

A preliminary evaluation of pre-treatment hypodontia patients using the Dental Aesthetic Index. How does it compare with other commonly used indices?

A. T. Shelton, R. S. Hobson and D. Slater

Orthodontic Department, Newcastle-upon-tyne Dental Hospital, UK

SUMMARY There is currently no specific occlusal index related to hypodontia and there is a paucity of published literature on this subject. The aim of this study was to determine the relationship, if any, between the Peer Assessment Rating (PAR) Index, the Index of Complexity, Outcome and Need (ICON), and the Dental Aesthetic Index (DAI) score and the severity of hypodontia. All new patients attending the Newcastle Dental Hospital hypodontia clinic between February 2002 and March 2003 were included in the study. Of the 60 patients, two were excluded as the models were unavailable and one because they were predominantly in the primary dentition, making scoring impractical. The patient casts were scored with respect to PAR, ICON, and DAI. The mean patient age at presentation was 12 years, with a standard deviation of 1.89 and a range of 9–16 years, and a female to male ratio of 1.1:1.

A significant positive correlation, using Kendall tau b, was found between the number of missing teeth, excluding third molars, and the DAI score ($\tau = 0.215$, $P = 0.027$). There was no significant positive correlation between PAR ($\tau = -0.186$, $P = 0.056$) and ICON ($\tau = 0.017$, $P = 0.861$) score and the number of missing teeth. The results of this investigation indicate that further research is required in order to assess if the DAI could be used to determine whether or not to refer hypodontia patients for specialist advice.

Introduction

Hypodontia is the congenital absence of teeth and has a prevalence rate in British children in the permanent dentition of 3.5–6.5 per cent (Brook, 1974). There is currently no specific occlusal index related to hypodontia and there is a paucity of published literature, where an occlusal index has been used to score a unique sample of patients with hypodontia. Hypodontia can have a profound effect on anterior aesthetics and research has shown that missing anterior teeth are considered to be the most unattractive of occlusal traits (Shaw, 1981). The congenital absence of teeth can seriously disable a young person both physically and emotionally, especially during adolescence (Nunn *et al.*, 2003). There is clearly an advantage in being able to sensitively assess treatment need and outcome in patients with hypodontia, for referral treatment, and research purposes.

The three most commonly used occlusal indices in the United Kingdom (UK) are the Index of Orthodontic Treatment Need (IOTN; Brook and Shaw, 1989), the Peer Assessment Rating (PAR) Index, (Richmond *et al.*, 1992) and the Index of Complexity, Outcome and Need (ICON; Daniels and Richmond, 2000).

The IOTN is used to identify individuals who would benefit from orthodontic treatment, but its use has significant limitations for hypodontia patients. With this index, there are only two categories into which hypodontia patients may be classified: 5h for extensive hypodontia with restorative implications requiring pre-restorative orthodontics and 4h

for less extensive hypodontia requiring pre-restorative orthodontics or orthodontic space closure. This dichotomous scoring indicates significant limitations with the index and for that reason it was not used for the present study. The aesthetic component of IOTN may give an indication of treatment need, although this is subjective.

The PAR index was developed in the UK over a series of six meetings in 1987 with a panel of 10 orthodontists (Richmond *et al.*, 1992). It is designed to measure the outcome of orthodontic treatment and provides a single summary score indicating the extent to which the case deviates from a normal occlusion. The difference between pre- and post-treatment scores illustrates whether orthodontic treatment has been a success. The ICON was developed in the UK and is used to assess treatment need, complexity, improvement, and outcome. It is based on the international opinion of 97 orthodontists from nine countries (Daniels and Richmond, 2000). There is no published work to date where PAR and ICON have been used to assess only patients with hypodontia. Previous research (Slater, 2003) has shown that in a sample of purely hypodontia patients, the mean PAR and ICON scores did not increase with respect to the number of absent teeth, i.e. incisors, canines, premolars, or molars. This work suggested that these indices were not particularly sensitive for hypodontia cases; however, the data suggests further analysis would be valuable (Slater, 2003).

