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RESEARCH

Assessment of the prevalence of nasal deviation in patients requiring orthognathic surgery: association with maxillary, mandibular, or chin asymmetry

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Abstract

Purpose Identifying nasal deviation in patients requiring orthognathic surgery is critical for developing an accurate treatment plan, particularly in the axial plane. This study aimed to evaluate the prevalence and degree of nasal and septal deviation in patients requiring orthognathic surgery, and to assess their relationship with maxillary, mandibular, and chin asymmetries, as well as dento-skeletal class.

Material and methods A retrospective study was conducted on patients who required orthognathic surgery between July 2020 and February 2021. Exclusion criteria included congenital craniofacial anomalies, history of mandibular condylar hyperplasia, or prior rhino-septoplasty procedures.

Results Of the 103 patients studied, 97.1% exhibited some degree of nasal deviation, and all presented with septal deviation. Nasal septum deviation correlated significantly with nasal tip deviation ($r = 0.44$, $p < 0.001$) and dorsum deviation ($r = 0.41$, $p < 0.001$). A combination of nasal, maxillary, mandibular, and chin deviations was present in 77.3%, 83.5%, and 88.3% of patients, respectively. Significant correlations were found between the directions of maxillary ($r = 0.21$, $p = 0.032$), mandibular ($r = 0.25$, $p = 0.012$), and chin deviations ($r = 0.19$, $p = 0.050$).

Conclusions This study highlights that nasal and septal deviations are highly prevalent in patients requiring orthognathic surgery, and their accurate diagnosis is essential for successful orthognathic diagnosis and surgical planning. These findings support the inclusion of nasal assessments in the treatment plans for orthognathic surgery patients.

Keywords Chin · Cone-beam computed tomography · Facial asymmetry · Mandible · Maxilla · Nasal septum · Nose · Orthognathic surgery

Introduction

In orthognathic surgery, precise identification of the facial midline is crucial for planning treatment. However, midline structures such as the oral commissures, dental midline, philtrum, nasion, and nasal tip often do not align. Currently, no standardized guidelines exist for determining the facial or oral midlines, and the treatment team must make an approximation to guide treatment [1].

Achieving facial symmetry is one of the primary goals of orthognathic surgery, alongside improving occlusion, appearance, and addressing sleep-disordered breathing [2]. So, making accurate diagnosis of nasal deviations is critical in surgical planning, because an undiagnosed nasal asymmetry could jeopardize proper marking of the facial midline. Moreover, since nasal deviations can impact upper lip position and overall facial symmetry, correction of nasal deviation should be considered. Simultaneous correction of nasal deviations during orthognathic surgery has been proven to obtain good results and can grant great benefit to

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the patients in terms of morbidity and costs [3]. Even the change of tube from nose to mouth after the maxillomandibular surgery, which might be stressing, can be avoided if the nasal tube is placed downwards and angulated at 45° with regards to the patient's skin without compressing it [4]. On the other hand, septum alterations can be managed through the LeFort I approach. Likewise, orthognathic surgery followed by staged rhinoplasty is an option in specific scenarios.

The incidence of nasal-septum deviation in normal population ranges from 18 to 89.2%, depending on the criteria applied and the populations examined [5–7]. This variability reported in the literature could probably be due to different confounding factors such as an underlying dentofacial anomaly (DFA). Therefore, it is hypothesized that the incidence of nasal-septum deviation could be increased in the population with an underlying DFA or maxillo-mandibular asymmetry [8]. DFA and nasal deformities relationship were first described by Angle in 1907 [9], who reported that patients with an underlying DFA had a higher incidence of obstruction of the upper airway at the nasal cavity level. In the same way, contemporary studies have reported a significant correlation between alterations in breathing patterns and significant nasal obstructions, with mandibular posture, tongue protrusion and dysmorphic maxillofacial characteristics [7]. The etiology of deviated nasal septum is multifactorial, with a reported genetic component and environmental factors such as injury during childbirth, trauma, infection, tumor, and/or neoplasia being the main factors. The reported incidence in the literature reflects the importance of the environmental component (especially trauma), being the incidence of septal deviation in children up to 1 year up to 21%, from 2 to 22 years between 29% and 35%, and in the adult population up to 89.2% [7].

