

# The Reliability of the Index of Orthodontic Treatment Need over Time

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**Abstract.** *The aim of this investigation was to establish whether the Index of Orthodontic Treatment Need is reliable over time between the ages of 11 and 19 years. It consisted of a longitudinal sample of 314 11- and 15-year-old and 142 19-year-old subjects who had not received orthodontic treatment or extractions. The changes in the aesthetic component (AC) and the dental health component (DHC) of the Index of Orthodontic Treatment Need (IOTN) were measured between the ages of 11 and 19 years.*

*The results suggested that the dental health component of IOTN was reliable over time between the ages of 11–19 years despite temporal changes in the separate occlusal traits that comprise the index. The aesthetic component of IOTN tended to show an improvement over time.*

*The Index of Orthodontic Treatment Need is a reliable index over time when taking into account occlusal changes that are occurring during the 11–19-year age range. The study provides some reassurance to clinicians that an IOTN grading at age 11 years is unlikely to change by the time the patient is 19 years.*

*Index words:* Index of Orthodontic Treatment Need, Occlusal Index, Reliability.

*Refereed Scientific Paper*

## Introduction

Epidemiological indices have been used to measure orthodontic treatment need from a normative or clinician's viewpoint. Such measurements are important for health services planning and monitoring of population trends. Previous indices (Angle, 1899; Bjork *et al.*, 1964) were not designed to quantify treatment need. Later, Summer's Occlusal Index (Summers, 1971) and Grainger's Treatment Priority Index (Grainger, 1967) were developed that included well defined measurements, but no assessment of function.

The Index of Orthodontic Treatment Need (IOTN; Brook and Shaw, 1989) defines specific, distinct categories of treatment need, whilst including a measure of function. It has been shown to be easy to use for epidemiological studies, acceptable to the profession and public and amenable to statistical analysis (Brook, 1987; Holmes, 1992).

The reliability of IOTN over time has not previously been investigated and this is important because there are minor changes in occlusion, during adolescence, that might influence IOTN recordings. Previous literature provides evidence for such minor changes in occlusion, for example, an increase in lower labial segment crowding during development of the dentition (Sakuda *et al.*, 1976; Sinclair and Little, 1983). Other examples include a tendency for above average overjets to decrease between 12 and 20 years

(Bjork, 1953; Savin and Savara, 1972) and overbite to reduce as well, despite increasing between 9 and 12 years of age (Moorrees, 1959; Adams, 1972, Sinclair and Little, 1983).

In the light of these occlusal changes, it is pertinent to ask whether any index, currently in use, records the same grading throughout adolescence. It could then be used to inform patients who are 11–12 years old, with more certainty, that their priority for treatment would be unlikely to change as they grow older. Therefore, the aim of this study was, first, to establish whether IOTN was reliable over time between the age of 11 and 19 years old for subjects who had not received orthodontic treatment. The second aim was to investigate the changes over time in the occlusal traits that comprise the dental health component of IOTN.

## Sample

Study casts of a longitudinal sample of 11-year-old ( $n = 314$ ), 15-year-old ( $n = 314$ ) and 19-year-old ( $n = 142$ ) subjects were examined. The study casts originated from an observational survey reported by Shaw and Addy (1986). Originally, a sample of 1018 11–12-year-old South Wales school children were selected by disproportionate stratified sampling so that occlusal features of low prevalence, but high orthodontic interest were represented. In this study, children were selected according to the following criteria:

1. No history of orthodontic treatment.
2. No history of extractions for orthodontic or carious reasons.

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3. No history of anterior crowns, although some subjects with posterior crowns on first permanent molars were included.
4. Subjects with congenitally absent permanent teeth and retained primary teeth were included.
5. The study casts were of acceptable quality and not damaged.

Table 1 shows the number of children followed up in Shaw's study and the number obtained after the selection criteria for this study were applied. The reduction in sample size at age 19 years was because the subjects had either failed to return, had commenced orthodontic treatment

between 15 and 19 years of age, had teeth extracted or anterior crowns placed.

