A retrospective investigation of orthognathic patients and functional needs

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Purpose: The present study aimed to explore the malocclusion trends, sagittal skeletal discrepancies, and the index of orthognathic functional treatment need (IOFTN) scores in a sample of Iranian and Turkish orthognathic patients.

Methods: Four hundred and three orthognathic patients were retrospectively examined (203 Iranian/200 Turkish, 229 females/174 males, aged between 16 and 50 years). The following variables were recorded: malocclusion type (incisor-based), overjet, sagittal skeletal relationship (ANB angle) and IOFTN scores. The sagittal skeletal relationships and malocclusion patterns of the orthognathic patients were statistically examined using Chi-square tests and further explored graphically. The relationship between the IOFTN scores and overjet, as well as the sagittal skeletal discrepancies (ANB angle) was evaluated using box plots and at the 95% confidence interval (CI) in different IOFTN treatment categories (1–3,4,5). The characteristics of a subgroup sample of orthognathic patients and previous studies that identified with low IOFTN scores (1–3) were also explored.

Results: Class III malocclusions and Class III skeletal patterns were the most prevalent (62.3%), forming 69% and 55.7% of the Turkish and Iranian samples, respectively. Turkish and Iranian samples had more Class III [Mean (SD) ANB angle = -1.24° (4.75°)] and Class II cases [Mean (SD) ANB angle=1.06° (5.63°)], respectively. The mean overjet and reverse overjet for Class II and III malocclusions were 6.96 mm (95% CI, 6.40–7.53 mm) and 3.26 mm (95% CI, 2.87–3.65 mm), respectively. The mean ANB angle for Class II and III malocclusions was 6.64° (95% CI, 6.15°–7.13°) and -3.57° (95% CI, -3.92° to -3.21°), respectively. IOFTN scores of 4 or 5 were identified in 93.8% of the sample. Patients with low IOFTN scores (<4) presented with a nearly normal overjet (mean = 3.19 mm, 95% CI, 2.62–3.76 mm, range = 1–5 mm), accompanied by a wide range of ANB angles [mean (SD)=3.44° (3.86°), range = -4° to 9°]

Conclusions: The findings at the 95% CI for overjet and the ANB angle can be used as identifiers for patients who would benefit from orthognathic surgery. Analysing patients with a low IOFTN score, particularly with scores of 3.3, 3.10, 2.8, and 1.14, revealed that IOFTN could be used in conjunction with a clinical examination plus diagnostic imaging to facilitate the identification of orthognathic surgery patients.

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Introduction

Detecting and appreciating the characteristics of patients with a dentofacial deformity is crucial for appropriate diagnosis and treatment planning. As an example, Class III skeletal patients constitute the majority of orthognathic cases and there is a notable occurrence of mandibular asymmetry within this group.[1] The prevalence of a Class III malocclusion

in the permanent dentition is estimated to range from 0.7% to 19.9%,[2,3] with a varying prevalence across populations, particularly in Southeast Asia (15.8%), Middle Eastern nations including Iran (7.8–10.2%), Indians (1.2%), Europeans (1.5–5.3%), and Caucasians (1–4%).[4–7] Patients presenting with a skeletal Class III malocclusion typically exhibit mandibular prognathism, maxillary retrognathism, or a combination of both.[7]

A systematic review of 10 studies which assessed the Turkish population, reported a pooled prevalence of 11% for Class III and 31% for Class II malocclusions.[8] Similarly, an alternative study[9] documented a sagittal skeletal relationship prevalence of 10% Class III and 26% Class II malocclusions. In the Iranian population, a pooled prevalence of 21 studies found 21% (CI 95%: 17.5–25.1%) for Class II malocclusions and 5.5% (CI 95%: 3–10%) for Class III malocclusions.[10]

Despite available information on malocclusion prevalence in Turkey and Iran, there is limited evidence regarding the characteristics of orthognathic patients in these countries. Further, the use of a relatively new Index of Orthognathic Functional Treatment Need (IOFTN)[11] that has been developed by Ireland and colleagues, was explored. A systematic review of previous retrospective studies[12] revealed that IOFTN successfully identified approximately 93% (95% CI, 0.91–0.94%) of pre-treatment records of patients who had orthognathic surgery as having the greatest need (IOFTN score >4). Remarkably, no study to date has investigated the characteristics (sagittal skeletal discrepancy and overjet) of the remainder of the orthognathic patients who scored low (<4) on the IOFTN. This group comprised approximately 7% of the retrospectively investigated orthognathic samples.[12]

Therefore, the primary objective of the present study was to explore the characteristics of a relatively large sample of orthognathic patients, with a focus on the prevalence and severity of Class I, II, or III sagittal skeletal discrepancies and overjet ranges.

