Little's irregularity index (Little, 1975)
Orthodontic treatment need indices	Handicapping Labio-lingual Deviation Index (HLD) (Draker, 1960, 1967) Swedish Medical Board Index (SMBI) (Swedish Medical Health Board, 1966; Linder-Aronson, 1974, 1976). Dental Aesthetic index (DAI) (Cons et al., 1986) Index of Orthodontic Treatment Need (IOTN) (Brook & Shaw, 1989) Index of Complexity, Outcome and Need (ICON) (Daniels & Richmond, 2000)
Orthodontic treatment outcome indices	Peer Assessment Rating index (PAR) (Richmond et al., 1992a) ICON
Orthodontic treatment complexity indices	Index of Orthodontic Treatment Complexity (IOTC) (Llewellyn et al., 2007) ICON

Table 1. Different types of occlusal indices.

2. Orthodontic treatment need indices

These types of occlusal indices categorize the malocclusion based on treatment need. It is estimated that at least one-third of the population has a clear need for orthodontic treatment (Richmond et al., 1992b); however, this estimation varies depending on the population and/or the perception of need in that population. An orthodontic treatment need index identifies patients in need of orthodontic treatment and prioritizes their treatment needs (Carlos, 1970; Tang & Wei, 1993). There is usually a cut-off point for each index and the lowest index score that allows treatment determines the cut-off point. Exploring the ideas and conventions that made up the ranking systems and cut-off points for orthodontic treatment need indices is beyond the scopes of this chapter, but briefly, this was the opinion of experts in the field, the orthodontists, that initially determined the cut-off points (Järvinen, 2001). These cut-off points are adjustable depending on available resources and the perception of need in the country which index is used. Clearly, the perception of treatment need can be different among various cultures, and that is why index validation in different countries is advisable. Orthodontic treatment need indices have been used to plan the provision of orthodontic treatment in the Northern Europe. In these countries, government subsidizes the dental health services either as part of the National Health

Service or national health insurance. Some authors also used these indices to determine the prevalence and severity of malocclusions in epidemiological studies.

Several orthodontic treatment need indices have been introduced to quantify the malocclusion. Examples can include, but not limited to, the Salzmann's Handicapping Malocclusion Assessment Record (Salzmann, 1968), the Draker's HLD index (Draker, 1960, 1967) and its modifications [HLD (CalMod) (Parker, 1998), HLD (Md) (Code of Maryland Regulations, 1982; Han & Davidson, 2001), and the Washington modification (Theis et al., 2005)], the Orthodontic Treatment Priority Index (Grainger, 1961), the Summer's occlusal index (Summers, 1971), the Swedish national board for health and welfare index or 'the Swedish Medical Board Index (SMBI)' (Swedish Medical Health Board, 1966; Linder-Aronson, 1974, 1976), the Indication Index (Lundstrom, 1977), the DAI (Cons et al., 1986), the Norwegian index of orthodontic treatment need (Espeland et al., 1992), the SCAN index (the Standardized Continuum of Aesthetic Need) (Evans & Shaw, 1987), the IOTN (Brook & Shaw, 1989), and the ICON (Daniels & Richmond, 2000). Some orthodontic treatment need indices are non-parametric, such as the first version of the SMBI (Linder-Aronson, 1974) and the Norwegian index of orthodontic treatment need (Espeland et al., 1992). For instance, the Norwegian index of orthodontic treatment need and the first version of the SMBI use 4 categories of need: very great, great, obvious, and little/no need. Alternatively, there are other indices that employ scales to rate malocclusion such as, the DAI (Cons et al., 1986) and the ICON (Daniels & Richmond, 2000).

The scoring or rating system that indices employ reflects the opinion of index developer (s) about the health risks (e.g. dental or physiological) of malocclusion and the potential benefits of orthodontic treatment (Burden, 2007). These indices consider the psycho-social gain and oral health-related benefits of orthodontic treatment. However, based on the existing research evidence there is only a weak association between occlusal abnormalities and dental health (Burden, 2007). With the exception of severe conditions, such as cleft lip and palate, the contemporary orthodontics does not claim to prevent caries, periodontal disease, and temporo-mandibular dysfunction (Burden, 2007; Bollen, 2008). This is perhaps a reason for general agreement among orthodontists that orthodontic treatment indices cannot be completely validated (SBU, 2005; Mockbil & Huggare, 2009). The American Association of Orthodontists (AAO) does not recognize any index as a scientifically valid measure of need for orthodontic treatment (AAO, 2001). The use of orthodontic treatment need indices reduces the subjectivity associated with orthodontic diagnosis and assessments (Richmond & Daniels, 1998a), and despite the lack of evidence and clinical trials to support the ranking systems in orthodontic treatment need indices, they are widely used in the Northern Europe and are part of the daily practice in some countries such as the United Kingdom (Shaw et al., 1995). In the United States public health planners in 15 states have adopted several orthodontic treatment need indices with cut-off points to determine eligibility for orthodontic treatment with state funds (Younis et al., 1997). However, because of the AAO view on orthodontic indices (AAO, 2001), the use of occlusal indices in the United States is not encouraged and is limited (Han & Davidson, 2001).

3. The Swedish Medical Board Index (SMBI) and the Index of Orthodontic Treatment Need (IOTN)

The SMBI and the IOTN have some similarities. Peter Brook and William Shaw developed the IOTN and initially called it the Index of Orthodontic Treatment Priority (Brook & Shaw,

1989). Later, it was renamed to the Index of Orthodontic Treatment Need (IOTN). The IOTN is one of the most commonly used occlusal indices that assesses the orthodontic treatment need among children and adults. The IOTN has two separate components, a clinical component called the Dental Health Component (DHC) and an Aesthetic Component (AC). There was no attempt to combine these two components and both are recorded separately (Brook & Shaw, 1989). The DHC of IOTN is similar to an index used by the Swedish Medical Health Board 'the Swedish Medical Board Index (SMBI) ' (Swedish Medical Health Board, 1966; Linder-Aronson, 1974, 1976). The original form of this Swedish index was developed having 4 categories of need (grade 1 to 4). Later on, Linder-Aronson and co-workers (1976) revised the index and added a fifth category, the grade zero, describing subjects with no need for treatment (Table 2). This revised SMBI index is very similar to the DHC of IOTN; however, the DHC in IOTN is graded from 1 to 5. The SMBI calls for the subjective views and patient's wishes to be considered when deciding on the treatment need (Mockbil & Huggare, 2009). It has been suggested the arbitrary grading system in the SMBI leads to low level of reproducibility, particularly when the index is used by non-professionals (Danyluk, 1998).

Grade		
4	Very urgent need	Aesthetically and/or functionally handicapping anomalies, such as deft lip and palate, extreme post-normal or pre-normal occlusion, retained upper incisors, extensive aplasia.
3	Urgent need	Pre-normal forced bite, deep bite with gingival irritation not only on papilla incisiva, large overjet with lower lip behind upper centrals, extremely open bite, crossbite causing transverse forced bite, scissors bite interfering with articulation, severe frontal crowding or spacing, retained canines, aesthetically and/or functionally disturbing rotations.
2	Moderate need	Aesthetically and/or functionally disturbing proclined or retroclined incisors, deep bite with gingival contact but without gingival irritation, severe crowding or spacing, infra-occlusion of deciduous molars and permanent teeth, moderate frontal rotations.
1	Little need	Mild deviations from normal (ideal) occlusion, such as pre-normal occlusion with little negative overjet, post-normal occlusion without other anomalies, deep bite without gingival contact, open bite with little frontal opening, crossbite without a forced bite, mild crowding or spacing, mild rotations of only little aesthetic and/or functional significance.
0	No need	Normal (ideal) occlusion without deviations.

Table 2. The modified 5-grade index (ISMHB) for orthodontic treatment need (Swedish Medical Health Board, 1966; Linder-Aronson, 1974, 1976).