Therefore, given the importance of nasal asymmetry diagnosis in patients requiring orthognathic surgery, this study aims to evaluate the prevalence and extent of nasal and septal deviations in DFA patients and their association with maxillary, mandibular, and chin asymmetries. Additionally, dento-skeletal class according to Angle classification was also evaluated.

Patients and methods

According to the reviewed literature and for study purposes, a convenience sample of 103 consecutive subjects was retrospectively reviewed. Patients had undergone orthognathic surgery at the Maxilofacial Institute, Teknon Medical Centre, Barcelona, Spain, from July 2020 to February 2021. All patients fulfilled the following inclusion criteria: (1) requiring an orthognathic surgery to correct any underlying DFA; (2) age > 18 years; (3) completed growth of the maxillofacial complex; and (4) availability of preoperative cone-beam computed tomography (CBCT) scan.

Patients with congenital craniofacial anomalies, history of condylar hyperplasia of the mandible or previous rhinoseptoplasty procedures were excluded.

In the design phase it was determined that a minimum of 100 patients were necessary to detect a weak correlation ($r = 0.3$) as significant with 85% power and a confidence level of 95%.

The study was approved by the Ethics Committee of Teknon Medical Center (Barcelona, Spain) (Ref. 2023/82-MAX-CMT), and was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki (1964 and later amendments).

Study variables of orthognathic analysis

Patient's records were obtained pre-operatively, which included occlusal and facial pictures (sitting upright in the natural head orientation (NHO) [10]), and a cone-beam computed tomography (CBCT) scan (iCAT, Imaging Sciences International, Hatfield, PA, USA). The DICOM datasets were exported to the Dolphin Imaging 3D version 11.8 software (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA), where the virtual head was oriented according to the NHO using the photographs as a reference. At this point the dento-skeletal class was assessed.

Facial midline was traced in three-dimensional 2D coronal view over crista Galli of the ethmoid bone. Then, the 'Caliper Left/Right Symmetry' tool was used to position with the 3D bone tissue window the midline equidistant from: nasal bones, ascending process of the maxilla and frontozygomatic suture (Fig. 1). Then, deviations of maxillary, mandible and chin were evaluated as follows: (a) the distance from A point to facial midline and its direction; (b) the distance from B point to facial midline and its direction; (c) the distance from pogonion to facial midline and its direction (Fig. 1); and (d) in the coronal 2D view, the distance from most deviated point of cartilaginous septum to facial midline and its direction (Fig. 2). Moreover, nasal measurements using the soft tissue window were recorded at different levels (radix, dorsum and tip): (e) the distance of the right side of the soft tissue nasal radix (RR) to the midline; (f) the distance of the left side of the soft tissue nasal radix (LR) to the midline; (g) the distance of the right side of the soft tissue nasal dorsum (RD) to the midline; (h) the distance of the left side of the soft tissue nasal dorsum (LD) to the midline; and (i) the distance of the nasal tip to facial midline and its direction (Fig. 3).

