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Applicability of the IOTN-AC index in a bimaxillary protrusion population

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Objective: The objective of this study was to assess the validity of the IOTN-AC in the assessment of aesthetic impairment in bimaxillary protrusion patients.
Materials and methods: A cross-sectional study was conducted and involved 110 patients comprising 52 males (47.3%) and 58 females (52.7%) who were accepted for fixed appliance treatment at The University of the West Indies Dental Hospital and provided consent for the use of their records. The mean age was 13.45 years. Participants were asked to complete a questionnaire regarding their reasons for seeking orthodontic treatment and score their self-perceived IOTN-AC. An orthodontist also scored the malocclusion using the IOTN (AC and DHC).
Results: Spearman's correlation between patient IOTN-AC and orthodontist IOTN-AC was $r = 0.435$, ($p < 0.001$). However, the patient IOTN-AC and the 'normative' need ($p = 0.198$), as well as the orthodontist IOTN-AC and the 'normative' need ($p = 0.334$), were not correlated ($r = 0.124$ and $r = 0.094$, respectively). Both patient and the orthodontist IOTN-AC scores were not in agreement with 'normative' need (IOTN-DHC). Cohen's kappa test determined an agreement between the patient's IOTN- AC and an orthodontist's IOTN AC score, $k = 0.395$, $p < 0.001$. The questionnaire revealed aesthetics as the primary reason for seeking treatment but there was poor correlation between the questionnaire items and the patient or orthodontist IOTN-AC score, an AC score of 3 being the most common score for both.
Conclusion: The IOTN-AC is not a valid tool to determine patient perception of the need for treatment in a bimaxillary protrusion population when scored by either patients or orthodontists.
(Aust Orthod J 2023; 39: 120 - 129. DOI: 10.2478/aoj-2023-0010)

Received for publication: December, 2022
accepted: January, 2023.

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Introduction

Patients most commonly seek orthodontic treatment to enhance their dental and facial appearance.[1,2] The perception of facial attractiveness underpins the development of self-esteem and the assessment of personal attractiveness. Self-perception, peer and parental factors all influence the need for treatment.[3]

Bradshaw[4] distinguished four types of need, 'normative', 'felt', 'expressed' and 'comparative' of which the first three are of relevance in this study. 'Normative' need is defined by an orthodontist based upon an assessment against an agreed set of criteria (from the application of an index or full orthodontic assessment). 'Felt' need is an individual's own assessment of their need. 'Expressed' need is felt need turned into action and becomes a demand. The provision for orthodontic treatment is determined by demand and normative need. This means that orthodontic treatment is influenced, not only by patient perception but also the orthodontist's clinical examination.[1,5]

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Occlusal indices can quantitatively assess orthodontic treatment need. Many occlusal indices have highlighted the importance of aesthetics and these include the Aesthetic Component of the Index of Orthodontic Treatment Need (IOTN),[6] the Dental Facial Attractiveness scale, the Social Acceptability Scale of Occlusal Conditions[7] and the Oral Aesthetic Subjective Impact Scale.[8]

The Index of Orthodontic Treatment Need (IOTN) is a widely used assessment tool. It consists of two parts, one of which is the aesthetic component (which looks at aesthetic impairment) (AC).[9,10] The AC measures anterior tooth attractiveness and can be regarded as a subjective assessment. The other part is the dental health component (DHC) which ranks different occlusal traits, their likely impact on oral health and is a more objective component of the IOTN.

Ngom et al. stated that there was evidence that dental aesthetics may be judged variably in different populations[11] and, in some ethnic groups, the IOTN assessment of need does not coincide with the patient's perception. Performing a full orthodontic assessment to ascertain treatment need in various ethnic groups may be a more valid assessment.[12] This may be especially true in populations in which bimaxillary protrusion is more prevalent since several occlusal traits common to bimaxillary protrusion are not represented in the IOTN.[13] An additional critique of the IOTN is that it deals solely with dental malocclusion rather than facial aesthetics.[14] A bimaxillary protrusion is an example in which an unacceptable facial profile is likely present without measurable dental or occlusal irregularity.[14] The impact on psychosocial well being can be severe, and many bimaxillary protrusion patients seek orthodontic treatment to improve their facial appearance,[15,16] but IOTN and other occlusal indices may not categorise these patients as in need and therefore exclude them from publicly funded treatment provision.[14]

In the present study, the participants presented a facial profile described as bimaxillary protruded as a result of bimaxillary prognathism (prognathic maxilla and mandible) and bimaxillary proclination (proclined upper and lower incisors).[12] The cephalometric norms for this sample had been previously published.[12]

Aim

Therefore, the present study aimed to assess the validity of the AC component of the IOTN in bimaxillary protrusive patients.