The secondary objective was to apply the IOFTN[11] to determine the functional needs within these groups, with particular emphasis on exploring the characteristics of the orthognathic patients who scored low (<4). This information is considered vital for the international use of IOFTN, and the secondary objective would provide valuable insights into this unexplored area.

Methods and materials

For the present study, data from three previous studies that investigated the Index of Orthognathic Functional Treatment Need (IOFTN) and orthognathic surgeries was gathered from three samples: two from Iran (n = 203)[13–15] and one from Turkey (n = 200).[16] In total, there were 403 orthognathic patients (229 females and 174 males, aged between16 and 50 years).

The following variables were available and considered in the present investigation:

Malocclusion

This was classified based on the British standard incisor classification[17] as

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

Class II division 1: The lower incisal edges occlude behind the cingulum of the upper central incisors and the upper incisors are proclined.

Class II division 2: The lower incisal edges occlude behind the cingulum of the upper central incisors, and the upper incisors are retroclined.

Class III: The lower incisal edges occlude in front of the cingulum of the upper incisors.

For the present study, the data as Class I, Class II (combined Class II division 1 and 2) and Class III is presented.

Overjet

Overjet was defined as the distance from the most labial point of the maxillary incisal edge to the most labial surface of the corresponding mandibular incisor and measured parallel to the occlusal plane to the nearest half a millimetre.[6] A reverse overjet (negative) was registered when the lower incisors were anterior to the upper incisors.

Index of orthognathic functional need (IOFTN)

The IOFTN consists of five scoring categories (Very Great Need, Great Need, Moderate Need, Mild Need, and No Need) and each category has subgroups. The assessment begins at the fifth category and ends at

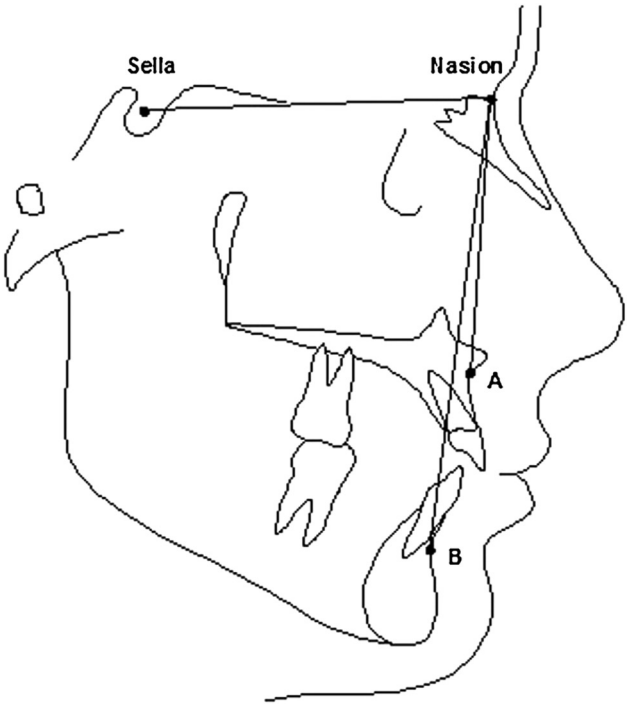

Figure 1. Subspinale (A), Nasion (N), Supramentale (B) and the ANB angle was used to classify the sagittal skeletal relationship as follows: Class I (1°< ANB <4°), Class II (ANB >4°), and Class III (ANB <1°).

the first category. The full details of the IOFTN scoring system have been previously published in an open access article.[11]

Sagittal Skeletal relationship

The cephalometric variable of the ANB angle [A point (Subspinale)—Nasion—B point (Supramentale)] was used to measure the relative position of the maxilla to the mandible (Figure 1) and is a commonly-used variable for determining the sagittal skeletal relationship.[5] In order to identify skeletal relationships, the ANB angle of Class I (1° ≤ ANB ≤ 4°), Class II (ANB > 4°), and Class III (ANB < 1°), were used.