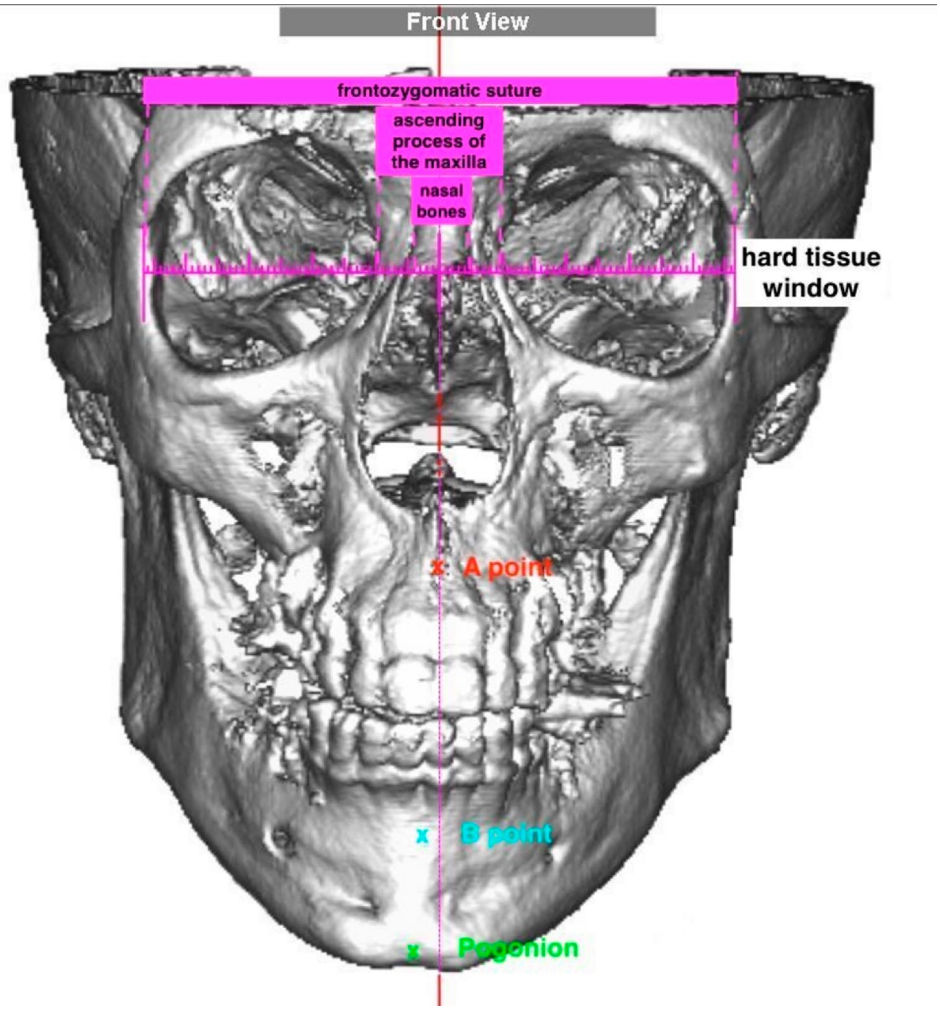

Fig. 1 Shows a frontal 3D view bone tissue window using the 'Caliper Left/Right Symmetry' tool to position the midline equidistant from: nasal bones, ascending process of the maxilla and frontozygomatic suture (purple ruled line). Then, deviations of maxillary, mandible and chin were evaluated measuring the distance and direction from facial midline to A point (red cross), B point (blue cross) and pogonion (green cross), respectively

Statistical analysis

Statistical analysis was carried out using SPSS for Windows (version 15.0.1, SPSS Inc., Chicago, IL).

The predominant direction of the asymmetry was interpreted as follows: $\text{Difference} = \text{Right side} - \text{Left side}\,|$", while the absolute magnitude of the deviation was assessed regardless the direction as "$\text{Abs. Diff} = |\,\text{Right side} - \text{Left side}\,|$". The absolute difference was categorized by level of magnitude as follows: a) mild: 0.5–3.5 mm; b) moderate: 3.5–7 mm; and c) severe: >7 mm.

Binomial test was used to compare prevalence of right to left deviation. Two-sample t-test was used to assess the mean nasal tip distance according to lateral deviation and to study the sexual dimorphism. Paired t-test was used to compare mean distance between both sides of the midline.

Chi^2 test (or Fisher's exact test if frequencies were too low) were used to study the association of gender or skeletal class with categorical variables related to nasal deviation (presence and direction). Kruskal-Wallis test was employed to compare distributions of dimensional parameters according to skeletal class. Significance level used in all analysis was 5% ($\alpha = 0.05$).

Results

Out of the 103 patients involved in the study, 73 were women (70.9%) and 30 were men (29.1%), averaging 32.2 years old in a range from 16 to 56. Dento-skeletal class II according to Angle classification was the most common one among the subjects of the sample (48.5%), followed by class III (42.7%), while the remaining 8.8% presented a class I.

Of the total sample, 97.1% of patients showed nasal deviation (95%CI: 91.7-99.4%). Left deviations were more frequent than right ones: 59% vs. 41% (of $n = 100$ patients with nasal deviation).