Subjects and methods

The University of The West Indies Ethics Committee granted ethical approval (Ref: CEC001/12/12) before the commencement of the project. The study was designed according to the principles of the Helsinki declaration.

The sample consisted of 110 patients who were accepted for fixed appliance treatment at The University of the West Indies Dental Hospital, all of whom gave consent for the use of their records. The age range of the subjects was 10–17 years.

The study recruited patients who sought treatment and presented with bimaxillary protrusion malocclusions within the twin-island republic. Only patients accepted into the fixed appliance program based on predetermined inclusion/exclusion criteria were included in the study.

The applied inclusion criteria were: a bimaxillary protrusion (presence of bimaxillary prognathism and dental bimaxillary protrusion); a Class 1, Class 2 division 1 or a Class 3 incisor relationship; no previous orthodontic treatment; and an IOTN-DHC score of 3 or 4. Excluded from the study were patients who required surgery, had a systemic

Table I. Inter and intra examiner reliability for orthodontist IOTN scores.

Test	Intra-examiner reliability (IOTN-AC)		Intra-examiner reliability (IOTN-DHC)		Inter-examiner reliability (IOTN-AC)		Inter-examiner reliability (IOTN-DHC)	
Spearman's correlation	0.821	<0.001	0.604	0.002	0.914	<0.001	0.713	<0.001
Cohen's Kappa	0.681	<0.001	0.477	<0.001	0.872	<0.001	0.599	<0.001

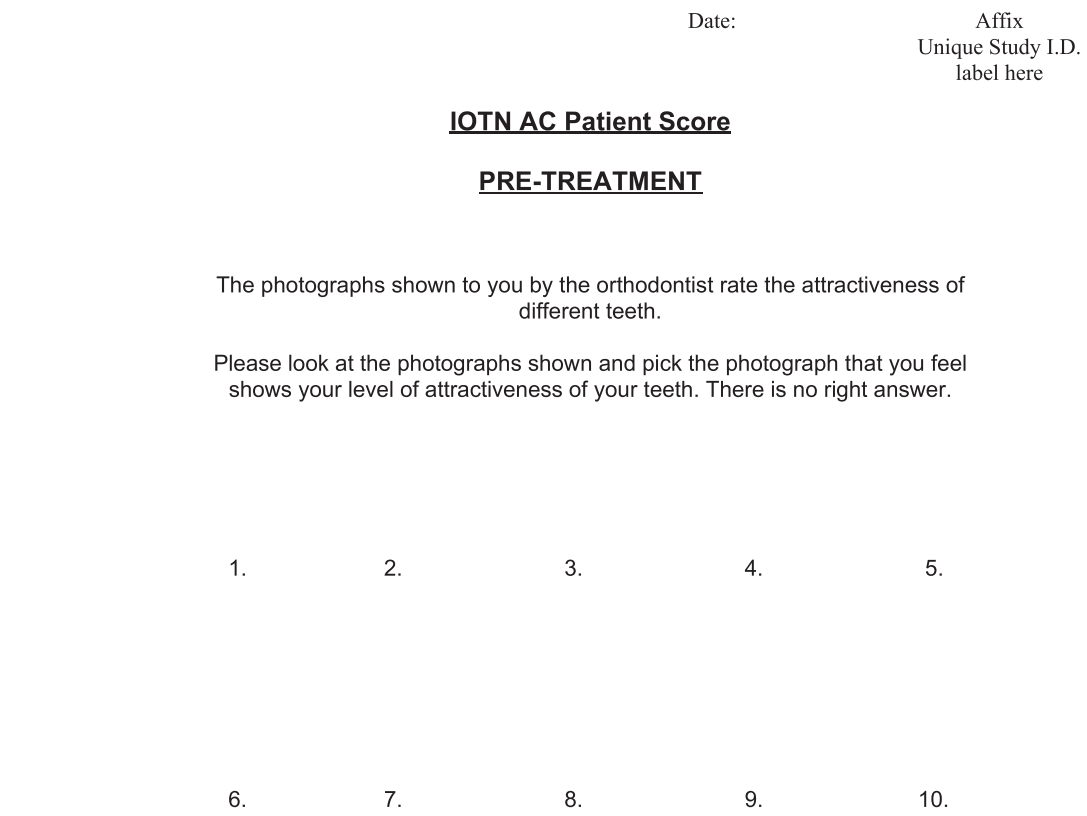


Figure 1. IOTN-AC score sheet.

illness, who were taking anti-inflammatory drugs or had a cleft lip or palate or a cranio-facial syndrome.

