Journal of Plastic, Reconstructive & Aesthetic Surgery (2016) 69, 796–801

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Functional needs of subjects with dentofacial deformities: A study using the index of orthognathic functional treatment need (IOFTN)

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Received 5 January 2016; accepted 6 March 2016

KEYWORDS
IOFTN;
IOTN;
Orthognathic surgery;
Malocclusion;
Dentofacial deformity

Summary *Objectives:* To assess the functional needs of orthognathic patients treated in Isfahan University of Medical Sciences affiliated hospitals using the index of orthognathic functional treatment need (IOFTN).
Materials and methods: A retrospective study was conducted using 2011–2015 records of 103 patients [58 female, 45 males, 16–45 years, mean (SD) age = 23.47 (6.44) years] who had orthognathic surgery. Malocclusion type (incisor classification), sagittal skeletal pattern (ANB angle), IOFTN score, and Dental Health Component of the IOTN [IOTN (DHC)] were recorded.
Result: Overall, 92.2% and 82.5% of subjects scored 4 or 5 for IOFTN and IOTN (DHC), respectively, and no gender differences detected for both indices ($P > 0.05$). Gender differences detected for malocclusions/skeletal patterns ($P < 0.05$). Class III malocclusions (45.6%) and Class II skeletal patterns (51.5%) were the most prevalent type. Subjects with Class I, Class II, and Class III sagittal skeletal bases formed 4.8%, 51.5%, and 43.7% of the sample, respectively. IOFTN score of 5.3 (reverse OJ $\geq$ 3 mm, 27.2%) was the most prevalent, followed by 4.2(19.4%), 4.3(13.6%), 4.10 (12.6%), and 5.2 (8.7%). Subjects with Class III sagittal skeletal patterns or malocclusions had higher percentages of grade 5 IOFTN scores (62.2% and 59.6%), compared to Class II sagittal skeletal patterns or malocclusions (18.9% and 21.2%) and the distribution of functional needs between malocclusions or sagittal skeletal patterns were different ($p < 0.01$).

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http://dx.doi.org/10.1016/j.bjps.2016.03.008

Conclusion: IOFTN identified 92.2% of orthognathic surgery patients as having great and very great functional needs and appeared to be reliable tool to identify patients in need of orthognathic surgery. Higher percentages of Class III subjects scored grade 5 of IOFTN, indicating higher functional need for orthognathic surgery in this group.

Introduction

Orthognathic surgery often involves surgical procedures on the mandible, maxillae, or both, as well as their dentoalveolar segments to reposition the jaws into their normalised or functional relationship in subjects with dentofacial deformities.

Reports indicates that approximately 5% of the UK or USA population present with dentofacial deformities that are not amenable to orthodontic treatment only, requiring orthognathic surgery as a part of their definitive treatment.[1] Although preparation of orthognathic patients has been recently modified with introduction of the surgery-first approach,[2] conventional approach often includes a course of orthodontic treatment before and after orthognathic surgery.

Approximately, 2600—2900 patients undergo orthognathic surgery annually in England and Wales and the average costs of these treatments in 2012 ranged from £4000 to £8000 per case.[3] In the UK, orthognathic surgeries are funded by NHS England for patients with malocclusions and severe dentofacial deformities. The funding should be allocated to patients with the Index of Orthodontic Treatment Need (IOTN)[4] score of 4 or 5 and functional symptoms that have an important impact on patients' quality of life. With the current drive to reduce costs within the NHS, and in particular, to redirect resources from low priority treatments, to those considered to be high priority and their use is supported by evidence, having an index to objectively identify those treatment/patients seems necessary.