As it can be seen in Table 3, the DHC has five grades ranging from grade one, 'no need', to grade five, 'very great need'. A grade is allocated according to the severity of the worst single occlusal trait and describes the priority for treatment. In recording the worst trait following hierarchical scale is used (in a descending order), Missing teeth, Overjet, Crossbites, Displacement of contact points, and **O**verbite (including open bite). To remember the hierarchical scale, the acronym of 'MOCDO' can be constructed and used

Grade 5	**Very great need**
5i	Impeded eruption of teeth (with the exception of third molars) due to crowding, displacement, the presence of supernumerary teeth, retained deciduous teeth and any pathological cause.
5h	Extensive hypodontia with restorative implications (more than one tooth missing in any quadrant) requiring pre-restorative orthodontics.
5a	Increased overjet > 9 mm.
5m	Reverse overjet greater than 3.5 mm with reported masticatory and speech difficulties.
5p	Defect of cleft lip and palate/craniofacial anomalies.
5s	Submerged deciduous teeth.
Grade 4	Great need
4h	Less extensive hypodontia requiring pre-restorative orthodontics or orthodontic space closure to obviate the need for a prosthesis.
4a	Increased overjet > 6 mm but ≤ 9 mm.
4b	Reverse overjet > 3.5 mm with no masticatory or speech difficulties.
4m	Reverse overjet greater than 1 mm but ≤ 3.5 mm with recorded masticatory and speech difficulties.
4c	Anterior or posterior crossbites with > 2 mm discrepancy between retruded contact position and intercuspal position.
4l	Posterior lingual crossbite (scissors bite) with no functional occlusal contact in one or both buccal segments.
4d	Severe contact point displacements of teeth > 4 mm.
4e	Extreme lateral or anterior open bites > 4 mm.
4f	Increased and complete overbite with gingival or palatal trauma.
4t	Partially erupted teeth, tipped and impacted against adjacent teeth.
4x	Presence of supernumerary (e.g. Supplemental teeth).
Grade 3	Borderline need
3a	Increased overjet > 3.5 mm but ≤ 6 mm with incompetent lips.
3b	Reverse overjet greater than 1 mm but ≤ 3.5 mm.
3c	Anterior or posterior crossbites with >1 mm but ≤ 2 mm discrepancy between retruded contact position and intercuspal position.
3d	Contact point displacement of teeth > 2 mm but ≤ 4 mm.
3e	Lateral or anterior open bite greater than 2 mm but ≤ 4 mm.
3f	Increased and complete overbite without gingival or palatal trauma.
Grade 2	Little need
2a	Increased overjet > 3.5 mm ≤ 6mm with competent lips.
2b	Reverse overjet > 0 mm but ≤ 1mm.
2c	Anterior or posterior crossbite with ≤ 1 mm discrepancy between retruded contact position and intercuspal position.
2d	Contact point displacement of teeth >1 mm but ≤ 2 mm.
2e	Anterior or posterior open bite > 1 mm but ≤ 2mm.
2f	Increased overbite ≥ 3.5 mm without gingival contact.
2g	Pre-normal or post-normal occlusions with no other anomalies. Includes up to half a unit discrepancy.
Grade 1	No need, Extremely minor malocclusions including displacements ≤ 1 mm.

Table 3. Dental Health Components of the IOTN (Brook & Shaw,1989)

(Richmond et al., 1992b). For instance, if two or more occlusal anomalies achieve the same DHC grade, the hierarchical scale is used to determine which dental anomaly should be recorded (i.e. dental anomaly with higher rank in the hierarchical scale is recorded). In recording the DHC, only in recording the DHC only the worst occlusal feature/anomaly is recorded.

The Aesthetic Component (AC) consists of a 10-point scale illustrated by a series of photographs that were rated for attractiveness by a panel of lay judges and were selected as being equidistantly spaced through the range of grades (Evans & Shaw, 1987). The AC, as Figure 1 shows, is based on the SCAN scale (Evans & Shaw, 1987). The SCAN scale, as described by Ruth Evans and William Shaw (Evans & Shaw, 1987), is arranged from the least to the most attractive dentition, while the AC scale is arranged from the most to the least attractive. The photographs for this study were taken from 12-year-olds during a large multi-disciplinary survey (Evans & Shaw, 1987). Orthodontists rarely use the SCAN scale nowadays. The recording of the IOTN components should take between 1 to 3 minutes (Shaw et al., 1995). The DHC and AC can be applied clinically and on study casts (Richmond et al., 1992b). Without clinical information, *the dental cast protocol* is used when recording the DHC on study casts (Richmond et al., 1992b). This protocol always assumes the worst case scenario. For instance, if crossbite is present on study cast, the protocol assumes that a discrepancy between retruded contact position and the intercuspal position of more than 2 mm is present, and therefore, the DHC recording will be 4a. The details and conventions for the IOTN can be found in the literature (Richmond et al., 1992b).

The validity and reliability of the IOTN have been verified previously (Richmond et al., 1993; Burden & Holmes 1994; Burden et al., 1994). In order to assess the validity of the Aesthetic Component of IOTN, a validation exercise involving 74 dentists (44 orthodontist and 30 non-orthodontist) was carried out (Richmond, 1990). This was aimed at determining cut-off points that represent different levels of orthodontic treatment need. A scale of 10 colour photographs showing different levels of dental attractiveness was used, grade 1 representing the most attractive and grade 10 the least attractive dentitions. The validation panel judged grades 1-4 to represent 'no or little need', grades 5, 6, and 7 as 'borderline need', and grades 8, 9, and 10 to represent a clear need for treatment on aesthetic grounds. However, different cut-off points and major changes in the Aesthetic and Dental Health Components of the IOTN has been suggested (Lunn et al., 1993; Beglin et al., 2001). An improved reliability has been reported for the IOTN if both Dental Health and Aesthetic Components were reduced to three grades (Lunn et al., 1993). In an interesting study, Beglin and co-workers (Beglin et al., 2001) assessed the validity of DHC and the AC of the IOTN by a group of American orthodontists and suggested the optimized cut-off points of 3 and 5, respectively.

Sometimes, there is a discrepancy between the DHC and AC grades and they can be contradictory. Some occlusal anomalies such as ectopic teeth, hypodontia, deep traumatic overbites or crossbites have dental health implications; however, they do not necessarily attract a high Aesthetic Component grade. When using AC, the use of frontal photographs of dentition limits overjet and lip-incisor evaluations (Fields et al., 1982). A recent study showed there is only a moderate diagnostic agreement between AC and DHC (Borzabadi-Farahani & Borzabadi-Farahani, 2011a). This difference between the DHC and AC reflects that AC assesses the aesthetic aspects of the malocclusion, only in frontal view, and highlights the subjective nature of it. Therefore, any clinician who is interested in using the IOTN should receive proper training and undergoes the calibration process (Richmond et al., 1995).