The Dental Aesthetic Index (DAI) was developed in America (Cons *et al.*, 1986) and has been used

internationally (Cons *et al.*, 1989; Onyeaso and Aderinokun, 2003). It is based on public perceptions of the dental aesthetics of 200 photographs of occlusal configurations, selected by a disproportionate, stratified, random sampling procedure from a larger sample of 1337 study models. The study models represented a probability sample of 500 000 high school students in New York state, aged 15–18 years (Ast *et al.*, 1965). Available for each photograph were anatomical measurements of traits, selected by an international committee as important occlusal traits to be considered in the development of an orthodontic index (Baume *et al.*, 1975). The ratings of approximately 2000 adolescents and adults of the dental aesthetics of each photograph were related to the anatomical measurements of each photograph, using regression analysis. The resulting regression equation, consisting of the 10 components (physical measurements of occlusal traits) and their appropriate regression coefficients (weights), is called the DAI. Although the DAI was developed for use in the permanent dentition, it can also be adapted for use in the mixed dentition World Health Organisation (WHO) 1997.

The aims of this study were to determine whether there is a relationship between PAR, ICON, or DAI score and the severity of hypodontia, and if there is a relationship whether it is sufficiently significant to be used clinically.

Subjects and methods

Sixty patients with varying degrees of hypodontia who had been seen at the monthly hypodontia clinic at Newcastle Dental Hospital between February 2002 and March 2003 were included. This number represented all new patients attending the clinic during this time. The hypodontia clinic in Newcastle is a referral centre for patients with hypodontia in the North East of England with a population of approximately 2 500 000. Alginate impressions were taken of each patient and the resultant study models were used. Dental pantomographs were also taken and the number of

congenitally absent teeth determined. Three subjects were excluded from the study; one, as the patient was predominantly still in the primary dentition, making scoring impossible, and two, because the models were unavailable.

The 57 remaining study models were scored with respect to PAR and ICON by a clinician (DS) calibrated in both indices. Twenty of the study models were then randomly selected and rescored, six weeks later, in order to assess intraexaminer reliability. The 57 study models were also scored with respect to the DAI by the same clinician, who followed the instruction manual for the DAI (Cons *et al.*, 1986). Again 20 of the study models were randomly selected and rescored, six weeks later, in order to assess intra-examiner reliability.

As the use of the DAI has not been well reported in the literature, the methodology is described below. The standard DAI regression equation calls for the measured components of the DAI to be multiplied by their rounded weights and the resultant products to be added, along with a constant, to achieve a total. The rounded weights are in effect rounded regression coefficients. Table 1 illustrates the components of the DAI and shows a worked example.

The score for each DAI component is attained as follows (Cons *et al.*, 1986):

1. Missing visible teeth, incisors, canines, and premolars:
The number of missing incisors, canines, and premolars in both the upper and lower arches are recorded. If spaces are closed, the tooth is not counted as missing. If a missing tooth is replaced by a fixed prosthesis, it is not counted as missing. If a primary tooth is still in position and its successor not yet erupted, it is not counted as missing. When a case in the mixed dentition is scored, the space from a recently exfoliated tooth is not scored as missing if it appeared that the permanent replacement would soon erupt (WHO, 1997). It is for this reason that radiographs were essential to obtain a score in the mixed dentition.

Table 1 The Dental Aesthetic Index (DAI) components and an example of a worked DAI score.

DAI components	Patient value	Rounded weighting	Total
Missing incisors, canines, and premolars	2	6	12
Crowding	2	1	2
Spacing	0	1	0
Diastema	1	3	3
Largest anterior irregularity (upper)	1	1	1
Largest anterior irregularity (lower)	2	1	2
Anterior maxillary overjet	6	2	12
Anterior mandibular overjet (reversed overjet)	0	4	0
Vertical anterior open bite	0	4	0
Antero-posterior molar relationship	2	3	6
Constant	13	13	13
Total	29		61

DAI, Dental Aesthetic Index.