The index of orthognathic functional treatment needs (IOFTN) has been recently developed by Ireland et al. in the UK, aiming at prioritizing severe malocclusions not amenable to orthodontic treatment alone and need orthognathic surgery.[5] IOFTN has 5 categories, from a Very Great Need (grade 5) through to No Need for treatment (grade 1) (Table 1). Ideally, the funding should be used for patients with grades 4 and 5 of the IOFTN. The index has similarities with the IOTN, however, it has modifications to reflect the functional aspects of treatment need for orthognathic patients, which are missing in the IOTN, such as patients with sleep apnoea not amenable to *Mandibular Advancement Device (*MAD) or *Continuous Positive Airway Pressure* (CPAP), complete buccal scissors bite with functional implications (both categorised as graded 5 IOFTN) as well as maxillary labial gingival exposure greater than 3 mm (grade 4 IOFTN). The index does not support the provision of orthognathic treatment for speech or TMJ disorders.

IOFTN has been used in the UK,[5–7] but its external validity has not been tested outside the UK. It would be interesting to see if IOFTN identifies subjects who had

Table 1 Different functional need categories according to the IOFTN, adapted from Ireland et al.[5]

IOFTN Grade	
5	**Very Great Need for Treatment**
5.1	Defects of cleft lip and palate and other craniofacial anomalies
5.2	Increased overjet $>$ 9 mm
5.3	Reverse overjet $\geq$3 mm
5.4	Open bite $\geq$4 mm
5.5	Complete scissors bite affecting whole buccal segment(s) with signs of functional disturbance and or occlusal trauma
5.6	Sleep apnoea not amenable to other treatments such as MAD or CPAP (as determined by sleep studies)
5.7	Skeletal anomalies with occlusal disturbance as a result of trauma or pathology
4	**Great Need for Treatment**
4.2	Increased overjet $\geq$ 6 mm and $\leq$9 mm
4.3	Reverse overjet $\geq$ 0 mm and $<$3 mm with functional difficulties
4.4	Open bite $<$ 4 mm with functional difficulties
4.8	Increased overbite with evidence of dental or soft tissue trauma
4.9	Upper labial segment gingival exposure $\geq$ 3 mm at rest
4.10	Facial asymmetry associated with occlusal disturbance
3	**Moderate Need for Treatment**
3.3	Reverse overjet $\geq$ 0 mm and $<$3 mm with no functional difficulties
3.4	Open bite $<$ 4 mm with no functional difficulties
3.9	Upper labial segment gingival exposure $<$ 3 mm at rest, but with evidence of gingival/periodontal effects
3.10	Facial asymmetry with no occlusal disturbance
2	**Mild Need for Treatment**
2.8	Increased overbite, but no evidence of dental or soft tissue trauma
2.9	Upper labial segment gingival exposure $<$ 3 mm at rest with no evidence of gingival/periodontal effects
2.11	Marked occlusal cant with no effect on the occlusion
1	**No Need for treatment**
1.12	Speech difficulties
1.13	Treatment purely for TMD
1.14	Occlusal features not classified above

orthognathic treatment outside the UK as having great or very great functional need for surgery. Therefore, the primary objective of the present study was to assess, retrospectively, the functional needs of orthognathic cases treated in a university setting in Isfahan, Iran, using the IOFTN; and to compare the finding to reports from the UK. The secondary aim was to compare the functional needs (using the IOFTN) of patients with different malocclusions and sagittal skeletal patterns.

Materials and methods

The present research was approved by Isfahan University of Medical Sciences institutional review board (ethical approval committee) and complies with the World Medical Association Declaration of Helsinki on medical research protocols and ethics. A retrospective study was conducted on 103 subjects were assessed [58 female, 45 males, 16–45 years, mean (SD) age = 23.47 (6.44) years] who had orthognathic surgery between September 2011 to June 2015.

Variables measured and recorded

Skeletal sagittal relationship

The cephalometric variable of ANB angle (A point – Nasion – B point) was used to measure the relative position of the maxilla to mandible (Figure 1). The ANB angle can be also calculated from the formula: ANB = SNA–SNB. The sagittal skeletal relationship was classified as follows; Class I ($1 < ANB < 4$), Class II ($ANB > 4$), Class III ($ANB < 1$).

