



A case series on a new reference in mandibular angles harmonization: the Frontozygomatic-Infraorbital Line (FZ-IOL)

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ABSTRACT

the aim of this paper, is to propose a new reference line: the Frontozygomatic-Infraorbital Line (FZ-IOL). This reference line can guide the surgical team planning mandibular angle harmonization, based on the patient's skeletal proportion. The Frontozygomatic-Infraorbital Line has been adopted for symmetrization surgery, masculinization surgery, and in unsatisfactory results of previous orthognathic surgery.

From March 2021 to December 2022, 3 patients were treated for severe facial asymmetry affecting mainly the lower third of the face. All cases were planned with the reference FZ-IOL. Patients were treated in the same center, at the Orthognathic Surgery Department of the Instituto Portugues da Face, Lisbon, Portugal. The Frontozygomatic-Infraorbital Line is designed virtually using software to reconstruct a 3D image from a digital imaging and communications in medicine (DICOM) file obtained from a cone beam computer tomography (CBCT)., connecting the two orbital rims. Then, a vertical line, the frontozygomatic line perpendicular to the IOL and passing through the outmost lateral portion of the frontozygomatic suture is drawn.

The proposed line demonstrated how establishing appropriate reference lines is crucial for the success of the surgery. The selection of reference lines should be based on the patient's anatomy, the symmetrization process's complexity, and the surgery's desired outcome. The Frontozygomatic-Infraorbital Line represents an adequate reference line for managing mandibular angle lateral projection, improving lower third of the face symmetrization.

1. Introduction

Facial asymmetry, stemming from soft or hard tissue deficits (Arias et al., 2019; Kwon et al., 2006). It leads to aesthetic and functional challenges, impacting patients' quality of life and confidence. Causes include congenital anomalies, developmental disorders, trauma, or previous unsatisfactory surgery (Medina-Rivera 2016). The lower third of the face is prone to asymmetry due to its numerous edges and prominences, varied growth vectors during development, and parafunctional habits disrupting symmetry. (Cottrell et al., 2012; da Hora Sales et al., 2022).

The severity of facial asymmetry can range from mild to severe, and

its correction often requires highly specialized surgical procedures belonging to the group of facial symmetrization surgery (FSS) (Cintra et al., 2018; Staal et al., 2016; Wu et al., 2019). Symmetrization of midface-lower third hard tissues can include orthognathic surgery, patient-specific implants, and ancillary techniques such as bone blurring and reshaping (Cottrell et al., 2012; Goldsmith et al., 2012; Ramieri et al., 2021). Due to the significant number of possibilities, the surgical planning of facial symmetrization represents a great challenge for the maxillofacial surgeon (Wu et al., 2019). The success of a symmetrization related to hard tissues depends on precise and accurate preoperative virtual surgical planning, achievable using adequate points of reference of the facial skeleton (Arnett and Gunson 2010). Three-dimensional

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imaging techniques, such as cone-beam computed tomography (CBCT) with 3D virtual reconstruction, have become increasingly popular in facial surgery (Ha et al., 2023; Stokbro et al., 2014). Technological advances improve preoperative surgical planning accuracy. In cases of predominant facial asymmetry, 3D software can digitally mirror the healthy side for symmetrization (Ciocca et al., 2009). However, complex cases may need additional study and planning if mirrored anatomy isn't suitable for orientation.

Reference lines offer a valuable solution by providing orientation independent of the contralateral side (Ha et al., 2023). They rely on identifiable anatomical landmarks in patient radiographs, photographs, and 3D virtual imaging, ensuring predictable outcomes (Arnett and Gunson 2010). In maxillofacial surgery, reference lines are used to establish the ideal position of the jaws, to restore symmetry in a deviated face, but also to change secondary gender traits, making a face more feminine or masculine (Bannister et al., 2022; Ching and Persing 2021). The strength of reference lines lies in their easy reproducibility and objectivity, as well as the possibility of being used independently bilaterally, bypassing the mirrored approach (Hernández-Alfaro 2010). Considering these assumptions, reference lines are an optimal and widely used tool in symmetrization processes. This study aims to present the outcomes achieved using a new reference line in mandibular angle harmonization, the Frontozygomatic-Infraorbital Line (FZ-IOL).