## Methods

### *The Index of Orthodontic treatment Need (IOTN)*

IOTN consists of two components, the dental health component (DHC) and the aesthetic component (AC). The dental health component is a grading of 1–5, where 1 = no need for treatment and 5 = great need for treatment. The grade allocated depends on the measurement of the most severe occlusal trait and is summarized in Figure 1.

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

FIG. 1 The Dental Health Component of the Index of Orthodontic Treatment Need (IOTN).

The aesthetic component of the index is designed to complement the dental health component by recording the severity of anterior aesthetic tooth arrangement with grade 1 being no aesthetic need through to grade 10, great aesthetic need for treatment (Figure 2).

TABLE 1 The number of children fulfilling the selection criteria in this study compared with the original longitudinal sample (Shaw and Addy 1986)

	11 years	15 years	19 years
Original sample	1018	792	456
This study sample	*	314	142

\*Three-hundred-and-fourteen study casts of 11-year-old children were obtained corresponding to the 314 available at age 15 years.

The aesthetic and dental health components of IOTN were recorded for each set of study casts. Each part of the dental health component was recorded separately and information such as lip competency and displacement on closure was gained from the Cardiff database that accompanied the study casts.

*Examiner Reliability*

One examiner (SC), who was calibrated in the use of IOTN, assessed the study models. Intra-examiner reliability was measured by re-scoring a random sample of 100 models 6 weeks apart.



FIG. 2 The aesthetic component of IOTN.

### Statistics

IOTN scores for the index and each dental health component were compared across ages 11–15, 15–19, and 11–19 years. However, for some dental health components, the recorded frequencies were too small to allow analysis therefore, they were excluded. The data were dichotomised to allow McNemar test to be carried out. This looks specifically for statistically significant changes in IOTN score in one direction or another, and ignores any IOTN scores that stay the same over time. Weighted kappa statistic was used to confirm the examiner calibration and to assess intra-examiner reliability.

### Results

#### Reproducibility

The results of the examiner calibration were 0.80 for the dental health component and 0.77 for the aesthetic component of IOTN. Over the 6-week time interval, intra-examiner reliability was 0.88 for the dental health component of IOTN and 0.70 for the aesthetic component. Kappa values ranged from 0.61 to 1.00 for the separate occlusal traits recorded as part of IOTN DHC.

#### Descriptive Statistics

The final sample therefore consisted of study models of 314, 11, 314, 15, and 142, 19-year-olds. The data in Table 2 describes the percentage of subjects in different aesthetic and dental health component categories over time. Tables 3–8 summarize the percentage of subjects with specific malocclusion traits at 11, 15, and 19 years. However, it is not possible to infer trends from these initial summary statistics because some subjects may have moved IOTN grading in an upward or downwards direction, and some may have stayed in the same category.

The numbers of subjects that moved IOTN categories, the direction of movement and those that stayed in a consistent category are summarized in Table 9. Potential important trends that these results highlighted were that 11-year-old children's IOTN AC seemed to stay fairly constant or improve over time. Similarly, an appreciable

TABLE 2 Changes in the percentage aesthetic component (AC) and dental health component (DHC) of IOTN between 11 and 19 years of age

		Age		
		11 years	15 years	19 years
IOTN AC	1–4	58	61	66
	5–7	38	36	31
	8–10	4	4	3
IOTN DHC	1–2	28	32	31
	3	38	39	48
	4–5	34	28	21

For aesthetic need for treatment: Grades 1–4 = no need; Grades 5–7 = borderline need; Grades 8–10 = definite need. For dental health component need for treatment: Grades 1 and 2 = no or little need; Grade 3 = moderate need; Grades 4 and 5 = definite need.