Statistical analysis

The SPSS statistical software (IBM SPSS Statistics 28; IBM Corp., Chicago, IL, USA) was utilised for data analysis. The sagittal skeletal characteristics of Class I, II, and III malocclusions were assessed in the samples from the two countries using Chi-square tests. Box plots were created for the sagittal skeletal relationship (ANB angle) associated with the different malocclusions for both Iranian and Turkish orthognathic patients. The range and 95% CI for overjet and the ANB angle involving the entire sample, was recorded.

Based on the IOFTN scores, the orthognathic patients were categorised into three groups: IOFTN 5, 4, and 1–3. Subsequently, the relationship between the IOFTN scores and overjet, as well as the sagittal skeletal discrepancies (ANB angle), was evaluated using box plots and at the 95% confidence interval (CI) for different IOFTN treatment categories. Specifically, the characteristics of a subgroup of orthognathic patients in the present sample was examined and also in previous studies that reported the sub-categories of IOFTN[18–21] which were identified as having a low need (IOFTN scores of 1–3) for orthognathic surgery. The level of significance was set at $p < 0.05$.

Results

Orthognathic patient characteristics

The mean (SD) of overjet and the ANB angle for the entire sample was 0.17 (5.47) mm (range = -14 to 15 mm) and -0.08° (5.33°) (range = -12° to 13°), respectively. For the Turkish patients, the values

Table I. Breakdown of the malocclusions and sagittal skeletal patterns in the Turkish and Iranian orthognathic samples

	Malocclusion			
Country	I	II	III	Total
Iran	12 (5.9%)	78 (38.4%)	113 (55.7%)	203
Turkey	27 (13.5%)	35 (17.5%)	138 (69%)	200
	Sagittal skeletal pattern			
	I	II	III	
Iran	5 (2.5%)	85 (41.9%)	113 (55.7%)	203
Turkey	24 (12%)	38 (19%)	138 (69%)	200

were [mean (SD) overjet = -1.05 (5.53) mm, range =-12 to 13 mm; mean (SD) ANB angle = -1.24° (4.75°), range = -12° to 12°]. For Iranian patients the values were [mean (SD) overjet = 1.37 (5.15) mm, range = -14 to 15 mm; mean (SD) ANB angle = 1.06° (5.63°), range=-12° to 13°]. Overall, within the sample of orthognathic patients from both countries, Class III malocclusions and Class III skeletal patterns were the most prevalent (62.3%), followed by Class II malocclusions (28%) and Class II skeletal patterns (30.5%), with a Class I malocclusion being the least prevalent (9.7%) along with a Class I skeletal pattern (7.2%). Table I shows the breakdown of the malocclusions and sagittal skeletal patterns in the Turkish and Iranian orthognathic samples.

As Figure 2 shows, the number of Class II/III malocclusions (Chi-Square = 24.601, $P< 0.001$) or sagittal skeletal patterns (Chi-Square= 32.877, $P< 0.001$) differed in the Turkish and Iranian samples. The Turkish sample had more Class III cases [Mean (SD) of ANB angle = -1.24° (4.75°), 95% CI, -1.90 - (-0.58)], and the Iranian sample had more Class II cases [Mean (SD) of ANB angle=1.06° (5.63°), 95% CI, 0.28°–1.83°]; the difference was also significant (Table I, ANB angle mean difference = 2.30°, 95% CI, 1.27°–3.31°, $p < 0.001$) (Figure 2).

In total, the mean (SD) of overjet for patients with Class II and III malocclusions was 6.96 (3.03) mm (95% CI, 6.40–7.53 mm) and -3.26 (3.13) mm [95% CI, -3.65- (-2.87) mm]. The mean of the ANB angle for patients with Class II and III malocclusions was 6.64° (2.61°) (95% CI, 6.15°–7.13°) and -3.57° (2.83°) [95% CI, -3.92°- (-3.21°)].

IOFTN and patient characteristics

Of the 403 orthognathic patients, IOFTN identified 93.8% with a great or very great need for treatment, comprising 214, 164, and 25 patients in the IOFTN 5, 4, and IOFTN 1–3 categories, respectively. Figures 3 and 4 depict the characteristics of the three groups related to overjet and cephalometric ANB angle. Notably, patients in the IOFTN 1–3 group exhibited interesting features, such as a nearly normal range of overjet [mean (SD) = 3.19 (1.38) mm, 95% CI, 2.62–3.76 mm, range = 1–5 mm], accompanied by a wide range of ANB angles [mean (SD) = 3.44° (3.86°), 95% CI, 1.85°–5.04°, range = -4° to 9°].