2. Case series

2.1. Drawing the Frontozygomatic-Infraorbital Line

The FZ-IOL is designed virtually using software to reconstruct a 3D image from a digital imaging and communications in medicine (DICOM) file obtained from a cone beam computer tomography (CBCT). The natural head position (NHP), obtained from the comparison between clinical photos and CBCT 3D reconstruction, can represent the orientation used. Since the line is drawn using static bony landmarks, such as the frontozygomatic suture and the infra-orbital rim, choosing to position the head with the Frankfurt plane or the NHP does not change the result, as the sagittal view is not considered in this measurement. On the frontal plane, a horizontal infra-orbital line (IOL) is drawn, connecting the two orbital rims. Then, a vertical line, the frontozygomatic line, perpendicular to the IOL, and passing through the outmost lateral portion of the frontozygomatic suture is drawn. A second vertical line parallel to the previous one is drawn tangent to the outermost point of the mandibular angle (MAL) and perpendicular to the infra-orbital line. In this way, the angular excess or the defect is individuated (Fig. 1).

From March 2021 to December 2022, 3 patients were treated for

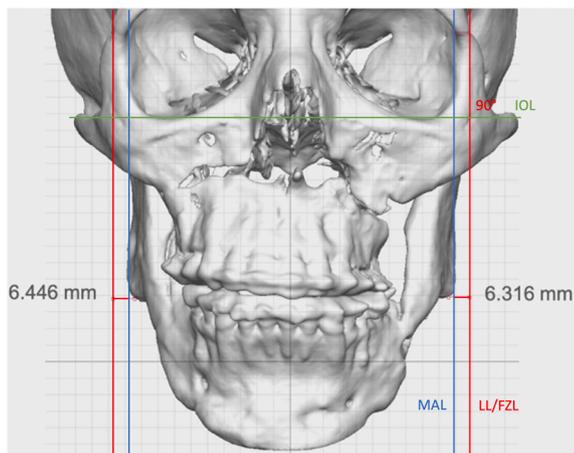


Fig. 1. – Drawing the Frontozygomatic-Infraorbital Line. IOL, horizontal infra-orbital line; LL, Frontozygomatic-Infraorbital Line, perpendicular to the IOL; MAL, mandibular angle line, and perpendicular to the IOL.

severe facial asymmetry affecting mainly the lower third of the face. The treatment was performed adopting the FZ-IOL concept. All patients were treated in the same center, at the Orthognathic Surgery Department of the Instituto Portugues da Face, Lisbon, Portugal. Data were collected from the department database including name, sex, age, gender, previous medical and surgical history, patient desires and expectations, clinical evaluation, and radiological exams. Informed consent was obtained from all included patients. The virtual surgical plannings were made in Geomagic Freeform + software from 3DS System (3DS System, Inc). All the surgical procedures were performed by the same surgeon (DS) under general anesthesia. The day after the surgical procedure, patients were studied with a CBCT to evaluate the correct positioning of implants and osteosynthesis material. All surgeries were realized in total respect of the virtual surgical planning without postoperative complications. Patients' data are summarized in Table 1.

2.2. Case 1 – Secondary Symmetrization and masculinization

TFCRN, a 34 year-old- male patient, came to the authors' observation after unsatisfactory bimaxillary orthognathic surgery with genioplasty in another clinic. The patient's main complaints were facial asymmetry, low definition of the mandibular border, reduced representation of mandibular angles, asymmetry of the chin, and asymmetry of the tip of the nose. Treatment included: custom-made implants for the chin, the mandibular angles, the malar bone, and rhinoplasty (Figs. 2–3).

2.3. Case 2 – Symmetrization and masculinization

ACCC, a 54 year old male patient, came to the authors' observation with a primary complaint of facial asymmetry, especially in the mandibular area. Reduced definition of mandibular angles and chin asymmetry were also presented as patient complaints. Treatment included: a custom-made cutting guide for the chin; and custom-made implants for mandibular angles (Figs. 4–5).

Table 1 - Casuistic characteristics divided by patient main complaints, Frontozygomatic-Infraorbital Line type of use, and treatments performed.

Case	Age	Sex	Complaints	FZ-IOL Line use	Treatments
1	34	M	Facial asymmetry, low definition of the mandibular border, reduced representation of mandibular angles, asymmetry of the chin, asymmetry of the tip of the nose	Symmetrization and Masculinization	Custom-made implants for chin, mandibular angles, and malar bone, and rhinoplasty
2	54	M	Facial asymmetry, reduced definition of mandibular angles, asymmetry of the chin	Symmetrization and Masculinization	Custom-made cutting guide for sliding genioplasty, custom-made implants for mandibular angles
3	31	M	Facial asymmetry, low definition of the mandibular border, asymmetry of the chin, left maxillary skin depression due to bone resorption.	Symmetrization	Custom-made implants for mandibular angles bilaterally, custom-made left maxillary prosthesis