Participants were asked to complete a questionnaire that checked items related to their subjective assessment of their dental appearance. They were also asked to score their malocclusion using the IOTN-AC. No interview was conducted to evaluate patient perception. Pretreatment intraoral photographs were obtained and edited by the faculty photographer at the initial records appointment. The orthodontist (TH) scored the IOTN-DHC on obtained patient's dental casts. Twenty-three records were randomly selected for review by a second author (D.B) to assess measurement error and to measure inter- and intra-examiner reliability (Table I).

Data collection

All data were recorded on a customised data collection form. The first section identified demographic information including age and gender. In the second section, dental aesthetics were assessed using the IOTN- AC[17] (Figure 1). The participants were presented with ten coloured images of anterior teeth and were asked to indicate which image most closely resembled the level of attractiveness of their dentition (Figure 2).

The third section consisted of a previously validated survey[18] consisting of 23 questions related to the participant's perception of their reasons for seeking orthodontic treatment (Figure 3).

Statistical analysis

The SPSS statistical package (IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armok, N.Y., USA) was used for statistical analysis and the level of significance was set at $p < 0.05$.

Based on treatment need for the aesthetic component of the IOTN, three categories were formed and graded mild (grade 1–4), moderate (grade 5–7), or severe (grade 8–10). The dental health component

of the IOTN categories were mild (grade 1 and 2), moderate (grade 3), and severe (grades 4 and 5).

Descriptive statistics were calculated for gender and patient IOTN-AC scores, gender and orthodontist IOTN-AC scores and gender and IOTN-DHC scores. As no cases were scored as moderate IOTN-AC by the orthodontist, it was decided to dichotomise scores into 'severe' or 'not severe' for further analysis.

Spearman's correlation was used to determine any association and Cohen's kappa was used to assess agreement between the patient's self-perception and orthodontist's perception of need, self-perception and normative treatment need and the relationship between orthodontist perception and normative need.[19,20]

The Pearson correlation was applied to assess the relationship between selected questionnaire items related to perceived dental aesthetics (Q1 and Q5) and the original patient IOTN-AC scores.

Twenty-three cases were randomly selected and rescored by the principal investigator (T.H) and for confirmation, a second investigator (D.B) scored the same cases. Spearman's correlation was used to evaluate inter- and intra-examiner reliability (Table I).

Results

The sample consisted of 110 participants, of whom 52 were males (47.3%) and 58 were females (52.7%). The age range of the subjects was between 10 and 17 years. The mean age was 13.45 years with a standard deviation of 1.83 years. The mean age fell within a 95% confidence interval (13.11, 13.80). The standard deviation was small and so



Figure 2. IOTN Aesthetic Scale.

Date:

Affix Unique Study I.D. label here

Treatment Questionnaire (Before)

These are some of the reasons why people want nicer teeth.
Please draw a ring round **one** of the numbers on each line.

	Not a reason			**Very** much a reason
To make my smile nicer	1	2	3	4
To help me chew food better	1	2	3	4
To make my family happy	1	2	3	4
To help me with my school work	1	2	3	4
To make my teeth look nicer	1	2	3	4
To help my breathing	1	2	3	4
To feel more confident	1	2	3	4
To help my top and bottom teeth fit together	1	2	3	4
To help me speak more clearly	1	2	3	4
To make my face look better	1	2	3	4
To make me feel better about myself	1	2	3	4
To keep my gums healthy	1	2	3	4
To make me healthier	1	2	3	4
To keep me from losing teeth in the future	1	2	3	4
To help me make friends	1	2	3	4
To keep my jaw joints healthy	1	2	3	4
To help my front teeth fit together	1	2	3	4
To make me look better	1	2	3	4
To make me feel better about going out	1	2	3	4
To help keep my jaw joint from clicking	1	2	3	4
To help my back teeth fit together	1	2	3	4
To make it easier to get on with people	1	2	3	4
To make it easier to bite into food	1	2	3	4

Please tell us on the other side of the page if there are any other reasons why you want nicer teeth

Figure 3. Participants assessments of their aesthetics.

there was little variation. The mean age of male participants was 13.15 years, and 13.72 years for the female participants. The inter- and intra-examiner reliability tests indicated a high level of reliability (Table I).