Table II shows the breakdown of patients in the sample (n = 25) and previous studies reporting the sub-categories of the IOFTN that were categorised as IOFTN scores of 1-3 forming a sample of 64 patients. Of particular interest are the IOFTN grades of 3.3 (reverse overjet ≥ 0 mm and < 3 mm with no functional difficulties), of 3.10 (facial asymmetry with no occlusal disturbance), of 2.8 (increased overbite, but no evidence of dental or soft tissue trauma) and 1.14 (occlusal features not classified in the IOFTN need categories), that formed about 87.5% of the patients who received surgery but in whom the IOFTN did not detect a great need for surgery (Table II).

Discussion

Orthognathic patient characteristics

In the present study of Turkish and Iranian orthognathic patients, a Class III malocclusion and Class III skeletal pattern prevailed (62.3%). This was

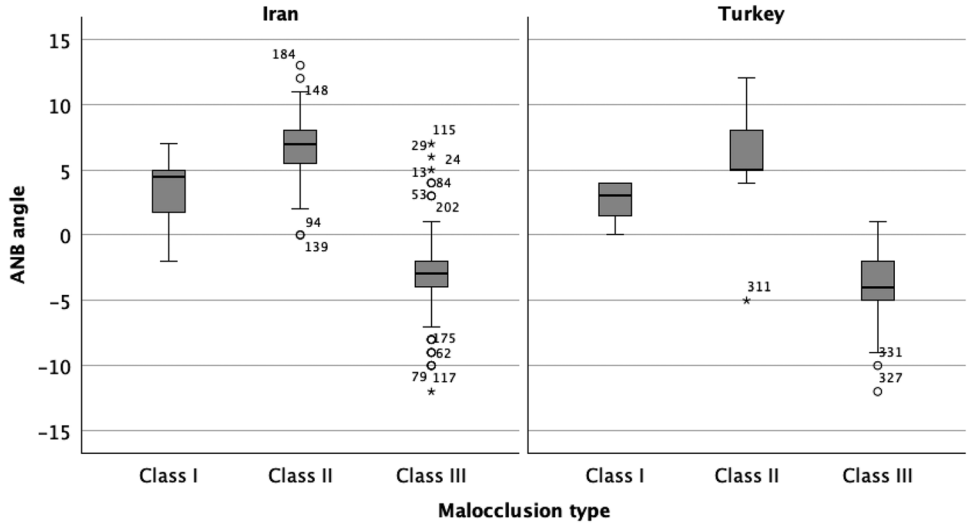

Figure 2. Box plots of the different malocclusions (I, II, III) in the Iranian and Turkish orthognathic samples.