2. Crowding in the incisal segments of the arch: The number of incisal segments (each incisal segment consisting of four incisors) with crowding is recorded as 0, 1, or 2. 0 = no segments crowded; 1 = 1 segment crowded; 2 = 2 segments crowded. The incisal segment is not marked as crowded if the four incisors were correctly aligned, but either of the canines were displaced.
3. Spacing in the incisal segment of the arch: If one or more incisor teeth had proximal surfaces without any interdental contact, the segment is recoded as having space. The number of incisal segments in both arches with spacing is recorded as 0, 1, or 2. The scoring was identical to that of crowding.
4. Diastema: This is the space in millimetres between the two maxillary incisors.
5. Largest anterior irregularity for upper teeth: Irregularities are either displacements from, or rotations out of, normal alignment. The greatest irregularity between adjacent teeth is measured, in millimetres, from labial surface to labial surface. If there is sufficient space for all four incisors in normal alignment but some are rotated, the segment is not recorded as crowded but the largest irregularity is recorded.
6. Largest anterior irregularity in the lower arch: The measurement principles are the same as the upper.
7. Anterior maxillary overjet: With the teeth in centric occlusion, the maximum overjet is recorded to the nearest millimetre from the labio-incisal edge of the most prominent upper incisor to the labial surface of the corresponding lower incisor, holding the ruler parallel to the occlusal plane.
8. Anterior mandibular overjet (reverse overjet): Measurement is in the same manner as for maxillary overjet. A mandibular overjet is not marked if a lower incisor is rotated so that one part of the incisal edge is in crossbite but another part is not.
9. Vertical anterior open bite: If there is a lack of vertical overlap between any of the opposing pairs of incisors, it is measured to the nearest millimetre. The largest open bite is recorded.
10. Antero-posterior molar relationship: This assessment is most often based on the relationship of the first permanent molars but, if they are missing or misshapen, the relationship of the canines and premolars is assessed. The right and left sides are assessed in occlusion and the largest deviation from normal is recorded. A score of 0, 1, or 2 is obtained. 0 = Angle Class I molar relationship, 1 = Angle half unit Class II or III molar relationship, and 2 = whole unit Angle Class II or III molar relationship.

Statistical analyses

Kendall tau-b correlation was used in order to compare the relationship between the index score and the number of missing teeth as the independent variable (number of

missing teeth) was assumed not to be normally distributed. An intraclass correlation coefficient (ICC) was calculated in order to assess rater reliability.

Results

The mean patient age at presentation was 12 years with a standard deviation of 1.89 and a range of 9–16 years. Thirty patients were female and 27 were male giving a female to male ratio of 1.1:1. The mean average DAI score was 42 with a range 26–84, indicating that the majority of patients had very severe or handicapping malocclusions with treatment considered mandatory. The average PAR score was 19 with a range of 3–45 and the average ICON score 73 with a range of 34–114. The ICON scores indicate again that the majority of patients were in need of treatment (greater than 43). It is impossible to comment on the PAR scores in this context due to disagreements in the literature with regard to its use to predict treatment need (Bergström and Halling, 1997; McGorray *et al.*, 1999).

The ICC for the initial and retest scores was 0.99 for PAR, 0.97 for ICON, and 0.98 for DAI indicating excellent reliability.

Discussion

The DAI was originally developed for 'intraoral use without the use of radiographs' (Cons *et al.*, 1986); however, it was the experience of the authors that to give a score for the missing teeth component, a radiograph was essential when scoring casts in the mixed dentition. In hypodontia patients, when a primary tooth is exfoliated the only way of knowing whether a permanent successor is present is to look at the radiograph. The fact that the scores were completed on study models, rather than introrally, may introduce measurement errors, although these are unlikely to significantly affect the results. This study would have been improved from a scientific point of view if the dental development of the patient was standardized, i.e. all in the permanent dentition; however, logistically this was not possible. In contrast, a sensitive occlusal index should be effective in assessing patients with hypodontia at all stages of dental development, and the wide age range of patients in this study allowed an assessment of the index in this context.