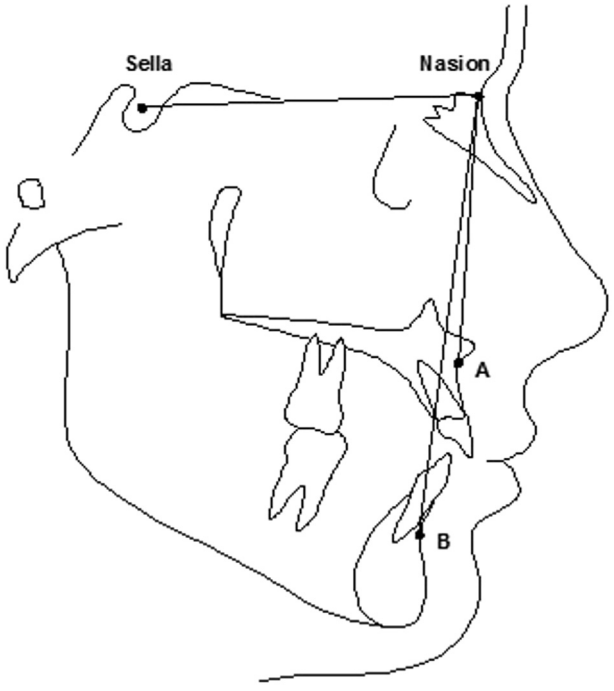

Figure 1 The ANB angle [A point (Subspinale) – Nasion – B point (Supramentale)] was used to classify the sagittal skeletal relationship as follows; Class I ($1 < ANB < 4$), Class II ($ANB > 4$), Class III ($ANB < 1$).

Malocclusion

This was classified based on the *British* standard incisor classification[8] as follows:

Class I, The lower incisal edges occlude with or lie immediately below the cingulum of the upper incisors.

Class II division I, The lower incisal edge occludes behind the cingulum of the upper central incisors and the upper incisors are proclined.

Class II division II, The lower incisal edge occludes behind the cingulum of the upper central incisors, and the upper incisors are retroclined.

Class III, The lower incisal edge occludes in front of the cingulum of the upper incisors.

Orthodontic treatment need

This was recorded using the Dental Heath Component (DHC) of the IOTN.[4]

Orthognathic functional need

This was recorded using the IOFTN.[5] Table 1 demonstrates the scoring system used in categorising functional needs in orthognathic patients.

Statistical analysis

Descriptive analyses such as Mean and standard deviation were calculated. The frequency of different components of the IOFTN and IOTN (DHC) were compared between genders using the Chi-Square test as well as among subjects with different malocclusions and sagittal skeletal patterns. The percentages of cases with IOFTN scores of 4/5 for various malocclusions and sagittal skeletal patterns were also calculated. The $P < 0.05$ was considered statistically significant.

Result

Gender differences detected for malocclusions/skeletal patterns ($P < 0.05$). Class III malocclusion was the most prevalent type (45.6%), which appeared most often in

Table 2 Gender Distribution [n (%)] of the malocclusions [based on incisor relationship[8]] and sagittal skeletal patterns (based on ANB angle) in the study sample.

Sagittal skeletal pattern	Gender[a]		Total
	Male	Female	
Cl I	1 (2.2)	4 (6.9)	5 (4.8)
Cl II	18 (40)	35 (60.3)	53 (51.5)
Cl III	26 (57.8)	19 (32.8)	45 (43.7)
Total	45	58	103
Malocclusion	**Gender[b]**		**Total**
	Male	Female	
Cl I	3 (6.7)	6 (10.3)	9 (8.8)
Cl II	14 (31.1)	33 (56.9)	47 (45.6)
Cl III	28 (62.2)	19 (32.8)	47 (45.6)
Total	45	58	103

[a] Chi-Square = 6.809, df = 2, P = 0.033.
[b] Chi-Square = 8.905, df = 2, P = 0.012.

males (Table 2). Class II skeletal pattern was the most prevalent type (51.5%) and mainly seen in females. There were 9, 42, 5, and 47 subjects with Class I, Class II Division I, Class II Division II, and Class III malocclusions, as well as 4.8%, 51.5%, and 43.7% presenting with subjects with Class I, Class II, and Class III sagittal skeletal bases, respectively.