Figure 4 summarizes magnitude and severity of nasal deviations. At the radix level, the mean distance of the right side of radix to midline was 6.79 ± 1.61 mm (95%CI: 6.48–7.11) and on the left side it was 7.02 ± 1.42 mm (95%CI:

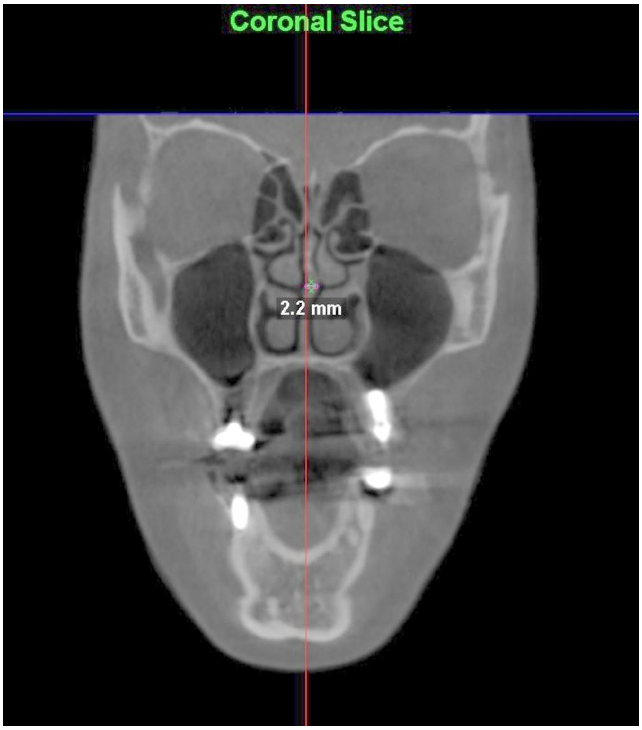

Fig. 2 In the coronal 2D view, the distance from the most deviated point of cartilaginous septum to facial midline and its direction is assessed

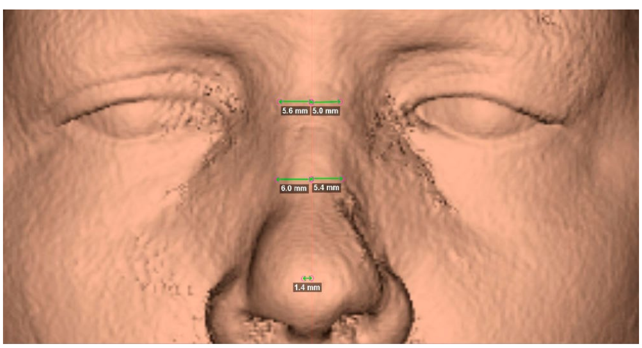

Fig. 3 Shows nasal measurements at different levels (radix, dorsum and tip) using the 3D soft tissue window

6.75–7.30), being the mean distance similar in both sides ($p=0.199$, paired t-test). The mean difference right-left was -0.23 ± 1.82 mm (95%CI: -0.59 0.12) and the mean absolute difference was 1.36 ± 1.23 mm (95%CI: 1.12–1.60). At the dorsum level, the mean distance of the right side of dorsum to midline was 8.64 ± 1.95 mm (95%CI: 8.26–9.02) and 9.25 ± 1.86 mm (95%CI: 8.89–9.62) on the left side, being the mean distance significantly higher on the left ($p=0.013$, paired t-test).

Mean septum deviation was 3.80 ± 1.80 mm (95%CI: 3.45–4.16), and both right and left deviations were similar ($p=0.694$, binomial test) although it was significantly stronger in patients with right deviation ($p=0.001$, t-test). There

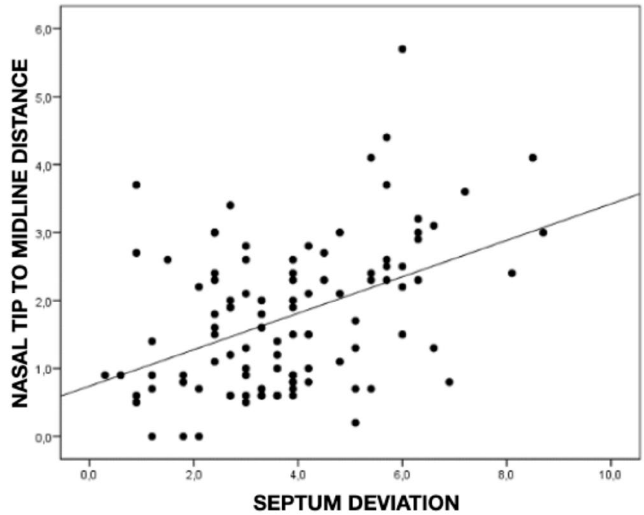

Fig. 4 The magnitude and predominant direction of nasal deviation at each level (radix, dorsum and tip) was interpreted as follows: Difference=Right side-Left side". Severity of nasal deviation (pie charts) was classified as mild (under 3.5 mm deviation), moderate (between 3.5 and 7 mm deviation) or severe (over 7 mm)