The greatest number of IOTN-AC patient scores fell into the mild need for treatment category (n = 81, 73.6%), with fewer falling into the moderate (n = 11, 10%) or severe (n = 17, 15.5%) categories. The majority of the orthodontist IOTN-AC scores also were graded as mild (n = 84, 76.4%), with none graded as moderate but a number noted as severe (n = 24, 21.8%). The outcome for the DHC scores indicated that 10 (9.1%) cases fell into the moderate need category and 100 (90.9%) cases were in the severe need category (Table II). There was one missing IOTN-AC patient score and 2 missing IOTN-AC orthodontist scores.

Table II. Frequency of IOTN scores by severity and gender.

	GENDER		
	Male (%)	Female (%)	Total (%)
Patient -Ac			
Mild	40 (49.4)	41 (50.6)	81 (73.6)
Moderate	7 (63.6)	4 (36.4)	11 (10)
Severe	4 (23.5)	13 (76.5)	17 (15.5)
Total	51 (46.8)	58 (53.2)	109 (99.1)
Missing			1 (0.9)
Orthodontist -Ac			
Mild	38 (45.2)	46 (54.8)	84 (76.4)
Moderate	0 (0)	0 (0)	0 (0)
Severe	14 (58.3)	10 (41.7)	24 (21.8)
Total	52 (48.1)	56 (51.9)	108 (98.2)
Missing			2 (1.8)
Orthodontist -DHC			
Moderate	5 (50)	5 (50)	10 (9.1)
Severe	47 (47)	53 (53)	100 (90.9)
Total	52 (47.3)	58 (52.7)	110 (100)

The most frequent IOTN-AC score determined by patients was 3 (n = 33). The most frequent score assessed by the orthodontist was also 3 (n = 42). The most frequent DHC score was 4D (n = 99). The orthodontist graded IOTN-DHC severe cases had the highest number of all categories (Figure 4).

A chi-square test was conducted to test for significant differences in gender between each component. The test revealed that there was no statistically significant difference between gender for patient IOTN-AC (p = 0.076), orthodontist IOTN-AC (p = 0.257) and IOTN-DHC (p = 0.856).

Spearman's correlation was used to determine the relationship between patient IOTN-AC and orthodontist IOTN-AC scores and the correlation between these and normative need (IOTN- DHC). A positive relationship (p < 0.0012) was observed between the patient IOTN- AC and the orthodontist IOTN-AC scores (r = 0.435). However, the patient IOTN-AC and the normative need (p = 0.198), as well as the orthodontist IOTN-AC and the normative need (p = 0.334), were not correlated (r = 0.124 and r = 0.094, respectively). Both, patient and the orthodontist IOTN-AC scores were not in agreement with normative need (IOTN-DHC). Cohen's kappa test for agreement was also used to assess the relationship between the IOTN scores and DHC scores due to the nature of the data. The results are shown in Table III and show the same significant differences as the Spearman correlation. A fair and statistically significant level of agreement was noted between the orthodontist and patient IOTN-AC (kappa = 0.395 p < 0.001, 95% CI, 0.218–0.572). However, no statistically significant level of agreement was found between the patient IOTN-AC and normative need (kappa = 0.017 p = 0.307, 95% CI, –0.006–0.040) as well as the normative treatment need and orthodontist IOTN-AC (kappa = 0.014 p = 0.329, 95% CI, –0.009–0.037).

Table IV shows the proportions and percentages of the responses to the 23 questions related to the participant's assessment of their aesthetics. More than half of the participants assigned 4 for Question 1 (55.5%) (to make their smile nicer was the main reason for seeking treatment). 63.6% assigned 1 for Question 3 (to make their family happy was not a reason for seeking treatment). 64.5% ascribed 4 for Question 5 (to make their teeth nicer was the main reason for seeking treatment). 51.8% allocated 4 for Question 8 (to help my top and bottom teeth fit together was the main reason for seeking treatment). Questions 1 and 5 indicated that the patient's self-reported reasons for seeking treatment were strongly related to dental aesthetics. The scores for the two questions were compared to the patient IOTN-AC scores (Table V). The Pearson correlation statistic showed a solid correlation between the two questions but a poor correlation for both questions related to patient IOTN-AC.