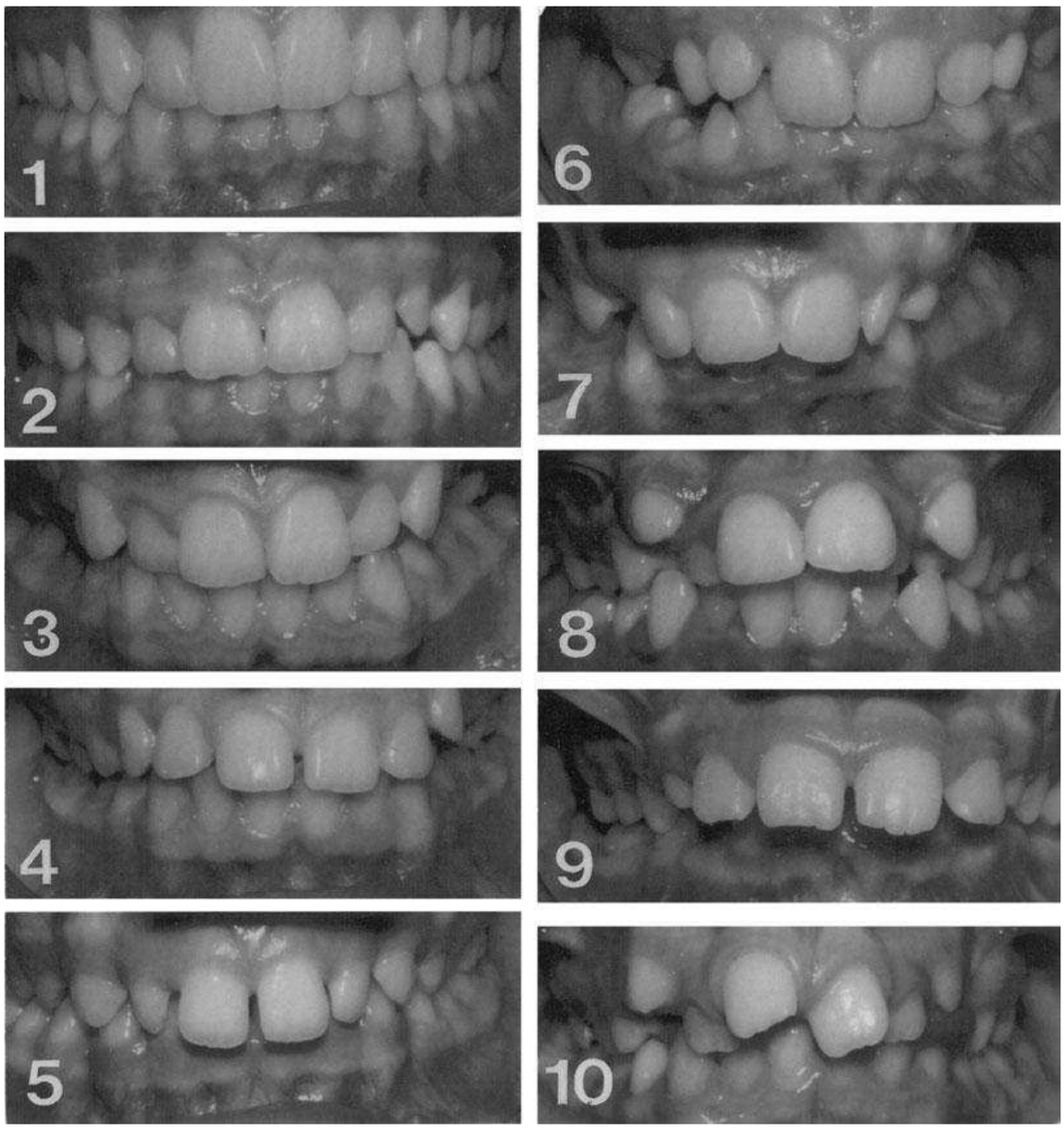


Fig. 1. The Aesthetic Component of the IOTN. The Aesthetic Component was originally described as "SCAN", Evans R and Shaw WC (1987). A preliminary evaluation of an illustrated scale for rating dental attractiveness European Journal of Orthodontics 9:314-18. By kind permission of Oxford University Press.

4. The modified IOTN

The modified IOTN is a two-grade scale (need/no definite need), instead of 5 grade scale with 30 sub-categories. The modified IOTN is based on idea that the IOTN is not an index to measure the complexity; and therefore, there is no benefit in recording the occlusal anomaly that placed the child in treatment need category (Burden et al., 2001. The modified IOTN simplifies identifying people in need of treatment and improves the reliability and validity of the index (Burden et al., 2001). By using the modified IOTN, every case with IOTN DHC ≥ 4 and/or IOTN AC ≥ 8 is classified as being in need of treatment. Since its introduction, few epidemiological studies used the modified IOTN (Chestnutt et al., 2006; Puertes-Fernandez et al., 2010). Briefly by using the modified IOTN, the index has been simplified to two categories: Definite Need for Treatment and No Definite Need for Treatment.

5. Dental Aesthetic Index (DAI)

The Dental Aesthetic Index (DAI) (Cons et al., 1986) looks into the aesthetic aspects of occlusion. The DAI links clinical and aesthetic components, mathematically, to produce a single score. This score reflects the malocclusion severity (Cons et al., 1986). By using cut-off points, index was subsequently used to determine the need for orthodontic treatment. The DAI is based on a social acceptability scale of occlusal conditions (Jenny et al, 1980). Dr. Naham C. Cons, a public health dentist, and co-workers used the opinions of the lay public to find out what constituted unacceptable dental arrangements from the aesthetic standpoint (Cons et al., 1986). Contrary to the European indices such as IOTN (Brook & Shaw, 1989), the DAI reflects the North American culture, aesthetic, and psychosocial values. The DAI highlights the importance of physical attractiveness and by considering societally defined norms for dental appearance, it recognizes conditions that are potentially psycho-socially handicapping.

The regression procedures used a sample of 200 photographs of occlusal configurations during development of DAI. These were selected by a disproportionate, stratified, random sampling procedure. This sample was selected from a larger sample of 1337 study models (collected from high school students in the New York state, with age range of 15 -18 years) (Ast et al., 1965; Cons et al., 1978). The regression procedures provided the statistical basis for regression coefficient weightings to be used against the 10 occlusal traits chosen by regression procedures (Proshek et al., 1979) (Table 4). The DAI used a regression equation that called for the measured components of DAI to be multiplied by their regression coefficients (weights), addition of their products and a constant number (n=13) to the total. The resulting sum was the DAI score. The World Health Organization Oral Health Survey Methods recognized the DAI as a cross-cultural index (1997). Table 4 shows the DAI components and the adopted weights. The DAI was designed to be used in permanent dentition and a modified version of the index has been suggested for the mixed dentition (Johnson et al, 2000). Nonetheless, the DAI index has also been used in the mixed dentition (Johnson & Harkness, 2000). The study by Keay and co-workers (Keay et al., 1993) revealed performance of the DAI in the mixed dentition group was slightly lower than the permanent dentition group. A longitudinal study of 150 children in New Zealand also revealed a fall in orthodontic treatment need which was attributed to over-sensitivity of Index in the mixed dentition period (Chi et al., 2000).

Several studies showed the DAI is a valid (Beglin et al., 2001; Spencer et al., 1992; Jenny et al., 1993; Jenny & Cons, 1996a) and reliable index (Jenny et al., 1993). An advantage of the

DAI is the use of threshold scores (i.e. 31 or higher) to equate with the need for orthodontic services. This threshold limits changes based on available resources and funding. Different cut-off points for the DAI have been proposed to prioritize orthodontic care needs. Jenny and co-workers (Jenny et al., 1993) initially suggested cut-off point of 36 to identify handicapping malocclusions. However, they later proposed a cut-off point of 31 to determine the number of individuals who require treatment (Jenny & Cons, 1996b). Similarly, Keay and Freer (Keay & Freer, 1993; Bernabé et al., 2006) and Beglin and co-workers (Beglin et al., 2001; Bernabé et al., 2006) suggested revised cut-off points of 32.5 and 28, respectively. Table 5 shows the current treatment need categories used for the DAI.