The age range of patients was 9–16 years compared with 8–13 years in a previous investigation of 451 patients attending a hypodontia clinic (Hobkirk *et al.*, 1994). This wider age range may be attributable to a low level of patient demand for treatment or a lack of early recognition of the condition by the general dental practitioner. The female to male ratio was 1.1:1 in this investigation, compared with 1.5:1 (Brook, 1974), showing a slight difference. However, the results compare favourably with the study of Schalk-van der Weide *et al.* (1992), whose

Table 2 Kendall tau-b values of the Dental Aesthetic Index (DAI), Peer Assessment Rating (PAR), Index of Complexity, Outcome and Need (ICON) versus the number of missing teeth (third molars excluded).

Correlated variables	τ value (Kendall tau-b correlation coefficient)	<i>P</i> value
DAI score versus number of missing teeth	0.215	0.027
DAI score versus number of missing teeth excluding second molars	0.261	0.008
PAR score versus number of missing teeth	-0.186	0.056
PAR score versus number of missing teeth excluding second molars	-0.219	0.025
ICON score versus number of missing teeth	0.017	0.861
ICON score versus number of missing teeth excluding second molars	0.052	0.593

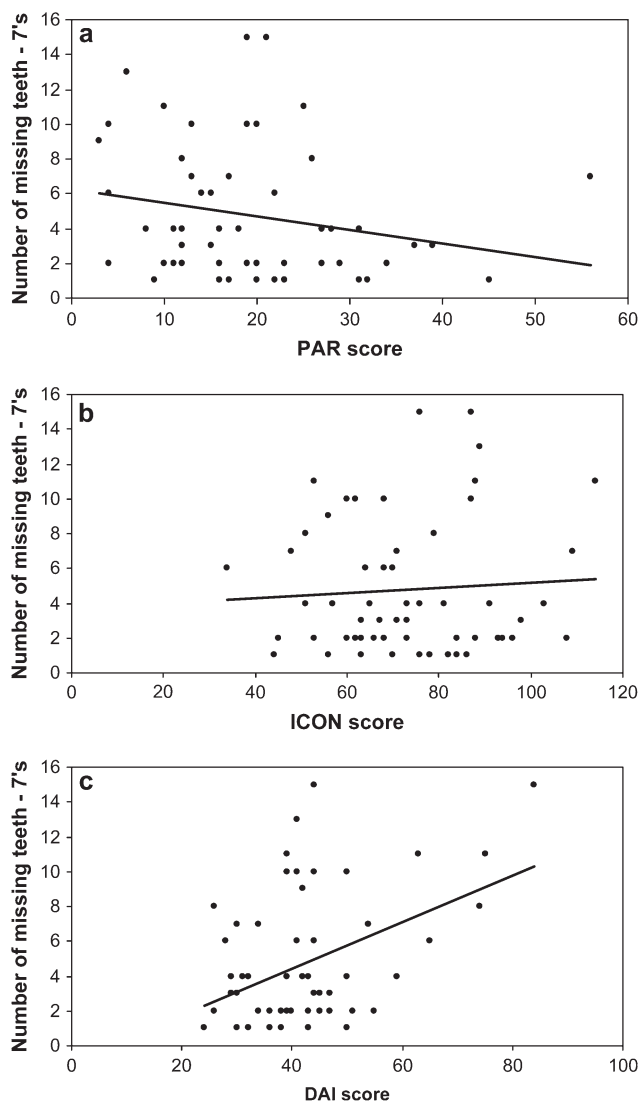
group were from referred patients, rather than from a whole population sample (Brook, 1974).