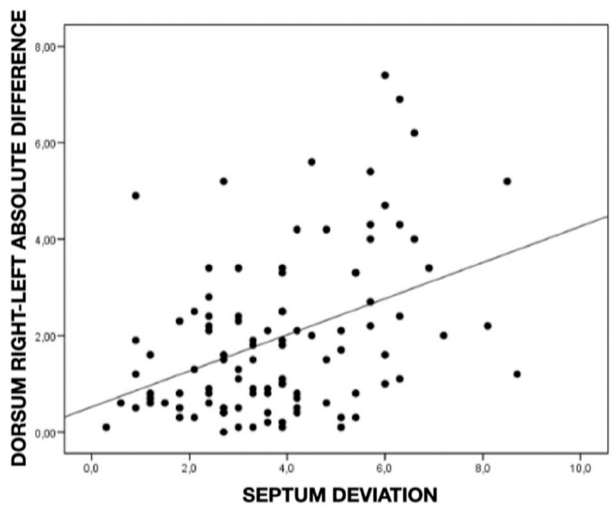

Fig. 5 Scatter plot depicting a moderate significant correlation between septum deviation and nasal tip distance to midline ($r=0.44$; $p<0.001$)

was found a correlation between nasal septum deviation and nasal tip deviation ($r=0.44$ and $p<0.001$) (Fig. 5) and dorsum deviation ($r=0.41$ and $p<0.001$) (Fig. 6), whereas none was found with radix deviation ($r=0.19$ and $p=0.063$).

Sexual dimorphism evaluation showed a more frequent right septum deviation in male (63.3%) than in female patients (41.1%) ($p=0.040$) (Table 1). On the other hand, no differences were found related to dento-skeletal class (Table 2).

Regarding deviations of the maxillomandibular complex, (a) maxillary midline was deviated in 80.5% of the cases, being the right direction the most usual but not statistically