DAI	Component	Calculated weights	Rounded weights
1	No. of visibly missing teeth: incisors, canines, and premolars in the maxillary and mandibular arches	5.76	6
2	Assessment of incisal segment crowding (0,1, or 2): 0= no segment crowded; 1=1 segment crowded; 2=2 segments crowded	1.15	1
3	Assessment of incisal segment spacing (0,1, or 2): 0=no segment spaced; 1=1 segment spaced; 2=2 segments spaced	1.31	1
4	Diastema (mm) $	3.13	3
5	Largest anterior maxillary irregularity (mm) *	1.34	1
6	Largest anterior mandibular irregularity (mm) *	0.75	1
7	Anterior maxillary overjet (mm) ^	1.62	2
8	Anterior mandibular overjet (mm) ^	3.68	4
9	Vertical anterior open bite (mm) ^	3.69	4
10	Assessment of antero-posterior molar relation: largest deviation from normal either left or right: 0= normal; 1= ½ cusp either mesial or distal; 2= full cusp or more either mesial or distal ^	2.69	3
11	Constant	13.36	13
	Total	DAI Score	

$ Largest measurement
* Site of greatest rotations or displacement from normal arch alignment
^ Measured with teeth in centric occlusion

Table 4. DAI components, their calculated, and final rounded weights

DAI score	Malocclusion severity	Treatment need category
=< 25	Normal / minor	No treatment need / slight need
26-30	Definite	Treatment elective
31-35	Severe	Treatment highly desirable
>= 36	Very severe / handicapping	Treatment mandatory

Table 5. The DAI treatment need categories

There are possible limitations with using the DAI. The lack of assessment of occlusal anomalies such as buccal crossbite, impacted teeth, centre-line discrepancy, and deep overbite weakens the index (Otuyemi & Noar 1996a, 1996b; Danyluk et al., 1999). The DAI also does not account for missing molars. Although deviations for crowding and spacing components are scored as present or absent, there is no distinction between varying degrees of arch length discrepancy. These limitations should be considered when using the DAI for epidemiological studies or in studies assessing relationship between malocclusion and other variables. There are inherent differences between the DAI and other orthodontic treatment need indices. For instance, the DAI and the modified IOTN (Burden et al., 2001) showed only a moderate agreement in estimating the treatment need (Kappa statistics=0.47) (Manzanera et al., 2010). Correspondingly, the observed percentage agreement between them was 83 percent, showing a difference of 17 percent in treatment need estimates of these indices (Manzanera et al., 2010). This highlights the different mechanisms these indices use to rank the malocclusion.

6. Handicapping Labio-lingual Deviation index (HLD)

The intent of the HLD index is to measure the degree of handicap caused by the different components of malocclusion. The Medicaid statutes in the early 1960s recognized there was a need for a method to identify those with a medically handicapping malocclusion. Dr Harry L. Draker developed the Handicapping Labio-lingual Deviation index (HLD) (Draker, 1960, 1967) which was one of the first indices used in the United States to identify those with handicapping malocclusions (Theis et al., 2005). The HLD selects deviations from ideal and these are scored and weighted. The HLD index has been modified by some states to determine and prioritize eligibility for the state-funded orthodontic treatment. The original cut-off point of 13 selected for the HLD index. The Maryland's version of HLD, the HLD (Md) index (Code of Maryland Regulations, 1982; Han & Davidson, 2001), modified the HLD's original scoring formula for overjet and overbite. The Maryland's index, the HLD (Md), changed the cut-off from 13 to 15 points and modified the Draker's scoring formula by subtracting 2 mm from overjet and 3 mm from overbite measurements (Code of Maryland Regulations, 1982; Cooke et al., 2010). The state of Washington HLD modification has five qualifying conditions and the cut-off point has changed to 30 (Theis et al., 2005).

The original form of the HLD index is not a reliable index to assess the orthodontic treatment need. This is because it does not record missing, impacted teeth, spacing between teeth, and transverse discrepancies such as midline deviations and crossbites. The HLD index was modified in the state of California, the HLD (CalMod) index (Parker, 1998), and used the cut-off point of 26. The HLD (CalMod) index (Parker, 1998) has been created because of the settlements originating from two lawsuits against the state of California claiming the state of California failed to comply with the orthodontic provisions of the Medicaid statutes (Brown V. Kizer, 1989; Duran V. Belshe, 1994). As a result of these lawsuits, two qualifying exceptions that cause tissue damage were added to the original HLD index, namely the deep impinging bites and crossbites of individual anterior teeth with tissue destruction (Parker, 1998). In addition, overjets greater than 9 mm and reverse overjets more than 3.5 mm were added as additional qualifying exceptions. The ectopic eruption and unilateral posterior crossbite were also added as weighted factors (Parker, 1998). Table 6 shows the components of the HLD (CalMod) index that is currently used in the state of California.

No	Condition	Score
1	Cleft palate deformity	
2	Cranio-facial anomaly	
3	Deep impinging overbite When the lower incisors are destroying the soft tissue of the palate. Tissue laceration and/or clinical attachment loss must be present.	
4	Crossbite of individual anterior teeth When clinical attachment loss and recession of the gingival margin are present.	
5	Severe traumatic deviations Attach a description of condition, i.e. loss of a premaxilla by burn, trauma or pathology.	
6	Overjet greater than 9 mm Reverse overjet greater than 3.5 mm	
7	Overjet (=<9 mm)	(mm)
8	Overbite including the reverse overbite	(mm)
9	Mandibular protrusion (reverse overjet =< 3.5 mm)	(mm) * 5
10	Open bite	(mm) * 4
11	Ectopic eruption: Count each tooth, excluding third molars	(count) * 3
12	Anterior crowding: Score one point for the maxilla, and/or one point for mandible; two points maximum for anterior crowding.	(0, 1, or 2) * 5
13	Labio-Lingual spread, Arch length insufficiency must exceed 3.5 mm excluding mild rotations that may react favorably to stripping or mild expansion procedures.	(mm)
14	Posterior unilateral crossbite Must involve 2 or more adjacent teeth, one of which must be a molar and not including the posterior bilateral crossbite	4
		Total Score

Table 6. The California Modification of the Handicapping Labio-lingual Deviation Index, the HLD (CalMod) index (Parker, 1998). Conditions 1 to 6 are the qualifying conditions and if present further scoring is not needed. Otherwise, the sum of other conditions (7-14) must be 26 or above to be considered as a handicapping malocclusion. All measurements are recorded in the order given and rounded off to the nearest millimeter (mm). If both anterior crowding and ectopic eruption are present in the anterior portion of the mouth, the most severe condition will be scored, not both conditions. Overjet is recorded with the patient's teeth in centric occlusion and measured from the labial portion of the lower incisors to the labial of the upper incisors.

The HLD (CalMod) index records twelve factors and occlusal traits to produce the final score. These factors are: Overjet, overbite, open bite, cleft lip-palate, anterior crowding, mandibular protrusion, labio-lingual spread, deep impinging overbite, severe traumatic deviations, crossbite of individual anterior teeth, ectopic eruption of anterior teeth, and posterior unilateral crossbite. Dr. William S. Parker who was involved in developing the HLD (CalMod) index recommended using the index on individuals of 13 years of age and

older (Parker, 1998). The different criteria's that were added to the HLD (CalMod) and HLD (Md) indices resulted in different treatment need thresholds and cut-off points. Han and Davidson compared the HLD (CalMod) and HLD (Md) indices using a sample of 313 patients (Han & Davidson, 2001). The HLD (CalMod) index showed a lower treatment need threshold compared to the HLD (Md) index (Han & Davidson, 2001). Cooke and co-workers assessed the validity of the HLD (CalMod) index with a panel of 13 practicing orthodontists (Cooke et al., 2010). They assessed the validity of the index using two cut-off points of 26 and 18.5. With the recommended cut-off point of 26, index failed to identify a considerable percentage of handicapping malocclusions (Cooke et al., 2010). According to their findings, with the cut-off point of 26, index showed a low sensitivity (25.9%) and high specificity (96.8%). Using the cut-off point of 18.5, specificity decreased to 55.6%; however, the sensitivity increased considerably to 92.9%. Similarly, Beglin and co-workers suggested the optimized cut-off point of 12 for the HLD (CalMod) index (Beglin et al., 2001). Despite these findings, the HLD (CalMod) index is still used in the state of California.