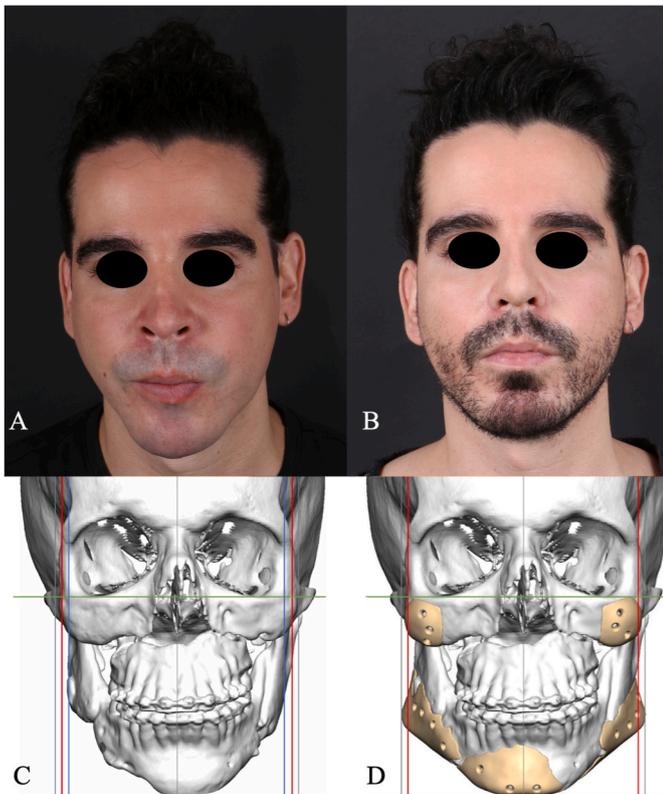


Fig. 2. – Case 1 collage 1: A) preoperative frontal clinical picture; B) postoperative frontal clinical picture; C) preoperative 3D analysis showing the Frontozygomatic-Infraorbital Line; D) surgical planning showing mandibular angles, chin, and malar harmonization by custom made PEEK implants.



Fig. 3. – Case 1 collage 2: A) preoperative both profiles clinical picture; B) postoperative both profiles clinical picture.

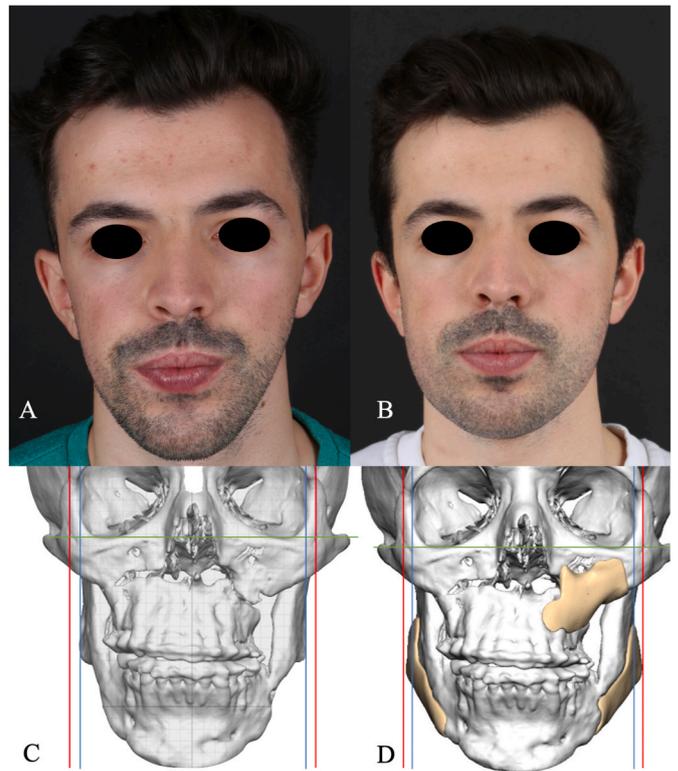


Fig. 4. - Case 2 collage 1: A) preoperative frontal clinical picture; B) postoperative frontal clinical picture; C) preoperative 3D analysis showing the Frontozygomatic-Infraorbital Line; D) surgical planning showing mandibular angles, and unilateral malar harmonization by custom made PEEK implants.



Fig. 5. - Case 2 collage 2: A) preoperative both profiles clinical picture; B) postoperative both profiles clinical picture.

2.4. Case 3 – Symmetrization

FS, a 31-year old male patient, came to the authors' observation after unsatisfactory bimaxillary orthognathic surgery in another clinic. The patient's main complaints were: facial asymmetry, low definition of the mandibular border, asymmetry of the chin, and left maxillary skin depression due to bone resorption. Treatment included: custom-made implants for mandibular angles bilaterally and custom-made left maxillary prosthesis (Figs. 6–7).