Discussion

The mean age of the study participants was 13.45 years. This age group is part of the modernisation of

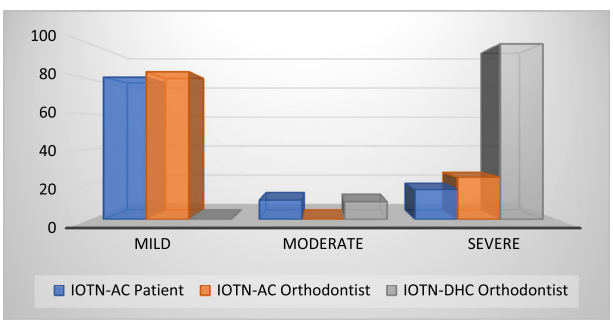


Figure 4. Frequency of scores for patient IOTN-AC and orthodontist IOTN-AC and IOTN-DHC.

Table III. Agreement and correlation between patient and orthodontist IOTN AC scores and normative need.

	IOTN-AC patient vs. Orthodontist		Patient IOTN-AC vs. IOTN-DHC		Orthodontist IOTN-AC vs. IOTN-DHC	
Test	*p* value		*p* value		*p* value	
Spearman's correlation	0.435	<0.001	0.124	0.198	0.094	0.334
Cohen's Kappa	0.395	<0.001	0.017	0.307	0.014	0.329

Table IV. Responses to questionnaire administered to participants.

Question	1(Not a reason)	2	3	4 (very much a reason)
1. To make my smile nicer	5 (4.5)	17 (15.5)	22 (20.0)	61 (55.5)
2.To help me chew food better	41 (37.3)	27 (24.5)	19 (17.3)	18 (16.4)
3. To make my family happy	70 (63.6)	11 (10.0)	15 (13.6)	9 (8.2)
4. To help me with my schoolwork	88 (80.0)	7 (6.4)	6 (5.5)	4 (3.6)
5. To make my teeth look nicer	7 (6.4)	6 (5.5)	21 (19.1)	71 (64.5)
6. To help my breathing	84 (76.4)	9 (8.2)	8 (7.3)	3 (2.7)
7. To feel more confident	21 (19.1)	14 (12.7)	23 (20.9)	46 (41.8)
8. To help my top and bottom teeth fit together	8 (7.3)	15 (13.6)	24 (21.8)	57 (51.8)
9. To help me speak more clearly	47 (42.7)	21 (19.1)	13 (11.8)	24 (21.8)
10. To make my face look better	31 (28.2)	23 (20.9)	28 (25.5)	23 (20.9)
11. To make me feel better about myself	32 (29.1)	14 (12.7)	23 (20.9)	36 (32.7)
12. To keep my gums healthy	16 (14.5)	19 (17.3)	32 (29.1)	37 (33.6)
13. To make me feel healthier	30 (27.3)	16 (14.5)	17 (15.5)	41 (37.3)
14. To keep me from losing teeth in future	23 (20.9)	15 (13.6)	14 (12.7)	52 (47.3)
15. To help me make friends	84 (76.4)	10 (9.1)	6 (5.5)	5 (4.5)
16. To keep my jaw joints healthy	23 (20.9)	23 (20.9)	25 (22.7)	33 (30.0)
17. To help my front teeth fit together	9 (8.2)	14 (12.7)	31 (28.2)	51 (46.4)
18. To make me look better	25 (22.7)	16 (14.5)	25 (22.7)	39 (35.5)
19. To make me feel better about going out	42 (38.2)	23 (20.9)	19 (17.3)	20 (18.2)
20. To help keep my jaw joint from clicking	47 (42.7)	20 (18.2)	18 (16.4)	19 (17.3)
21. To help my back teeth fit together	26 (23.6)	19 (17.3)	19 (17.3)	40 (36.4)
22. To make it easier to get on with people	79 (71.8)	8 (7.3)	9 (8.2)	8 (7.3)
23. To make it easier to bite into food	40 (36.4)	17 (15.5)	14 (12.7)	34 (30.9)

communication and the social media revolution.[21,22] Social media and television have increased knowledge and awareness of the benefits of orthodontic treatment and the pursuit of a 'Hollywood' smile.[22] The facial convexity associated with a bimaxillary protrusion is not seen as attractive by this standard.[23] These factors have increased the demand for orthodontic treatment in Trinidad and Tobago, where a bimaxillary protrusion is the most prevalent malocclusion.[24,25]