TABLE 3 Changes in overjet from 11 to 19 years of age (percentages shown for each age group)

Overjet measurement (mm)	IOTN DHC grade	11 years	15 years	19 years
<3.5	1	55	66	77
3.5–6 competent lips	2	19	22	17
3.5–6 incompetent lips	3	17	4	3
6–9	4	7	6	1
>9	5	3	2	1

TABLE 4 Changes in overbite (OB) from 11 to 19 years of age (percentages shown for each age group)

Overjet measurement (mm)	IOTN DHC grade	11 years	15 years	19 years
<1	1	11	15	13
1 < OB < 3.5	—	23	34	42
>3.5	2	56	43	37
no gingival contact				
Deep OB complete on gingival tissue but no trauma	3	9	7	6
Deep OB complete and traumatic on gingival or palatal tissue	4	2	1	3

TABLE 5 The percentage of subjects in each category for impeded eruption between the ages of 11 and 19 years

Impeded eruption	IOTN grade	11 years	15 years	19 years
None	—	85	94	98
Part impacted	4	5	3	1
Impacted	5	11	4	1

TABLE 6 Changes in the percentage of subjects exhibiting displacement of contact points

Displacement of contact points (DCP) (mm)*	IOTN grade	11 years	15 years	19 years
<1	1	7	4	3
1 < DCP < 2	2	37	36	35
2 < DCP < 4	3	46	47	55
>4	4	9	13	8

\*Note only the most severe contact point displacement is recorded.

TABLE 7 Changes in posterior crossbite (percentage) from 11 to 19 years and changes in mandibular path of closure from 15 to 19 years

Type of posterior crossbite	IOTN DHC grade	11 years	15 years	19 years
None	—	65	68	68
Unilateral	—	25	23	23
Bilateral	—	9	8	9
Mandibular path of closure				
< 1 mm discrepancy	2	—**	63	70
between ICP and RCP*				
1 mm < discrepancy between ICP and RCP < 2 mm	3	—	32	20
> 2 mm discrepancy				
between ICP and RCP	4	—	5	2

\*ICP = intercuspal position, RCP = retruded contact position.

\*\* No data available.

TABLE 8 Changes in percentage of subjects with lip competence and incompetence from the age of 11–19 years

Lip competence	11 years	15 years	19 years
Competent	59	89	88
Incompetent	41	11	12

TABLE 9 Summary of number of subjects over the age 11–19 years that stayed consistent within IOTN categories and those that changed category including the direction of the change

	Stayed in a same category	Moved to a higher category	Moved to a lower category
<b>IOTN AC category</b>			
1–4	128 (93%)	9 (7%)	—
5–7	14 (41%)	0 (0%)	20 (59%)
8–10	2 (67%)	—	1 (33%)
<b>IOTN DHC category</b>			
1–2	33 (67%)	16 (33%)	—
3	40 (74%)	5 (9%)	9 (17%)
4–5	22 (56%)	—	17 (44%)
<b>Overjet DHC grade</b>			
1–2	101 (99%)	1 (1%)	—
3	1 (3%)	0	29 (97%)
4–5	4 (40%)	—	6 (60%)
<b>Overbite DHC grade</b>			
1–2	127 (96%)	5 (4%)	—
3	4 (50%)	1 (13%)	3 (37%)
4	1 (50%)	—	1 (50%)
<b>Impeded eruption DHC grade</b>			
No impeded eruption	125 (98%)	2 (2%)	—
4	0 (0%)	0 (0%)	5 (100%)
5	1 (10%)	—	9 (90%)
<b>Displaced contact points DHC grade</b>			
1–2	44 (64%)	25 (36%)	—
3	51 (84%)	2 (3%)	8 (13%)
4	7 (58%)	—	5 (42%)
<b>Posterior crossbite*</b>			
None	89 (84%)	17 (16%)	—
Unilateral	19 (61%)	5 (16%)	7 (23%)
Bilateral	4 (80%)	—	1 (20%)

\*From 11–19 years, 39 patients with no mandibular displacement on closure stayed the same, 102 patients with no mandibular displacement went into a higher IOTN DHC category exhibiting a mandibular displacement on closure.

percentage of subjects tended to see a reduction in overjet and overbite between 11 and 19 years of age. It was further noted that 36 per cent of the children with IOTN displacement of contact points grades 1–2 at 11 years worsened during their teenage years.