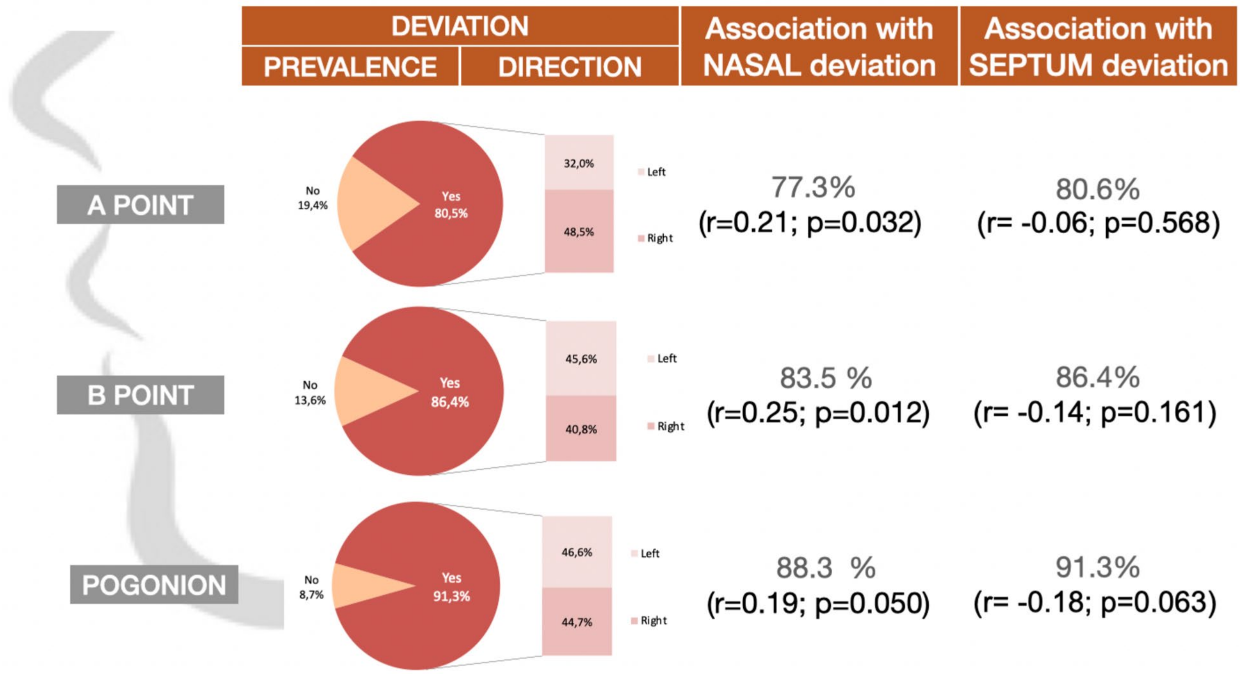

Fig. 6 Scatter plot depicting a moderate significant correlation between septum deviation and absolute difference (right-left) of dorsum to midline ($r=0.41$; $p<0.001$)

Table 1 Shows the association between sex and dimensional and surgical parameters: results of Chi2 test, Fisher´s exact test, and two sample t-test. Only septum deviation was proven statistically different among genres, being more frequent the right deviation in male patients (63.3%) than in female patients (41.1%)

	p-value
Nasal deviation (yes/no)	0.554 (Fis)
Direction (left/right)	0.308 (Chi^2)
Nasal tip distance	0.829 (t)
Absolute R-L at dorsum	0.980 (t)
Absolute R-L at radix	0.312 (t)
Septum deviation (CBCT)	0.223 (t)
Septum deviation direction (CBCT)	**0.040* (Chi^2)**

*$p<0.05$; **$p<0.01$; ***$p<0.001$

Table 2 No significant p-values show that no association between dento-skeletal class with dimensional parameters was found: results of Chi2 test, Fisher´s exact test, Kruskal-Wallis test. Provided that only $n=9$ patients showed class I, non-parametric Kruskal-Wallis were used instead of t-test

	p-value
Nasal deviation (yes/no)	0.309 (Fis)
Direction (left/right)	0.928 (Chi^2)
Nasal tip distance	0.638 (KW)
Absolute R-L at dorsum	0.768 (KW)
Absolute R-L at radix	0.861 (KW)
Septum deviation (CBCT)	0.552 (KW)
Septum deviation direction (CBCT)	0.711 (Chi^2)

*$p<0.05$; **$p<0.01$; ***$p<0.001$

significant ($p=0.078$, binomial test), although its magnitude was similar in both sides ($p=0.454$, paired t-test); (b) mandibular midline was deviated in 86.4% of the cases, being both directions equally prevalent ($p=0.672$, binomial test) and its magnitude was also similar in both sides ($p=0.454$, paired t-test); (c) pogonion was deviated in 91.3% of the cases, being both directions equally prevalent ($p=0.918$, binomial test) and its magnitude was also similar in both sides ($p=0.778$, paired t-test) (Fig. 7).

Assessment of association between nasal and maxillomandibular deviations showed the following results: (a) 77.3%, 83.5% and 88.3% of all patients had combination of nasal and maxillary, mandibular and pogonion deviations at once, respectively; and (b) there was a significant correlation between both directions at all points: maxillary ($r=0.21$; $p=0.032$), mandible ($r=0.25$; $p=0.012$), and pogonion ($r=0.19$; $p=0.050$). However, there was no relationship between the magnitude of the deviations.

Regarding association between septum and maxillomandibular deviations, only a weak and negative correlation was found at pogonion point ($r=$ -0.18; $p=0.063$), which means that septum deviation showed an opposite direction.

Finally, there were not found significant differences regarding nasal/septum deviation related to dental class (I, II, III).