Overall, 92.2% of orthognathic patients had great and very great functional needs according to the IOFTN (Table 3). Similarly, 82.5% scored as grade 4 or 5, according to the IOTN (DHC) (Table 4). As shown in Table 3, the most prevalent IOFTN score was the 5.3 (reverse OJ $\geq$ 3 mm, 27.2%), followed by 4.2 (6 mm $\leq$ OJ $\leq$ 9 mm, 19.4%), 4.3 (0 $\leq$ reverse OJ $<$ 3 mm, 13.6%), and 4.10 (facial asymmetry with occlusal disturbances, 12.6%).

We did not identify any patient who had orthognathic surgery purely due to the presence of sleep apnoea (grade 5.6) not amenable to other treatments such as MAD or CPAP.

There was a trend for different gender frequencies of the different components of the IOFTN and IOTN (DHC), but this was not significant at $p < 0.05$ level as follows; IOFTN (Chi-Square = 19.272, df = 11, P = 0.056) and IOTN (DHC) (Chi-Square = 18.934, df = 11, P = 0.062). However, when IOFTN scores were re-grouped to grades 5, 4 and, $\leq$3, no gender differences were observed ($P > 0.05$) (Table 5).

Overall, Class III subjects showed higher percentages of great (grade 4 IOFTN) and very great (grade 5 IOFTN) functional needs (Table 6); 95.7% and 95.6% of patients with Class III malocclusions and Class III sagittal skeletal patterns categorized as grade 4 or 5 of IOFTN. Corresponding figures for Class II malocclusions and Class II sagittal skeletal patterns were 87.2% and 88.7%, respectively. Subjects with Class II sagittal skeletal patterns or malocclusions had higher percentages of grade 4 IOFTN (69.8% and 66%); however, patients with Class III sagittal skeletal patterns or malocclusions had higher percentages of grade 5 IOFT (62.2% and 59.6%) and the differences were significant ($P < 0.01$).

Table 3 Distribution of the IOFTN functional need scores [n (%)]/categories in the study sample.

IOFTN	Gender		Total
	Male	Female	
1.14	0	1 (1.7)	1 (1)
2.8	4 (8.9)	2 (3.5)	6 (5.8)
3.3	0	1 (1.7)	1 (1)
4.10	4 (8.9)	9 (15.5)	13 (12.6)
4.2	5 (11.1)	15 (25.9)	20 (19.4)
4.3	9 (20)	5 (8.7)	14 (13.6)
4.4	0	1 (1.7)	1 (1)
4.8	0	1 (1.7)	1 (1)
4.9	3 (6.7)	4 (6.9)	7 (6.8)
5.2	1 (2.2)	8 (13.8)	9 (8.7)
5.3	18 (40)	10 (17.2)	28 (27.2)
5.4	1 (2.2)	1 (1.7)	2 (1.9)
Total	45	58	103

Table 4 Distribution of the IOTN Dental health component categories [n (%)] in the study sample.

IOTN (DHC)	Gender		Total
	Male	Female	
3a	1 (2.2)	3 (5.2)	4 (3.9)
3c	2 (4.4)	1 (1.7)	3 (2.9)
3d	2 (4.4)	6 (10.3)	8 (7.8)
3f	3 (6.7)	0	3 (2.9)
4a	6 (13.4)	14 (24.2)	20 (19.4)
4c	5 (11.1)	6 (10.3)	11 (10.7)
4d	1 (2.2)	3 (5.2)	4 (3.9)
4e	1 (2.2)	1 (1.7)	2 (1.9)
4f	0	2 (3.4)	2 (1.9)
4m	12 (26.7)	7 (12.1)	19 (18.4)
5a	1 (2.2)	8 (13.8)	9 (8.8)
5m	11 (24.5)	7 (12.1)	18 (17.5)
Total	45	58	103