Table 10 shows any statistically significant changes with age for the dental health component and aesthetic component of IOTN. In addition to overall IOTN grade, temporal changes in occlusal traits comprising the dental health component are also summarised in Table 10.

*No change or an improvement in IOTN grading over time (Table 10).* There was no statistically significant change in overall IOTN DHC grade or anterior crossbite between the ages of 11 and 19 years. In contrast, overjet measurement reduced significantly between 11 and 19 years,

meaning that there was a statistically significant change in this IOTN trait over time.

Of the children who changed IOTN category over time, more of the children went into a lower category than went into a higher category for the following additional variables:

1. IOTN AC.
2. Overbite.
3. Impeded eruption.
4. Incompetent lips.

Therefore, there was a trend for improvement (reduction in IOTN DHC score) for these variables.

*Worsening of IOTN grading over time (Table 10).* For posterior crossbites and displacement of contact points (crowding), more of the children, who changed IOTN category, went in a higher rather than a lower direction. Therefore, the trend was for these variables to worsen between 11 and 19 years of age.

For further analysis, the time periods 11–15 and 15–19 years were examined separately (Table 11). A statistically significant change was not seen in IOTN DHC grade, but was seen in the aesthetic component of IOTN grade between 11 and 15 years. As indicated before this tended to be an improvement in anterior aesthetic tooth appearance. Considering the separate components of IOTN DHC, most of the statistically significant changes were occurring in the 11–15-year age range, rather than 15–19 years. The notable exceptions to this were crowding and overbite changes that were also occurring at a statistically significant level between 15 and 19 years of age.

TABLE 10 Changes in IOTN and some of its dental health components between 11–19 years

Variable	Trend	P value
IOTN AC	Higher at 11 years	< 0.001
IOTN DHC	No statistically significant change	0.11
Impeded eruption	Higher at 11 years	0.004
Overjet	Greater at 11 years	< 0.001
Posterior crossbite	Worse at 19 years	0.02
Displacement of contact points	Worse at 19 years	0.01
Overbite	Greater at 11 years	< 0.001
Lip competency	Worse at 11 years	< 0.001

TABLE 11 Changes occurring in IOTN and some of its dental health components between 11–15, 15–19, and 11–19 years of age

Variable	P value 11 v. 15 years	P value 15 v. 19 years	P value 11 v. 19 years
IOTN AC	0.001	0.34	0.008
IOTN DHC	0.21	0.14	0.57
Impeded eruption	0.001	1.00	0.004
Overjet	0.001	0.07	0.001
Posterior crossbite	0.001	1.00	0.02
Displacement of contact points	0.09	0.02	0.01
Overbite	0.001	0.04	0.001
Lip competency	0.001	1.00	0.001

## Discussion

The study has suggested that the IOTN dental health component grade is reliable between 11 and 19 years of age. This is despite being comprised of occlusal traits that change over time. In contrast, the IOTN aesthetic component grade was not as reliable between the ages studied but showed that anterior aesthetic appearance tended to improve during adolescence.

### *Occlusal Traits Comprising the Dental Health Component of IOTN that Improved over Time*

Temporal occlusal changes recorded in this study were in broad agreement with previous literature. For example, a reduction in overjet during the teenage years was also found by Bjork (1953), and Savin and Savara (1972). However, we have shown that most of this overjet reduction is likely to occur between 11 and 15 years, and probably reflects facial changes during the pubertal growth spurt. Similarly, lip competency improved much more markedly during the latter age group although a general improvement in lip competency has previously been reported cross-sectionally (Stephenson, 1962; Luffingham, 1978). Despite the comparisons with previous literature that have been made, it is difficult to compare the results of this study with other work because of the drop-out between 15 and 19 years of age. This may have affected the distribution of occlusal traits for the 19-year age group data. Not all reductions in severity of occlusal traits were confined to the 11–15-year-old group. In the case of overbite, changes were occurring from 11 to 19 years and this is likely to reflect continued vertical growth that occurs during the teenage years. Previous studies also confirm a reduction in overbite depth between 11 and 19 years of age (Moorrees, 1959; Adams, 1972; Sinclair and Little, 1983).