7. Index of Complexity, Outcome and Need (ICON)

The Index of Complexity, Outcome and Need (ICON) was developed by Drs Charles Daniels and Stephen Richmond of Cardiff University (Daniels & Richmond, 2000). This was based on the average opinion of 97 practicing specialist orthodontists from eight European countries and the United States (Richmond & Daniels, 1998a, 1998b). In this exercise, the degree of need in 240 sets of pre-treatment study casts and the treatment outcome for 98 paired pre- and post-treatment records were subjectively assessed. The multiple regression analysis was then used and different occlusal traits were given weightings according to their relative importance. The sum of these weighted scores formed the final ICON score The ICON is a single assessment method to measure the orthodontic treatment complexity, outcome and need. The ICON is unique in incorporating an aesthetic score as an integral part of the treatment need evaluation. The ICON is a multifunctional index; it is both an index of treatment need and treatment outcome assessment. The ICON also assesses the malocclusion complexity, and therefore, it offers significant advantages over the other indices of treatment need. The need for treatment does not necessarily equate to the complexity of treatment (Richmond et al., 1997), and there is a need to assess the complexity of treatment. Assessing the complexity of malocclusion helps to: (I) to identify the most proper setting in which the patient receives treatment (i.e. general practice, hospital or specialized practices), (II) to inform the patient of treatment likely success, and finally (III) to identify cases that are more difficult and are likely to take longer to treat.

The ICON has been shown to be a reliable and valid index for assessing orthodontic treatment need (Koochek et al., 2001; Firestone et al., 2002). A relatively high sensitivity (being able to detect treatment need in an individual) and specificity (the ability to identify correctly those individuals who do not need treatment) have been reported for the ICON (Koochek et al., 2001; Firestone et al., 2002). The ICON was also found to be valid for assessing the complexity and outcome of orthodontic cases (Savastano et al., 2003). However, the perception of treatment need can be different in various countries. This leads to recommending different cut-off points. For instance, Dutch orthodontists suggested changing the cut-off point to 52, instead of the recommended cut-off point of 43, to increase the validity of the index (Louwerse et al., 2006).

	Components:	**Score**						**Weight**
		0	1	2	3	4	5	
1	Aesthetic assessment	Score 1 to 10						7
2$	Upper arch crowding	< 2mm	2.1-5mm	5.1-9mm	9.1-13mm	13.1-17mm	> 17mm	5
	Upper arch spacing	< 2mm	2.1-5mm	5.1-9mm	> 9mm		Impacted teeth	5
3	Crossbite	No crossbite	Crossbite present					5
4*	Incisor open bite	Edge to edge	< 1mm	1.1-2mm	2.1-4mm	> 4mm		4
	Incisor overbite	<1/3 lower incisor coverage	1/3 to 2/3 coverage	2/3 up to fully covered	Fully covered			4
5^	Buccal segment A-P	Cusp to embrasure only, Class I,II or III	Any cusp relation up to but not including cusp to cusp	Cusp to cusp				3

$ The difference between the sum of the mesio-distal tooth diameters and the available arch circumference in the upper arch is recorded on a 5 point score. Impacted teeth (score 5) must be un-erupted and either ectopic or have less than 4 mm of space between adjacent permanent teeth. Retained deciduous teeth (without permanent successor), erupted supernumerary teeth or lost teeth due to trauma are counted as space, unless they are to be maintained and obviate the need for prosthetic replacement or space is maintained for a prosthetic replacement (i.e. tooth lost in trauma).
* If both anterior open bite and deep bite are present only the highest score is counted.
^ Quality of buccal segment interdigitation, not the Angle Classification, is measured on both sides then added together

Table 7. The ICON scoring method and its components (Daniels & Richmond, 2000).

The ICON consists of five components: The Aesthetic Component (AC) which is similar to the Aesthetic Component of the IOTN (Brook & Shaw, 1989) (Figure 1), upper and lower crowding / spacing assessment, the presence of a crossbite, degree of incisor open bite/overbite, and the fit of the teeth in the buccal segment in terms of the anterior-posterior relationship (Table 7). Each component can be measured on the study cast as well as on the patient. The practical application of the index is simple and takes approximately one minute for each case (Daniels & Richmond, 2000). The various occlusal anomalies are scored and then weighted scores are summed to produce the final ICON score. A score of 44 or greater indicates the individual needs treatment. In assessing the treatment outcome, a score of 30 or less indicates the end treatment occlusion is acceptable. Table 7 shows the ICON scoring method and its components. The threshold for treatment need in ICON is lower compared to the IOTN (DHC and AC) (Daniels & Richmond, 2000; Borzabadi-Farahani et al., 2010). Similarly, the study by Theis and co-workers (Theis et al., 2005) revealed the ICON found

significantly more treatment need compared to the HLD index. Table 8 shows the complexity grades for the ICON. As previously mentioned ICON is unique in ability to assess the orthodontic outcome. The ICON uses the following formula to assess the orthodontic treatment outcome:

Improvement grade = Pre-Treatment Score – 4 x Post-Treatment Score

ICON Complexity Grade	Score Range
Easy	< 29
Mild	29 to 50
Moderate	51 to 63
Difficult	64 to 77
Very Difficult	> 77

Table 8. ICON complexity grade score ranges

Using the formula and the Table 9, the outcome of orthodontic treatment can be assessed. The ICON is a good substitute for the Dental Health Component (DHC) of IOTN (36) and showed high correlation with the DHC of the IOTN (Borzabadi-Farahani et al., 2010). The ICON and the DHC (IOTN) showed a good agreement in estimating the treatment need (Kappa statistics=0.78) (Borzabadi-Farahani & Borzabadi-Farahani, 2011a). The observed percentage agreement between them was 89.5 percent, indicating a difference of 10.5 percent in treatment need estimates between these indices (ICON and DHC of IOTN) (Borzabadi-Farahani & Borzabadi-Farahani, 2011a). The ICON offers several advantages over IOTN, including the ability to assess the complexity of malocclusion and assessing the treatment outcome. In comparison to the DAI (Cons et al., 1986), the ICON does not suffer from similar deficiencies (Otuyemi & Noar 1996a, 1996b; Danyluk et al., 1999). This is the lack of assessment of some occlusal anomalies such as posterior crossbites, impacted teeth, and deep overbite (Otuyemi & Noar 1996a, 1996b; Danyluk et al., 1999). Compared to the DAI, recording of the ICON is significantly easier, takes less time to calculate the final score (Daniels & Richmond, 2000), and ICON has been suggested as a good substitute for DAI in assessment of treatment need (Onyeaso & Begole, 2007).

Similar to other orthodontic treatment need indices there are possible limitations with using ICON. The index is heavily weighted for aesthetics (weighting of seven), which relies on subjective opinion of clinician. This reduces the objectivity of the index and potentially affects the intra or inter-examiner agreements for different functions of the ICON (Savastano et al., 2003; Koochek et al., 2001). Overall, ICON is simple to use, measures relatively few traits, does not need hierarchy and can be used on patients or study casts without protocol modification.

Improvement Grade	Score Range
Greatly improved	> -1
Substantially improved	-25 to -1
Moderately improved	-53 to -26
Minimally improved	-85 to -54
Not improved or worse	< -85

Table 9. Assessment of the orthodontic treatment improvement (outcome assessment) using the ICON

8. Possible applications of orthodontic treatment need indices

The ranking system that orthodontic treatment need indices employ helps the orthodontic profession in many ways. These are discussed briefly in the following.

Giving confidence to the orthodontic speciality. The use of orthodontic treatment indices by properly trained general dentist and dental specialists helps with identification and referral of potential orthodontic patients. This reduces the subjectivity of orthodontic referrals and gives confidence to the orthodontic speciality.

Resource allocation and manpower planning. Setting the cut-off points in different orthodontic treatment need indices helps the governments and dental bodies in resource allocation and future manpower planning.