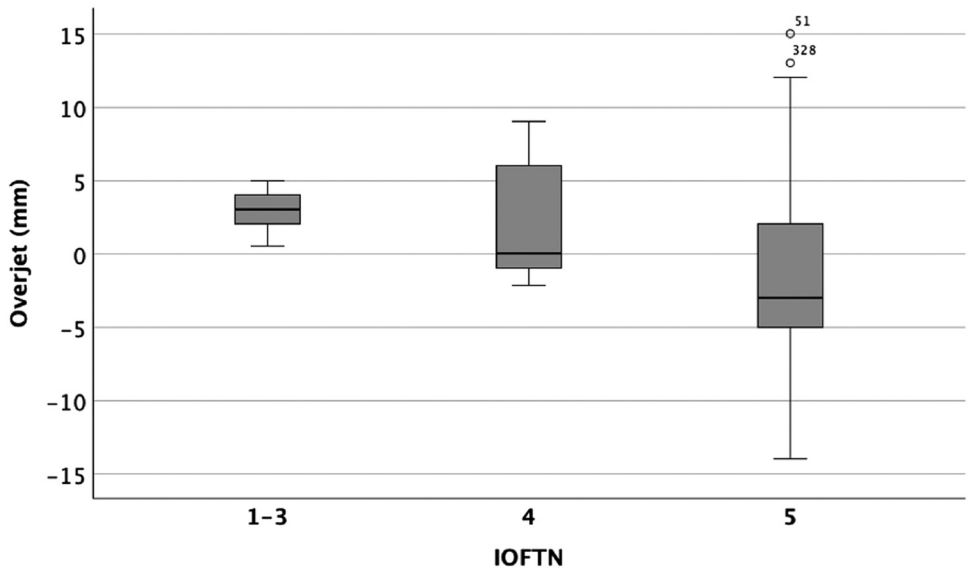

Figure 3. Box plots of overjet values (mm) in the 3 categories of IOFTN [5 (*n* = 214), 4 (*n* = 164), and 1–3 (*n* = 25)] showing a near normal range of overjet in IOFTN 1–3 category.

69% and 55.7% in the Turkish and Iranian samples, respectively. This trend aligns with the observations of Lee et al.,[22] who noted a similar prevalence of a Class III skeletal pattern in both Chinese and Caucasian patients. The present results resonate with the dominance of Class III patients reported in global studies, including those in Brazil,[23,24] Saudi Arabia,[25] the UK,[22,26] Norway,[27] Japan,[20] and the USA.[28]

Chew et al.[29] documented the spectrum of dentofacial deformities in a multi-ethnic Asian population in Singapore, revealing the majority presented with a Class III skeletal pattern (68%). Similarly, in Seoul, Korea, a noteworthy study found that Class III malocclusions constituted approximately 86% of their orthognathic case load.[30]

Ghorbani et al.,[31] in an examination of Class III and Class II patients following orthognathic surgery, reported heightened confidence and functional improvements in the Class III patients. This universal trend of more Class III patients seeking orthognathic surgery compared to Class II individuals suggests that individuals with a Class III malocclusion may

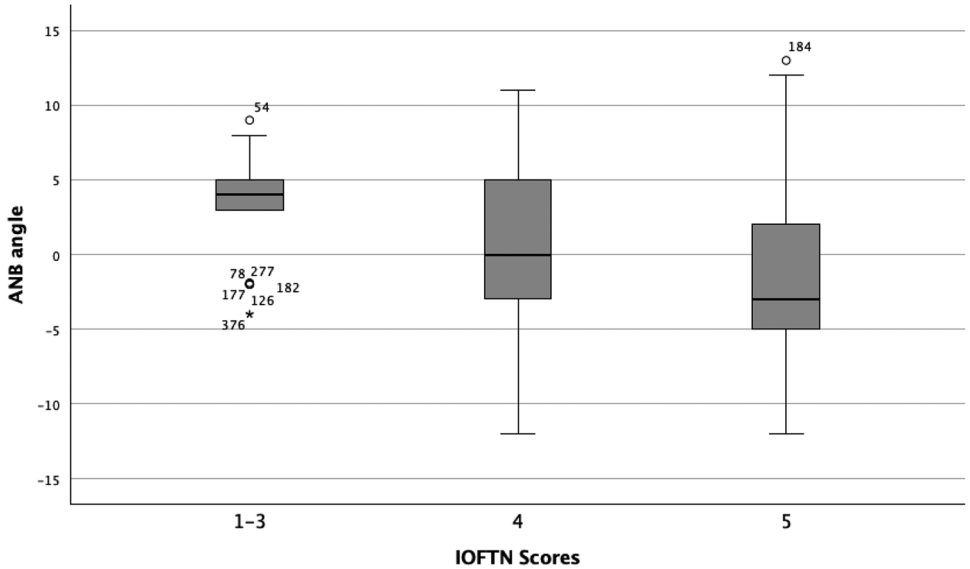

Figure 4. Box plots of ANB angles in the 3 categories of IOFTN [5 (*n* = 214), 4 (*n* = 164), and 1–3 (*n* = 25)] demonstrating a wide range of ANB angles in the IOFTN 1-3 category [mean (SD) = 3.44° (3.86°), 95% CI, 1.85°–5.04°, range = -4° to 9°].

perceive greater concerns, producing increased insecurity about their facial appearance and leading to a higher frequency for surgery.[32,33] Moreover, individuals with a retruded chin (Class II) are often perceived as good-natured, flexible, and gentle, while those with a prominent (protruded) chin (Class III) tend to be regarded as having contrasting character traits.[34,35]

Measuring the mean overjet and ANB angle allows a comparison of the severity of the present samples with other countries. For example, the mean ANB angle for a group of orthognathic patients in the North-East of Scotland[36] was 2.07° (SD = 5.17°) with a range of –17° to 22°. The range of ANB angles in the present groups, suggests that the Scottish sample had more extremes of sagittal skeletal discrepancy compared to the present samples presenting with -12° to 12° and -12° to 13° for the Turkish and Iranian samples, respectively. The difference may be due to the fact that orthognathic surgery is funded in the UK to the extent that only the most severe cases receive treatment.