The IOTN-AC assesses the visible part of the malocclusion.[26] It is important to assess patients using an aesthetic measure to evaluate the effect of a malocclusion on self-esteem and self-perception.[27] The patient's subjective assessment using the IOTN-AC indicated only 15.5% of the cases had a severe aesthetic need. The subjective assessment of need for both patients and orthodontists using IOTN-AC was much lower than expected given the findings of the questionnaire in which 63% reported smile aesthetics as the main reason for seeking treatment. This finding suggests that the validity of using the IOTN-AC to assess dental attractiveness in this population needs to be questioned.

Bimaxillary protrusion patients often present with bimaxillary proclination as the prime reason for treatment. This trait and the related occlusal traits such as a reduced overbite and an anterior open bite are not represented in the IOTN-AC.[13] This lack of image representation is the most likely factor that led to the patient's low self-reported IOTN-AC scores. In addition, the orthodontist's IOTN-AC scores was also low because the most common score for both groups was 3. The IOTN-AC was developed as a sensitive marker for the aesthetic needs of patients and should therefore be able to detect aesthetic impairment so that treatment services are appropriately directed.[28]

A more detailed insight into a patient's motivation for seeking treatment was obtained from the 23-item questionnaire. The incorporated questions were a supportive way to assess patients' opinions regarding their treatment needs, and a better assessment than the IOTN-AC for self-evaluation.[29] The questionnaire revealed that most participants sought treatment to improve aesthetics, self-esteem, and function (Table IV). Shaw et al. stated that the most important feature for overall appearance is facial attractiveness[30] which was similar to previous findings.[31,32] In the present study, 64.5% of participants rated dental aesthetics as the most important reason for seeking treatment. This was higher than the 55% of people reported by Graber and Lucker, and lower than the 99.4% assessed by Al-Zubair whose study attached significantly greater importance to dental appearance.[33,34]

The use of the IOTN-AC in the West Indian population does not appear to be sensitive to the patients' aesthetic concerns. The study participants all expressed a need for treatment and reported high aesthetic concern as the main reason. For an index to be effective, it needs to be valid as well as reliable and, further, must represent what it purports to measure. In a bimaxillary protrusive population, it appears that the IOTN-AC is not able to detect and record aesthetic need and therefore its usefulness is questionable. In addition, the IOTN-AC scores graded by the orthodontist were similar to the scores determined by the patients as correlation and agreement were sound. This further suggested that the issue lies with the IOTN-AC itself rather than a patient's inability to understand the concept and therefore use the scale incorrectly. Individual differences related to personality (reasons for wanting treatment) and gender must also be considered during treatment decision making.[35]

The present study determined that aesthetic improvement was the most common reason for a patient to seek orthodontic treatment[3,36] but has highlighted that their perceived need is not recorded by the IOTN-AC. For the West Indian population, the IOTN-AC appears to be an inappropriate tool to assess the aesthetic need for orthodontic treatment.

Limitations

The present study was conducted from a convenience sample from a single centre. Due to the potential bias in

Table V. Correlation between patient IOTN AC and Questionnaire items Q1 and Q5.

	IOTN-AC patient vs Q1		Patient IOTN-AC vs. Q5		Q1 vs Q5	
Test	*p* value		*p* value		*p* value	
Pearson correlation	0.110	0.226	0.143	0.147	0.437	<0.001

this sampling frame, the investigation serves as a pilot for assessing the aesthetic needs in patients presenting with a bimaxillary protrusion malocclusion, and the results must be interpreted accordingly. The study was performed on participants aged 10 to 17 years and the conclusions might only be valid in this age group. Class 1, 11, 111 patients were included in the study and it is a possible that this introduced a confounding factor.

Conclusion

The IOTN-AC is not a valid tool to measure a patient's perception of their dental aesthetic need for orthodontic treatment in a West Indian bimaxillary protrusion population.

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Conflict of interest

The authors declare that there is no conflict of interest.

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