Perhaps these improvements in overjet and overbite are instrumental in influencing changes in aesthetic component grades as the orthodontically untreated individual gets older. This could be a possible explanation for the improvement in IOTN AC scores over time. Alternatively, more subjects with higher aesthetic component grades at age 11 years, may have sought orthodontic treatment and therefore would not have been included in the 19 years old sample.

### *Occlusal Traits Comprising the Dental Health Component of IOTN that Worsened over Time*

Contact displacements or crowding increased between 11 and 19 years and this appears to be universally supported for the lower labial segment (Barrow and White, 1952; Cryer, 1966; Lundstrom, 1969; Humerfelt and Slagsfold, 1972; Sakuda et al., 1976; Sinclair and Little, 1983).

In contrast, there is a diversity of opinion about molar arch widths during the growth phase of the dentition. Some studies have shown a reduction in arch width (Brown and Daugaard-Jenson, 1951; Barrow and White, 1952; Sinclair and Little, 1983; Bishara et al., 1989), whilst others suggest small increases of approximately 1 mm (Moorrees, 1959; Sillman, 1964; Lundstrom, 1969; Humerfeld and Slagsfold,

1972). From this literature, a reduction in maxillary arch width over time, or perhaps growth changes between the arches, may explain why posterior crossbites were worse at 19 years than 11 years in this study. Alternatively, possibly the eruption of the second permanent molars may have been a factor in worsening the posterior crossbite grading. However, it is important that severity of IOTN grade for posterior crossbite relies on the amount of mandibular displacement and there does not seem to be any evidence of the extent of the displacement being correlated with the size of the crossbite. This is an area that would need further investigation.

### *The Reliability of the Dental Health Component of the Index of Orthodontic Treatment Need*

It is interesting to see that the dental health component of IOTN overall is reliable between 15–19 years despite being sensitive enough to detect changes in separate occlusal traits. However, it is important to see if these results might be applicable to the general population. When the 11-year-old data was compared with other population studies (Tables 12 and 13), the distribution of DHC grades compared favourably with Brook and Shaw (1989), and Holmes (1992) whose subjects could be divided into almost equal thirds of definite, borderline, and no treatment need. The subjects in this study followed a similar pattern with the exception of less subjects in grade 1 and slightly more subjects in grade 5. This may have been as a result of the disproportionate stratified sampling that was designed to increase the frequency of dental abnormalities.

## Conclusions

1. The dental health component of IOTN is reliable between 11 and 19 years despite temporal changes in the separate occlusal traits that comprise the index.
2. The study provides some reassurance to clinicians that on IOTN DHC grading at age 11 years is likely to be similar when the patient reaches 19 years.

TABLE 12 A comparison of IOTN DHC grades at 11 years with studies by Brook and Shaw (1989), and Holmes (1992)

IOTN DHC grade	Present study (n = 314) %	Brook and Shaw (1989) (n = 333) %	Holmes (1992) (n = 995) %
1	0	7	6
2	28	28	29
3	38	32	33
4	22	28	21
5	12	3	11

TABLE 13 A comparison of IOTN AC grades at 11 years with Brook and Shaw (1989)

IOTN AC grade	Present study (n = 314)	Brook and Shaw (1989) (n = 333)
1–4	57.4	58.2
5–7	38.4	36.3
8–10	4.2	5.4

3. The aesthetic component of IOTN tended to show an improvement over time. Therefore, perhaps treatment need categories at age 11 years could be adjusted so that the aesthetic need would also be reliable over time.
4. Most of the occlusal traits contributing to IOTN DHC improved over time except posterior crossbite and displacement of contact points that worsened between 11 and 19 years.

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