Assessing the relationship between malocclusion and other medical or dental conditions. Assessing the link between malocclusion and other medical and dental conditions is important. Within this context, indices that have a scale provide more information (e.g. ICON). Examples of these links can include, but not limited to, periodontal status (Ngom et al., 2007a), masticatory function (Ngom et al., 2007b), dental trauma (Borzabadi-Farahani & Borzabadi-Farahani, 2011b), and caries experience (Borzabadi-Farahani et al., 2011).

Assessing the orthodontic treatment outcome and clinical performance. The aim of orthodontic treatment is to deliver a high standard of care and this should be at the individual, institutional and national level. Therefore, it is important to find out the outcome of treatment and evaluate the outcome acceptability. In comparison to the PAR index (Richmond et al., 1992a), the ICON (Daniels & Richmond, 2000) has been shown to be more critical and suggested to be more valid in detecting the treatment failure (Fox & Chapple, 2004). This function is particularly helpful in orthodontic litigation cases.

Assessing the malocclusion complexity. Difficulty in achieving an ideal occlusion might arise from, but not limited to, the pre-treatment occlusion (e.g. complex or simple malocclusion), patient associated factors (compliance), and treatment related factors. The orthodontic treatment complexity has been defined as an entity that reduces post-treatment success (Richmond et al., 1997; Llewellyn et al., 2007). According to Richmond et al. (2001) difficulty and complexity in orthodontics are synonymous. They are measurement of effort and skill, while severity is a measurement of how far a malocclusion deviates from normal (Richmond et al., 2001; Llewellyn et al., 2007). Orthodontic indices that assess the complexity identify the individual that should be treated in hospital setting and need a different competency for their treatment (e.g. need surgical interventions) or those who have milder problems and can be treated by general dentists or specialist practices.

Assessing the cost-effectiveness of orthodontic treatment. In publicly funded or insurance-based services, the cost-effectiveness is of interest to health care providers. This is particularly important when patient pays the cost of treatment as it is of interest to both patients and practitioner. Improved cost-effectiveness results in lower patient costs, increased practitioner profit, and provides treatment for more patients in publicly funded orthodontic services (Deans et al., 2009). In order to perform a cost-effectiveness study, a well-defined treatment outcome is required (Deans et al., 2009, Richmond et al., 2005). An orthodontic index provides a valid and reliable method of measuring treatment outcomes (Shaw et al., 1991). The ICON (Daniels & Richmond, 2000) allows quality assurance assessments to be carried out and compared between different operators and clinics. A simple way of comparing the cost-effectiveness between practitioners is to calculate the

cost per ICON point reduction that is an average cost-effectiveness ratio (Shaw et al., 1991).

9. Conclusion

Despite the shortcomings of orthodontic treatment need indices they are used in many European countries and some states in the United States. The use of contemporary , multifunctional orthodontic indices, based on international consensus, that provides information on the need/complexity and treatment outcome is recommended. As mentioned earlier orthodontic treatment need indices are based on consensus opinion of their developer (s) and are not entirely based on the research evidence. Future studies should be aimed at creating an evidence-based scoring system for the orthodontic treatment need indices.

10. References

Acharya, S. (2006). Specific caries index: A new system for describing untreated dental caries experience in developing countries. Journal of Public Health Dentistry, Vol. 66, pp. 285-287.

Ackerman, JL; Proffit, WR. (1969). The characteristics of malocclusion: a modern approach to classification and diagnosis. American Journal of Orthodontics, Vol.56, pp.443-454.

Ainamo, J; Barmes, D; Beagrie, G; Cutress, T; Martin, J; Sardo-Infirri, J. (1982). Development of the World Health Organization (WHO) community periodontal index of treatment needs (CPITN). International Dental Journal, Vol.32, pp. 281-291.

AAO. (2001). American Association of Orthodontists, Bulletin 2001, Fall 2001.

Angle, H. (1899). Classification of malocclusion. Dental Cosmos, Vol.41, pp. 248-264.

Ast, DB; Carlos, JP; Cons, NC. (1965). The prevalence and characteristics of malocclusion among senior high school students in upstate New York. American Journal of Orthodontics, Vol.51, pp. 437-445.

Ballard, CF; Wayman, JB. (1964). A report on a survey of the orthodontic requirements of 310 army apprentices. Transactions of the British Society for the Study of Orthodontics, Vol.86, pp. 81-86.

Baume, LJ; Horowitz, HS; Summers, CJ; Dirks, BO; Brown, WAB; Carlos, JP; et al. (1973). A method for measuring occlusal traits. International Dental Journal, Vol.23, pp. 530-537.

Beglin, FM; Firestone, AR; Vig, KW; Beck, FM; Kuthy, RA; Wade D. (2001). A comparison of the reliability and validity of 3 occlusal indexes of orthodontic treatment need. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.120, pp. 240-246.

Bernabé, E; Flores-Mir, C. (2006). Orthodontic treatment need in Peruvian young adults evaluated through dental aesthetic index. Angle Orthodontist, Vol.76, pp. 417-421.

Bjork, A; Krebs, A; Solow, B. (1964). A method for the epidemiological registration of malocclusion. Acta Odontologica Scandinavica, Vol.22, pp. 27-41.

Bollen, AM. (2008). Effects of malocclusions and orthodontics on periodontal health: evidence from a systematic review. Journal of Dental Education, Vol.72, pp. 912-918.

Borzabadi-Farahani, A; Borzabadi-Farahani, A; Eslamipour, F. (2010). The relationship between ICON index and Dental and Aesthetic components of IOTN index. World Journal Orthodontics, Vol.11, pp. 43-48.

Borzabadi-Farahani, A; Borzabadi-Farahani, A. (2011a). Agreement between the index of complexity, outcome, and need and the dental and aesthetic components of the index of orthodontic treatment need. American Journal of Orthodontics and Dentofacial Orthopaedics, Vol. 140, pp. 233-238.

Borzabadi-Farahani, A; Borzabadi-Farahani, A. (2011b). The association between orthodontic treatment need and maxillary incisor trauma, a retrospective clinical study. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, In Press.

Borzabadi-Farahani, A; Eslamipour, F; Asgari, I. (2011). Association between orthodontic treatment need and caries experience, Acta Odontologica Scandinavica, Vol.69, pp. 2-11.

Brook, PH; Shaw, WC. (1989) The development of an index of orthodontic treatment priority. European Journal of Orthodontics, Vol.20, pp. 309-320.

Burden, DJ; Holmes, A. (1994). The need for orthodontic treatment in the child population of the United Kingdom. European Journal of Orthodontics, Vol.16, pp. 395-399.

Burden, DJ; Mitropoulos, CM; Shaw, WC. (1994). Residual orthodontic treatment need in a sample of 15- and 16-year-olds. British Dental Journal, Vol.176, pp. 220-224.

Burden, DJ; Pine, CM; Burnside, G. (2001). Modified IOTN: an orthodontic treatment need index for use in oral health surveys. Community Dentistry and Oral Epidemiology, Vol.29, pp. 220-225.

Burden, DJ. (2007). Oral Health-Related Benefits of OrthodonticTreatment. Seminars in Orthodontics, Vol.13, pp. 76-80.

Carlos, JP. (1970). Evaluation of indices of malocclusion. International Dental Journal, Vol.20, pp. 606-617.

Chestnutt, IG; Burden, DJ; Steele, JG; Pitts, NB; Nuttall, NM; Morris, AJ. (2006). The orthodontic condition of children in the United Kingdom, 2003. British Dental Journal, Vol.10, pp. 609-612.

Chi, J; Johnson, M; Harkness, M. (2000). Age changes in orthodontic treatment need: a longitudinal study of 10- and 13-year-old children, using the Dental Aesthetic Index. Australian Orthodontic Journal, Vol.16, pp. 150-156.

Code of Maryland Regulations. (1982). Attachment No 1, EPSDT Services Regulation. Baltimore, Maryland, USA.

Cons, NC; Mruthyunjay, YC; Pollard, ST. (1978). Distribution of occlusal traits in a sample of 1,337 children aged 15-18 residing in upstate New York. International Dental Journal, Vol.28, pp. 154-164.