Discussion

According to Posnick, "*dentofacial deformity*" refers to significant deviations from normal proportions of the maxilla–mandibular complex that also negatively affect the relationship of the teeth within each arch and the relationship of the arches with one another (occlusion).[1] The objective of orthognathic surgery is beyond achieving short-term improved occlusion.[9] Dentofacial deformities may be associated with traumatic bite (damage to dento-alveolar tissues in deep bite subjects), difficulty in chewing normally (Class III or open bite patients), or difficulty comfortably bringing lips together (patients with long face or open bite), swallowing, speaking, or even breathing (sleep apnoea in patient with very small mandible or retruded maxilla).[1] Management is often aimed at improving the quality of life by achieving long-term dental health, enhancing facial aesthetics, and maintaining an open airway.[9]

Using an index, such as IOTN, to allocate the funding to the most needed is extremely important. However, IOTN has limitations[10] including its subjective[11] assessment component (Aesthetic Component), which does not categorise Class III incisor relationships or anterior open bite

Table 5 Distribution of functional needs (IOFTN scores) and orthodontic treatment needs [IOTN (DHC)] in the sample [n (%)].

IOFTN Grades	Gender		Total
	Male	Female	
$\leq$3	4 (8.9)	4 (6.9)	8 (7.7)
4	21 (46.7)	35 (60.3)	56 (54.4)
5	20 (44.4)	19 (32.8)	39 (37.9)
Total	45	58	103
IOTN (DHC)	Gender		Total
	Male	Female	
$\leq$3	8 (17.7)	10 (17.2)	18 (17.5)
4	25 (55.6)	33 (56.9)	58 (56.3)
5	12 (26.7)	15 (25.9)	27 (26.2)
Total	45	58	103

Table 6 Relationship between malocclusions (based on incisor relationship), sagittal skeletal patterns (based on ANB angle), and IOFTN grades (functional need).

IOFTN grades	Sagittal skeletal pattern[a]			Total
	Cl I	Cl II	CL III	
≤3	0	6 (11.3)	2 (4.4)	8 (7.7)
4	4 (80)	37 (69.8)	15 (33.4)	56 (54.4)
5	1 (20)	10 (18.9)	28 (62.2)	39 (37.9)
Total	5	53	45	103
IOFTN grades	Malocclusion[b]			Total
	Cl I	Cl II	CL III	
≤3	0	6 (12.8)	2 (4.3)	8 (7.7)
4	8 (88.9)	31 (66)	17 (36.1)	56 (54.4)
5	1 (11.1)	10 (21.2)	28 (59.6)	39 (37.9)
Total	9	47	47	103

[a] Chi-Square = 21.005, df = 4, $P < 0.001$.
[b] Chi-Square = 19.921, df = 4, $P < 0.001$.

cases adequately. Similarly, IOTN's Dental Health component does not assess the skeletal component of the malocclusion; consequently, patients with skeletal discrepancies or facial asymmetries unless present with severe occlusal discrepancies, would not be scored high enough (4 or 5) to get NHS funding. IOFTN seems to be a simple and reliable tool fit for purpose. To our knowledge, present study is the first reporting on the use of IOFTN outside the UK, the birthplace of the index. The most prevalent IOFTN score in the present sample was the score 5.3 (reverse OJ ≥ 3 mm, 27.2%), this is similar to the findings from NHS Hospitals in Bath, Taunton and Bristol.[7] The second most prevalent IOFTN score was the 4.2 (6 mm ≤ OJ ≤ 9 mm, 19.4%), followed by 4.3 (0 ≤ reverse OJ < 3 mm, 13.6%), 4.10 (facial asymmetry with occlusal disturbances, 12.6%), and 5.2 (OJ > 9 mm, 8.7%). Another study[6] in the UK reported a different case mix, with the IOFTN score of 5.2 (29.5%) being the prevalent type, followed by 5.3 (15.5%), 4.2 (13%), and 4.3 (11.5%). The difference could be due to the varied frequencies of occlusal traits and facial skeletal patterns in those study samples. For instance, in the present sample Class III malocclusions and Class II skeletal patterns were the most prevalent, but in the UK study[6] Class III malocclusions and Class III skeletal patterns were the most prevalent type. Furthermore, subjects with Class III sagittal skeletal patterns or malocclusions had higher percentages of grade 5 IOFTN, compared to Class II sagittal skeletal patterns or malocclusions and the differences were significant. This may indicate that Class III malocclusions have more functional problems compared to Class II malocclusions as previously shown.[12]