Apart from obstructive sleep apnoea and severe dentofacial disharmonies that impair function such as patients with facial clefts, pathology or trauma induced dentofacial deformities, and syndromic cases, there is no agreed criteria that dictates treatment via orthodontic camouflage or a combination of orthodontics and orthognathic surgery.[37] When determining an appropriate treatment approach, whether a combination of orthodontic and orthognathic surgery or orthodontic treatment alone, several cephalometric variables are utilised. Of the most frequently employed parameters are the ANB angle, the Wits appraisal (mm),[38] the length of the maxilla or mandible,[39] and the Holdaway angle.[40] However, further guidelines have been suggested that identify patients who would benefit from surgery[37,41–44] and comprise:

- An overjet > 10 mm in patients who have passed their growth spurt (Class II)
- Lower incisor angulation (L1-MP angle) <83° (Class III)
- The ANB angle < -4° (Class III)
- A Wits appraisal of < -6.6 mm (Class III) or > 6 mm (Class II)
- The Holdaway angle <10.3° (Class III)
- Pogonion to nasion perpendicular distance > 18 mm (Class II)
- A mandibular body length < 70 mm (Class II)

Several compelling findings related to overjet and the sagittal skeletal patterns (ANB angle) emerged, that could provide valuable indicators for treatment planning Class II and Class III malocclusions which would benefit from orthognathic surgery. As an illustration, the boundaries for overjet and a reverse overjet in Class II and Class III malocclusions were 6.40 to 7.53 mm and 2.87 to 3.65 mm, respectively. Similarly, the boundaries for the cephalometric

Table II. Breakdown of patients with a low IOFTN score (<4) in the Turkish and Iranian orthognathic samples and previous studies which reported the sub-categories of the IOFTN

		James et. al.[18]	Soh et. al.[19]	Hasebe et. al.[20]	Almoammar et al.[21]	Total
IOFTN score	*n* (%)					*n* (%)
3.3 (Reverse overjet ≥ 0 mm and < 3 mm with no functional difficulties)	2 (8%)	9	6	4	5	26 (40.63%)
3.4 (Open bite <4 mm with no functional difficulties)		1	1	2	1	5 (7.81%)
3.9 (Upper labial segment gingival exposure <3 mm at rest, but with evidence of gingival/periodontal effects)	1 (4%)					1 (1.56%)
3.10 (Facial asymmetry with no occlusal disturbance)	10 (40%)		1			11 (17.19%)
2.8 (Increased overbite, but no evidence of dental or soft tissue trauma)	7 (28%)	3				10 (15.63%)
2.9 (Upper labial segment gingival exposure < 3 mm at rest with no evidence of gingival/periodontal effects)					1	1 (1.56%)
2.11 (Marked occlusal cant with no effect on the occlusion)					1	1 (1.56%)
1.14 (Occlusal features not classified in the IOFTN need categories)	5 (20%)				4	9 (14.06%)
Total	25 (100%)					64 (100%)

ANB angle in Class II and Class III malocclusions were 6.15° to 7.13° and -3.92° to -3.21°, respectively. It's important to note that only 5 cases (1.2%) out of 403 were identified with an IOFTN score of 5.1,[16] indicating craniofacial anomalies. Therefore, these findings could serve as a diagnostic aid for non-craniofacial orthognathic patients.