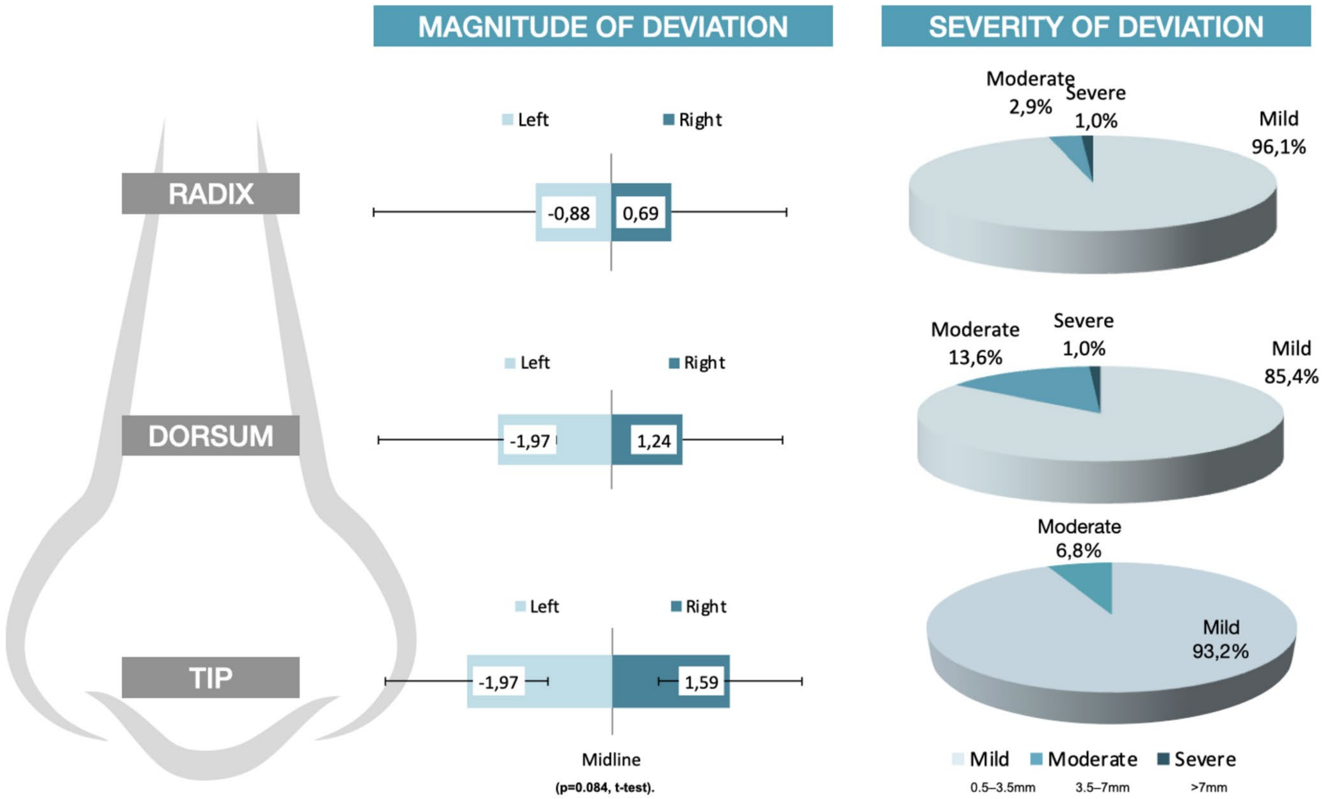

Fig. 7 Shows the percentage and direction of maxillary, mandibular and chin asymmetries an its correlation with nasal (positive or same side) and septum (negative or opposite side) deviations

Discussion

The results of the studied sample demonstrated significant association between nasal bones and septum deviation and asymmetries of the maxillary, mandibular and chin bones. But while the direction of deviation with nose was the same (positive correlation), the one of the septum was the opposite side (negative correlation).

It is clinically relevant because when performing orthognathic surgery virtual planning, deciding the precise facial midline in order to position accurately the maxillomandibular complex is considered a key-point, and an undiagnosed nasal deviation could hinder the clinician decision. Therefore, apart from evaluating the nasal symmetry very well, and since its root is frequently deviated, it is recommended to meet the facial midline from various measurements around the orbits, such as the ascending process of the maxilla (medial orbital border) and the frontozygomatic suture (lateral orbital border), among others.