The results show that there was a positive correlation between DAI score and the number of missing teeth which was significant at $P \leq 0.05$ (Table 2). In contrast to this, there appeared to be a negative correlation between PAR score and the number of missing teeth and very little correlation at all between ICON score and the number of missing teeth. In view of the fact that the DAI does not take into account teeth that are missing distal to the premolar, it was felt appropriate to calculate a Kendall tau correlation coefficient with the second molars excluded. The strength of the correlation was enhanced for both DAI scores and PAR scores, i.e. the larger the τ value the stronger the correlation (Table 2, Figure 1a–c).

As there is currently no published data available concerning the use of occlusal indices on hypodontia patients, it is impossible to relate this data to previous work. It is possible, however, to say that as the number of congenitally missing teeth increased, so did the DAI score, with a correlation coefficient of 0.215. This indicates that DAI has relevance in assessing hypodontia patients, whereas PAR and ICON do not. The clinical question is whether the DAI can be used effectively on hypodontia patients for referral, treatment, and research purposes.

Referral and treatment need

A previous study (Hobkirk *et al.*, 1994), reported that patients with hypodontia were referred late, with an age range between 8 and 13 years. The age range in the present study, 9–16 years, indicates again the late presentation of patients with hypodontia. It must be noted, however, that one patient was omitted from the study as they were predominantly in the primary dentition and this slightly skewed the age range. It would be incorrect to identify the primary care practitioner in terms of late referral since patient factors, e.g. eruption age of the permanent dentition, obviously plays a large role. However, any tool at the disposal of the primary care practitioner which would help in assessing the need for referral can only be beneficial. The DAI has decision points along its scale that approximate to the judgement of orthodontists (Jenny and Cons, 1996) and could potentially aid early referral:

**Figure 1** (a) Scatterplot showing the number of missing teeth excluding second molars versus Peer Assessment Rating (PAR). (b) Index of Complexity, Outcome and Need (ICON). (c) Dental Aesthetic Index (DAI) scores.

25 or less represents normal or minor malocclusions with no or slight treatment need; 26–29 definite malocclusions with treatment elective. 30–35 severe malocclusions with treatments highly desirable.

36 or more very severe or handicapping malocclusions with treatment considered mandatory.

The mean DAI score of 42 indicates that the majority of the hypodontia patients in this sample lie in the handicapping malocclusion category and would be referred for treatment. There was a small proportion (four) of the cases in the elective treatment category. It is difficult to speculate whether these four patients require elective treatment only or could be adequately managed by a single practitioner. A series of papers regarding the management of hypodontia highlight the importance and role of a multidisciplinary team in the care of hypodontia patients (Carter *et al.*, 2003; Hobson *et al.*, 2003; Jepson *et al.*, 2003; Meechan *et al.*, 2003; Nunn *et al.*, 2003). Combined clinics with specialists from orthodontics, paediatric dentistry, restorative dentistry, and oral surgery provide a wide range of expertise which is unlikely to be found in one individual (Oliver *et al.*, 1997). Therefore, it is considered essential for all patients with hypodontia to be referred since it can be seen that these cut off points on the DAI scale could be misleading for primary care practitioners. For example, if a patient had a DAI score of less than 29 they may not be referred due to the low DAI score, thus potentially missing the opportunity for treatment discussion on a combined clinic. However, the DAI has potential for identifying those with the greatest need for multidisciplinary care and further research is required.

Treatment outcome and research

The correlation between DAI score and the number of missing teeth indicates the relative sensitivity of the index to malocclusions in subjects with hypodontia. Although the DAI was originally developed to measure treatment need, not outcome, it has been used previously to assess outcome by Lobb *et al.* (1994); however, they indicated the need for further research. It would seem that the continuous nature of the DAI scale would lend itself to use for research purposes but at this stage it is not fully justified for treatment outcome.

Conclusion

The results of this investigation suggest that the DAI may be sufficiently clinically sensitive to be used for assessing whether or not to refer patients with hypodontia. Further research is required to determine the sensitivity of the index when used in this manner.

Address for correspondence

Dr A. T. Shelton
22 Roman Gardens
Roundhay
Leeds LS8 2AJ
UK
E-mail: andrewshelton22@yahoo.co.uk

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