Cons, NC; Jenny, J; Kohout, FJ. (1986). DAI: The dental aesthetic index. College of Dentistry, Iowa City, IA: University of Iowa.

Cooke, M; Gerbert, B; Gansky, S; Miller, A; Nelson, G; Orellana, M. (2010). Assessment of the validity of HLD (CalMod) in identifying orthodontic treatment need. Community Dentistry and Oral Epidemiology, Vol.38, pp.50-57.

Croxson, LJ. (1984). A simplified periodontal screening examination: the Community Periodontal Index of Treatment Needs (WHO) in general practice. International Dental Journal, Vol.34, pp.28-34.

Daniels, C; Richmond, S. (2000). The development of the index of complexity, outcome and need (ICON). Journal of Orthodontics, Vol.27, pp. 149-162.

Danyluk, K. (1998). The development of an objective orthodontic treatment-need index. MSc thesis, University of Manitoba. p.29.

Danyluk, K; Lavelle, C; Hassard, T. (1999). Potential application of the dental aesthetic index to prioritize the orthodontic service needs in a publicly funded dental program. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.116, pp. 279-286.

Deans, J; Playle, R; Durning, P; Richmond, S. (2009). An exploratory study of the cost effectiveness of orthodontic care in seven European countries. European Journal of Orthodontics, Vol.31, pp. 90-94.

Draker, HL. (1960). Handicapping labio-lingual deviations: a proposed index for public health purposes. American Journal of Orthodontics, Vol.46, pp. 295-305.

Draker, HL. (1967). American association of orthodontists approval of the assessment record form and the definition of handicapping malocclusion, Journal of American Dental Association, Vol. 75, pp. 1441-1442.

Espeland, LV; Ivarsson, K; Stenvik, A. (1992). A new Norwegian index of orthodontic treatment need related to orthodontic concern among 11-year-olds and their parents. Community Dentistry and Oral Epidemiology, Vol.20, pp. 274-279.

Evans, R; Shaw, WC. (1987). Preliminary evaluation of an illustrated scale for rating dental attractiveness. European Journal of Orthodontics, Vol.9, pp. 314-318.

Fields, HW; Vann, WF and Vig, KWL. (1982): Reliability of Soft Tissue Profile Analysis in Children, Angle Orthodontist, Vol.52, pp. 159-165.

Firestone, AR; Beck, FM; Beglin, FM; Vig, KW. (2002). Validity of the Index of Complexity, Outcome, and Need (ICON) in determining orthodontic treatment need. Angle Orthodontist, Vol.72, pp. 15-20.

Fox, NA; Chapple, JR. (2004). Measuring failure of orthodontic treatment: a comparison of outcome indicators. Journal of Orthodontics, Vol.31, pp. 319-322.

Grainger, RM. (1961). Burlington Orthodontic Research Center progress report. Series 6. University of Toronto, Division of Dental Research, pp. 9-11.

Han, H; Davidson, WM. (2001). A useful insight into 2 occlusal indexes: HLD (Md) and HLD (CalMod). American Journal of Orthodontics and Dentofacial Orthopedics, Vol.120, pp. 247-253.

Hooper, SM; Meredith, N; Jagger, DC. (2004). The development of a new index for measurement of incisal/occlusal tooth wear. Journal of Oral Rehabilitation, Vol.31, pp.206-212.

Järvinen, S. (2001). Indexes for orthodontic treatment need. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.120, pp. 237-9.

Jenny, J; Cons, NC. (1996a). Comparing and contrasting two orthodontic indices, the index of orthodontic treatment need and the dental aesthetic index. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.110, pp. 410-416.

Jenny, J; Cons, NC. (1996b). Establishing malocclusion severity levels on the Dental Aesthetic Index (DAI) scale. Australian Dental Journal, Vol.41, pp. 43-46.

Jenny, J; Cons, NC; Kohout, FJ; Frazier, PJ. (1980). Test of a method to determine socially acceptable occlusal conditions. Community Dentistry and Oral Epidemiology, Vol.8, pp. 424-433.

Jenny, J; Cons, NC; Kohout, FJ; Jakobsen, J. (1993). Predicting handicapping malocclusion using the Dental Aesthetic Index (DAI). International Dental Journal, Vol.43, pp. 128-132.

Johnson, M; Harkness, M. (2000). Prevalence of malocclusion and orthodontic treatment need in 10-year-old New Zealand children. Australian Orthodontic Journal, Vol.16, pp. 1-8.

Johnson, M; Harkness, M; Crowther, P; Herbison, P. (2000). A comparison of two methods of assessing orthodontic treatment need in the mixed dentition: DAI and IOTN. Australian Orthodontic Journal, Vol.16, pp. 82-87.

Keay, PA; Freer, TJ. (1993). Orthodontic treatment need and the dental aesthetic index. Australian Orthodontic Journal, Vol.13, pp. 4-7.

Keay, PA; Freer, TJ; Basford, KE. (1993). Orthodontic treatment need and the dental aesthetic index. Australian Orthodontic Journal, Vol.13, pp. 4-7.

Koochek, AR; Yeh, MS; Rolfe, B; Richmond, S. (2001). The relationship between Index of Complexity, Outcome and Need, and patients' perceptions of malocclusion: a study in general dental practice. British Dental Journal, Vol.191, pp. 325-329.

Llewellyn, SK; Hamdan, AM; Rock, WP. (2007). An index of orthodontic treatment complexity. European Journal of Orthodontics, Vol.29, pp.186-92.

Linder-Aronson, S. (1974). Orthodontics in the Swedish public dental health service. Transactions of the European Orthodontic Society, pp. 233-240.

Linder-Aronson, S; Fridh, G; Jensen, R. (1976). Need of orthodontic treatment and orthodontic specialists in Sweden. Swedish Dental Journal, Vol.68, pp. 383-402.

Little, RM. (1975). The irregularity index. American Journal of Orthodontics, Vol.68, pp. 554-563.

Louwerse, TJ; Aartman, IH; Kramer, GJ; Prahl-Andersen, B. (2006). The reliability and validity of the Index of Complexity, Outcome and Need for determining treatment need in Dutch orthodontic practice. European Journal of Orthodontics, Vol.28, pp. 58-64.

Lundstrom, A. (1977). Need for treatment in cases of malocclusion. Transactions of the European Orthodontic Society, pp. 111-123.

Lunn, H; Richmond, S; Mitropoulos, C. (1993). The use of the Index of Orthodontic Treatment Need (IOTN) as a public health tool: a pilot study. Community Dental Health, Vol.10, pp. 111-121.

Manzanera, D; Montiel-Company, JM; Almerich-Silla, JM; Gandía, JL. (2010). Diagnostic agreement in the assessment of orthodontic treatment need using the Dental Aesthetic Index and the Index of Orthodontic Treatment Need. European Journal of Orthodontics, Vol.32, pp. 193-198.

Massler, M; Frankel, JM. (195 1): Prevalence of Malocclusion in Children Aged 14 to 18 Years, American Journal of Orthodontics, Vol. 37, pp. 751-768.

Mockbil, N; Huggare, J. (2009). Uniformity in selection for subsidized orthodontic care--focus on borderline treatment need. Swedish Dental Journal, Vol.33, pp.19-25.

Ngom, PI; Benoist, HM; Thiam, F; Diagne, F; Diallo, PD. (2007a). Influence of orthodontic anomalies on periodontal condition, Odonto-stomatologie tropicale, Vol.30, pp. 9-16.

Ngom, PI; Diagne, F; Aïdara-Tamba, AW; Sene, A. (2007b). Relationship between orthodontic anomalies and masticatory function in adults. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.131, pp. 216-222.

Onyeaso, CO; Begole, EA. (2007). Relationship between index of complexity, outcome and need, dental aesthetic index, peer assessment rating index, and American Board of Orthodontics objective grading system. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.131, pp. 248-252.