The Class II skeletal pattern was the most prevalent (51.5%) sagittal skeletal relationship in the present sample, which was higher than the prevalence of individuals with Class III sagittal skeletal relationship (43.7%). The Class III malocclusion/sagittal skeletal pattern, which was more prevalent among males, can be due to hypoplastic maxillae, prognathic mandible, or a combination of both, leading to a concave profile.[13–23] In addition, Class III individuals can present with a short anterior cranial base with an acute saddle angle, a normal, excessive, or deficient vertical facial proportions along with proclined maxillary incisors and retroclined mandibular incisors.[13–23]

Similar to the findings of studies in the Brazil,[24] Saudi Arabia,[25] Hong Kong,[26] UK,[5,26] Norway,[27] and the USA,[28] Class III malocclusion was the prevalent type. Proffit et al. identified a trend for more Class III individuals seeking orthognathic surgery, compared to Class II individuals.[28] This finding suggests that a Class III subject may perceive to have more functional problems and therefore, requests orthognathic surgery. Similar to studies in Norway[27] and Brazil[24] we found more males with the Class III malocclusion/sagittal skeletal pattern. It should be noted that about 95% of patients with Class III malocclusion or sagittal skeletal pattern categorised as having very great (IOFTN grade 5) or great (IOFTN grade 4) functional need prior to orthognathic surgery.

According to the IOFTN, 92.2% of the patents were classified as having great or very great functional needs. This is within the range of previous findings in the UK, reporting 88–98% as having great (grade 4) or very great (grade 5) functional need. Although no patient was identified, who had orthognathic surgery purely due to the presence of sleep apnoea (grade 5.6), IOFTN offers this unique feature. For instance, a patient who presents with a well-compensated Class I malocclusion, but symptoms of sleep apnoea are present. These features cannot be identified merely using the IOTN.[10,11] It appears that IOFTN is a valid tool to identify patients in need of orthognathic surgery, helping resource allocation for patients with highest functional needs. Within he context of research, it can also be used to relate the orthognathic need to other health variables.

Similar to other occlusal indices,[29] IOFTN mostly assesses the occlusal traits, ignoring the skeletal component of malocclusion. Therefore, there are limitations associated with index,[30] such as the lack of assessment for the vertical, sagittal, and transverse component of the malocclusion, which can be masked in well-compensated malocclusions or following previous orthodontic treatment (camouflage). This is particularly important when assessing subjects who had previous orthodontic treatment, who do not necessarily score high using IOFTN, such as patients with well-compensated malocclusions (with minor occlusal discrepancies), but with severe sagittal, vertical, or transverse skeletal discrepancy. Addition of an element to IOFTN (a hard or soft tissue cephalometric variable) to assess the skeletal discrepancy, or reassessing malocclusion after *Orthodontic decompensation*, to reveal the true IOFTN grade, can potentially address these issues.

Conclusion

IOFTN identified 92.2% of subjects who had orthognathic surgery as having great and very great functional needs and appears to be a valid tool for identifying patients in need of orthognathic surgery. Higher percentages of Class III subjects scored grade 5 of IOFTN, indicating higher functional need for orthognathic surgery.

Conflict of interest

Authors have no conflict of Interest to report.

Funding

The study was self-funded.

Author contribution

Drs Eslamipour and Shahmoradi contributed to data collection for the manuscript. Dr Borzabadi-Farahani extracted the IOTN and IOFTN scores as well as contributed to study design, auditing the data, statistical analysis, preparation of the manuscript draft and revisions of the manuscript.

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