IOFTN and patient characteristics

In previous studies utilising the IOFTN and constrained by smaller sample sizes,[13,15,26] the assessment of patients with low IOFTN scores was challenging. However, the present investigation allowed for the exploration of patients with low IOFTN scores ranging from 1 to 3. Twenty-five patients who underwent orthognathic surgery were identified despite scoring low on the IOFTN in their pre-treatment records. The present investigation revealed that nearly 70% of this group (IOFTN scores of 1-3) consisted of patients who presented with a facial asymmetry or an increased overbite but without dental/soft tissue trauma. Severt and Proffit[45] reported a facial asymmetry prevalence of 34% in their assessment of patients with dentofacial deformities. Asymmetry was more prevalent in Class III than in Class II patients.[45] When facial asymmetry was present, it was noted in the upper face in 5%, the midface (primarily the nose) in 36%, and in the chin in 74% of patients.[45] A literature search suggested a prevalence of 11% to 37% for facial asymmetry, which was higher in orthognathic patients compared

to orthodontic patients.[46] When assessing facial asymmetry, the deviations in the mandible (chin point) relative to the midsagittal plane were the most striking characteristics.[46] This is usually perceived as asymmetry when the deviation is 4 mm or more relative to facial midline.[46] It is possible that in the group with IOFTN score <4, there was significant asymmetry without affecting the occlusal features.

The present findings underscore that patients with low IOFTN scores of 1 to 3 may present with a nearly normal range of overjet (1-5 mm) but a wide range of ANB angle (-4° to 9°), indicating a significant sagittal skeletal discrepancy. This identifies a subset of patients with well-compensated malocclusions who, despite scoring low on the IOFTN, may benefit from orthognathic surgery as part of comprehensive treatment. As previously suggested,[12] for the international use of IOFTN, a proposed guideline involves identifying and assessing patients with well-compensated malocclusions or those who underwent prior orthodontic treatment, but exhibit significant dentofacial skeletal deformity, including chin deformity or facial asymmetry, with diagnostic imaging alongside IOFTN scores. When the present sample of patients with a low IOFTN score and data from 4 previous studies was combined, the IOFTN grades 3.3 (Reverse overjet ≥0 mm and <3 mm with no functional difficulties), 3.10 (facial asymmetry with no occlusal disturbance), 2.8 (increased overbite, but no evidence of dental or soft tissue trauma) and 1.14 (occlusal features not classified in the IOFTN need categories) formed about 87.5% of patients who proceeded to surgery (Table II), but in whom the IOFTN did not detect a great need for surgery. It is therefore important to assess the sub-categories of patients along with diagnostic imaging (e.g., lateral or A-P cephalogram) to determine a better assessment of the dento-skeletal deformity. Clearly clinical examination augmented by cephalometric data taken in the correct head position are the most important aspects of diagnosis and highlighted by the mandibular condyles in a centric relation position, the head in natural head position, and the patient looking straight ahead with the Frankfort Horizontal plane parallel with the floor. This has been further investigated and highlighted in a recent studies.[47,48]

It is further essential to recognise patients who present with a mild to moderate dentofacial skeletal deformity and an extreme occlusal deviation who may not necessarily require orthognathic correction but could score highly on the IOFTN.[12] In such patients, diagnostic imaging and a comprehensive cephalometric analysis offer greater appreciation of the complexity of dentoskeletal deformities. However, it is considered that, a potential limitation of the present study is the potential selection bias and the representativeness of the samples.

Conclusions

The findings related to overjet and sagittal skeletal patterns can be used to identify patients who would benefit from orthognathic surgery. An analysis of patients with a low IOFTN score, revealed that the IOFTN could be used in conjunction with a clinical examination and diagnostic imaging to further facilitate the identification of patients who would benefit from orthognathic surgery. This is particularly important for patients with IOFTN scores of 3.3, 3.10, 2.8, and 1.14.

Conflict of interests

The authors declare that there is no conflict of interest.

Consent

Patient consent was not applicable, as the data was anonymised.

Ethical approval

Ethical approval for this study was granted previously by the respective universities in Iran and Turkey.

Authors' contribution

Ali Borzabadi Farahani: Conception, methodology and study design, determining the variables of the interest to be collected for the study, checking the data and double checking the occlusal traits, producing the scores for IOTN and IOFTN, statistical analysis, writing the first draft including the literature review and discussion, as well as the subsequent versions of the article. Hatice Kübra Olkun, Ladan Eslamian, and Faezeh Eslamipou: Data collection.

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Highlights

1. A 95% CI of overjet and ANB angle for a large cohort of Class II and III orthognathic cases may be used to assist diagnosis and treatment planning.

2. By using IOFTN, issues were identified in well-compensated malocclusions with close to a normal overjet, but with a diverse range of sagittal skeletal discrepancies.

3. It is suggested that the use of diagnostic imaging, along with IOFTN, better detects cases greatly benefiting from orthognathic surgery.

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