To the author's knowledge, this is the first study assessing relationship between all orthofacial midlines deviations in the frontal view, although it had been previously demonstrated that nasal asymmetry was present specifically in asymmetric mandibular prognathism patients [8, 11]. However, the impact of congenital nasal septum deviation on the skeletal nasal bone's development and growth has been previously assessed [12], which is in line with the presented results, where nasal septum deviation is highly correlated with nasal dorsum and tip deviations (Figs. 6 and 7). However, its impact on radix deviation looks nil.

It has been described in the literature that those skeletal classes II patterns associated with transverse maxillary deficiency, show decreased nasal cavity volume, which favors the appearance of nasal obstruction [13]. In fact, the most logical chronological order is in the opposite direction: deviation of nasal septum can influence growth and development of facial structures through the modification of airflow and pneumatization patterns, causing turbinate hypertrophy or even maxillary hypoplasia when the deviation is greater than 15° from the midline [14]. As well, children with obligate mouth breathing due to septal deviations tend to present dentofacial anomalies in the sagittal view, open mouth and class II [15, 16]. Literature suggests that this may be due to the fact that the septal cartilage plays a fundamental role in the development of the nasomaxillary complex, which functions as a growth center for the region

[17, 18]. However, although all patients of the studied sample showed septum deviation, this study failed to show an association between nasal deviation and dentoskeletal profile according to Angle classification.

Moreover, in the present study evaluating patients with DFA, all the sample showed some degree of nasal deviation at some level of the nose or septum, which doubles the percentage of nasal deviation in general population [15]. According to the literature, varying degrees of septal deformity occur at a constant rate at birth and in the adult (42% of nasal septum of infants are straight, 27% deviated and 31% kinked, while a similar pattern is found in adult skulls, namely 21% straight, 37% deviated and 42% kinked), which is in line with the maxillary molding theory of transmitted pressures during pregnancy or partitution, causing congenital septal deformity [15]. Then, after childhood, the prevalence of septum deviation is increased by other environmental components, being trauma the most relevant, and followed by infection or neoplasia. Besides, it was found that the more deviated the nasal septum, the smaller the nasopharynx volume [19], which support the early non-invasive septoplasty in growing patients as a solution to redirect the normal course of growth and re-establish a good function of the nasomaxillary complex.

Aesthetically, although attractiveness is highlighted when nose and maxilla are centered around the midline of the face [20], minor asymmetries are imperceptible for laypeople [21] and facial asymmetries are only perceived when they are higher than 2 millimeters from the midline or the angulation is bigger than 5° [20]. In such scenario, patients seeking for orthognathic surgery, often ask for the possibility of treating crooked or unpleasant noses or functional breathing deficiencies in the same surgery [22], which has been reported not to have a higher number of complications than doing both surgeries in two separate interventions [3, 4]. However, in cases where extensive paranasal swelling rises after maxillary surgery or complex cases, it is recommended delaying rhinoplasty in a second surgical time [23]. On the other hand, the Le Fort 1 down fracture provides an exceptional approach for septoplasties and inferior turbinate reduction, among others. Therefore, nasal and septum deviation diagnosis, as well as aesthetic assessment should be included in each patient treatment plan.

The present study has some limitations attributable to its single-center design and the limited sample, with the inherent bias it implies. Moreover, requirement of rhino-septoplasty could be assessed in order to evaluate perceptibility of asymmetries and its management.

To conclude, this study highlights that nasal and septal deviations are highly prevalent in patients requiring orthognathic surgery, and their accurate diagnosis is essential for successful diagnosis and surgical planning. These findings support the inclusion of nasal assessments in the treatment plans for orthognathic surgery patients.

Author contributions Conception and design of study: Hernández-Alfaro F, Valls-Ontañón A. Acquisition of data: Saavedra O, Botella-Casas G, Ghuloom M. Analysis of data: Saavedra O, Botella-Casas G, Giralt-Hernando M, Valls-Ontañón A. Drafting of article and/or critical revision: Hernández-Alfaro F, Saavedra O, Botella-Casas G, Valls-Ontañón A. Final approval of manuscript: Hernández-Alfaro F, Saavedra O, Botella-Casas G, Ghuloom M, Giralt-Hernando M, Valls-Ontañón A.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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