Otuyemi, OD; Noar, JH. (1996a). A comparison between DAI and SCAN in estimating orthodontic treatment need. International Dental Journal, Vol.46, pp. 35-40.

Otuyemi, OD; Noar, JH. (1996b). Variability in recording and grading the need for orthodontic treatment using the HMAR, OI and DAI. Community Dentistry and Oral Epidemiology, Vol.24, pp. 222-224.

Parker, WS. (1998). The HLD (CalMod) index and the index question. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.114, pp. 134-141.

Poulton, DR; Aaronson, SA. (1961): The relationship between occlusion and periodontal Status. American Journal of Orthodontics, Vol.47, pp. 690-699

Proshek, JM; Jenny, J; Cons, NC; Summers, CJ; Mruthyunjaya, YC. (1979). A factor analysis of traits measured by COCSTOC-MOT to identify occlusal trait combinations. Community Dentistry and Oral Epidemiology, Vol.7, pp. 274-282.

Puertes-Fernández, N; Montiel-Company, JM; Almerich-Silla, JM; Manzanera, D. (2010). Orthodontic treatment need in a 12-year-old population in the Western Sahara. European Journal of Orthodontics, 2010 Oct 6.

Quigley GA, Hein JW. (1962). Comparative cleansing efficiency of manual and power brushing. Journal of American Dental Associan, Vol.65, pp. 26-9.

Richmond, S. (1990). A critical evaluation of orthodontic treatment in the General Dental Services of England and Wales, PhD thesis. University of Manchester 1990.

Richmond, S; Shaw, WC; O'Brien. KD; Buchanan, IB; Jones, R; Stephens, CD; Roberts, CT; Andrews, M. (1992a). The development of the PAR Index (Peer Assessment Rating): reliability and validity. European Journal of Orthodontics, Vol.14, pp. 125-139.

Richmond, S; O'Brien, K; Buchanan, I; Burden, D. (1992b). An Introduction to occlusal indices, Mandent Press, Victoria University of Manchester, Manchester, UK.

Richmond, S; Shaw, WC; Stephens, CD; Webb, WG; Roberts, CT; Andrews, M. (1993). Orthodontics in the General Dental Service of England and Wales: A critical assessment of standards. British Dental Journal, Vol.174, pp. 315-329.

Richmond, S; Buchanan, IB; Burden, DJ; O'Brien, KD; Andrews, M; Roberts, CT; Turbill, EA. (1995). Calibration of dentists in the use of occlusal indices. Community Dentistry and Oral Epidemiology, Vol.23, pp. 173-176.

Richmond, S; O'Brien, K. (1996). Health gain in orthodontics: a comparison of the general dental services and the hospital service in England and Wales. Community Dental Health, Vol.13, pp. 128-132.

Richmond, S; Daniels, CP; Fox, NA; Wright, J. (1997). The professional perception of orthodontic treatment complexity. British Dental Journal, Vol.183, pp. 365-370.

Richmond, S; Daniels, CP. (1998a). International comparisons of professional assessments in orthodontics: Part 1--Treatment need. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.113, pp. 180-185.

Richmond, S; Daniels, CP. (1998b). International comparisons of professional assessments in orthodontics: Part 2--treatment outcome. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.113, pp. 324-328.

Richmond, S; Aylott, NAS; Panahei, ME ; Rolfe, B ; Harzer, W ; Tausche, E. (2001). A 2-centre comparison of orthodontists' perceptions of orthodontic treatment difficulty. Angle Orthodontist, Vol.71, pp. 404-410

Richmond, S; Dunstan, F; Daniels, C; Durning, P; Leahy, F. (2005). Measuring the cost, effectiveness and cost effectiveness of orthodontic care. World Journal of Orthodontics, Vol.6, pp. 161-170.

Salzmann, JA. (1968). Handicapping malocclusion assessment to establish treatment priority. American Journal of Orthodontics, Vol.54, pp. 749-765.

Savastano, NJ Jr; Firestone, AR; Beck, FM; Vig, KW. (2003). Validation of the complexity and treatment outcome components of the index of complexity, outcome, and need (ICON). American Journal of Orthodontics and Dentofacial Orthopedics, Vol.124, pp. 244-248.

SBU. (2005) The Swedish council on technology assessment in health care. malocclusions and orthodontic treatment in a health perspective.

Shaw, W; Richmond, S; O'Brien, K; Brook, P; Stephens, C. (1991). Quality control in orthodontics: indices of treatment need and treatment standards. British Dental Journal, Vol.170, pp. 107-112.

Shaw, WC; Richmond, S.; O'Brien, KD (1995). The use of occlusal indices: a European perspective. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.107, pp.1-10.

Silness, J; Löe, H. (1964). Periodontal Disease in Pregnancy II. Correlation between Oral Hygiene and Periodontal Condition. Acta Odontologica Scandinavica, Vol.22, pp.121-135.

Spencer, AJ; Allister, JH; Brennan, DS. (1992). Utility of the Dental Aesthetic Index as an Orthodontic Screening Tool in Australia. Adelaide, University of Adelaide, Australia.

Summers, CJ. (1971). The occlusal index: a system for identifying and scoring occlusal disorders. American Journal of Orthodontics, Vol.59, pp. 552-567.

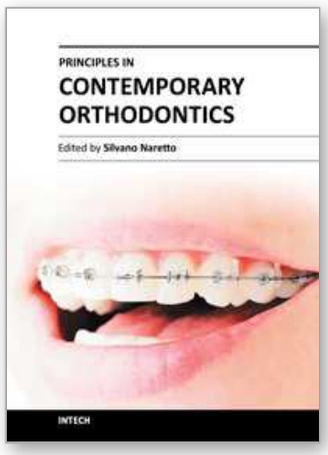
Swedish Medical Health Board. (1966). Socialstyrelsen Kungl Medicinalstyrelsens circular den 21 februari 1966 angående anvisningarna för journalföring inom folktandvårdens tandregleringsvård. Stockholm.

Tang, EL; Wei, SH. (1993). Recording and measuring malocclusion: a review of the literature. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.103, pp. 344-351.

Theis, JE; Huang, GJ; King, GJ; Omnell, ML. (2005). Eligibility for publicly funded orthodontic treatment determined by the handicapping labiolingual deviation index. American Journal of Orthodontics and Dentofacial Orthopedics, Vol.128, pp. 708-715.

Van Kirk, LK and Pennell, EH. (1959). Assessment of malocclusion in population groups. American Journal of Orthodontics, Vol. 45, pp. 752-758.

Younis, JW; Vig, KW; Rinchuse, DJ; Weyant, RJ. (1997). A validation study of three indexes of orthodontic treatment need in the United States. Community Dentistry and Oral Epidemiology, Vol.25, pp. 358-362.



Principles in Contemporary Orthodontics
Edited by Dr. Silvano Naretto

ISBN 978-953-307-687-4
Hard cover, 584 pages
Publisher InTech
Published online 25, November, 2011
Published in print edition November, 2011

Orthodontics is a fast developing science as well as the field of medicine in general. The attempt of this book is to propose new possibilities and new ways of thinking about Orthodontics beside the ones presented in established and outstanding publications available elsewhere. Some of the presented chapters transmit basic information, other clinical experiences and further offer even a window to the future. In the hands of the reader this book could provide an useful tool for the exploration of the application of information, knowledge and belief to some orthodontic topics and questions.

How to reference
In order to correctly reference this scholarly work, feel free to copy and paste the following:

Ali Borzabadi-Farahani (2011). An Overview of Selected Orthodontic Treatment Need Indices, Principles in Contemporary Orthodontics, Dr. Silvano Naretto (Ed.), ISBN: 978-953-307-687-4, InTech, Available from: http://www.intechopen.com/books/principles-in-contemporary-orthodontics/an-overview-of-selected-orthodontic-treatment-need-indices

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

IntechOpen