3. Discussion

Reference lines serve as a roadmap, allowing precise and accurate osteotomies to be performed during the surgical procedure (Arnett and Gunson 2010; Goldsmith et al., 2012; Oliver et al., 2019). Several reference lines are commonly used in facial surgery planning, including the Frankfort horizontal plane, the occlusal plane, and vertical projection lines (Kwon et al., 2006). The selection of reference lines should be based on the patient's anatomy and the desired outcome of the surgery (Hernández-Alfaro 2010). When selecting reference lines, the surgeon must analyze the patient's facial profile, symmetry, and the relationship between soft and hard tissue. The Frontozygomatic-Infraorbital Line is based on the concept that bilateral reference lines need points not included in the defect and with low variability in the human face, to be easily reproducible and reliable.

Technological advancements like 3D imaging improve surgeons' accuracy in establishing reference lines, resulting in better outcomes with fewer complications. (Arias et al., 2019; Cintra et al., 2018). The use of the appropriate reference lines leads to better outcomes and reduces the risk of unsatisfactory results and complications (Stokbro et al., 2014). Objectifying beauty is a challenge that facial surgeons have always faced, and reference lines have allowed them to get closer to that



Fig. 7. - Case 3 collage 2: A) preoperative both profiles clinical picture; B) postoperative both profiles clinical picture.

goal. Alfaro et al. described the Barcelona Line (BL), defined as the most aesthetic reference in surgical planning of dentofacial deformities, and reported as the upper incisor to soft tissue plane (Hernández-Alfaro et al., 2023).

In our experience, the Frontozygomatic-Infraorbital Line was used prevalently for mandibular angle harmonization, not only for aesthetics: the strength of this line stays in the possibility to be used as a bilateral but independent surgical reference whereas mirroring of the hemi-face could not guarantee proper symmetrization. Based on pre-surgical planning, the FZ-IOL can be graphically reached by augmentation or reduction, depending on the required outcome. For reduction procedures, osteotomies with bone remodeling or partial excision of excess can be performed, while for augmentation procedures, it is useful to use custom-made alloplastic implants, increasing projection and volume in particularly complex regions (Hsieh et al., 2021; Niechajev 2012).

The use of alloplastic prosthesis in the correction of skeletal asymmetry is relatively recent and in growing diffusion. Several materials have been proposed for this necessity. Disadvantages of silicone implants are resorption of the underlying bone and movement of the implant, and infections. Porous polyethylene such as Medpor (Stryker Co., Kalamazoo, MI) or Synpor (Depuy Synthes, West Chester, PA) allows fibrous tissue to grow into the implant due to the pore size, which reduces implant migration and resorption of the underlying bone (Niechajev 2012). Another alloplastic material is poly-ether-ether-ketone (PEEK), a semicrystalline polyaromatic linear polymer that is chemically inert, remains stable at high temperatures, is resistant to chemical and/or radiation damage, and has excellent strength. With both PEEK and Medpor implants, perfect anatomical fitting can be achieved with preoperative three-dimensional virtual planning, and if necessary, adjustments can be made during the surgical placement (Gerbinio et al., 2015; Narciso et al., 2021; Niechajev 2012).

Orthognathic surgery is performed to address facial balance and improve occlusion, airway, and speech (Cottrell et al., 2012; Ha et al., 2023; Stokbro et al., 2014). Although three-dimensional planning has enhanced operation planning, malposition, skeletal relapse, post-operative asymmetries, or malocclusion relapses still occur (Wu et al., 2019; Zaroni et al., 2024). Cases of recurrent malocclusion in orthognathic surgery can be extremely complex: osteotomies are more difficult due to anatomy variations, soft tissues are prone to fibrosis complicating



Fig. 6. - Case 3 collage 1: A) preoperative frontal clinical picture; B) postoperative frontal clinical picture; C) preoperative 3D analysis showing the Frontozygomatic-Infraorbital Line; D) surgical planning showing mandibular angles harmonization by custom made PEEK implants and expansion genioplasty.

bone exposure, and osteosynthesis materials are osteo-integrated and harder to remove. In cases of residual asymmetry with conserved good occlusion, alloplastic implants can be indicated to harmonize a face without extremely complex procedures (Wu et al., 2019). The Frontozygomatic-Infraorbital Line showed great potential in unsatisfactory orthognathic surgery cases, furnishing proper support for developing adequate custom-made alloplastic implants (Gerbino et al., 2015). With this approach, it was possible to redistribute the facial proportions and volumes obtaining symmetry without new osteotomies, adopting less invasive techniques, and improving patients' aesthetics and quality of life.

Reference lines change with gender and can represent a point of orientation in the path to feminizing or masculinizing a face (Bannister et al., 2022; Sanz et al., 2024). The man's face is more defined in the mandibular borders and angles, while the woman's is gentler and rounded. In analyzing facial traits, mandibular angles are one of the main elements that characterize the gender of the face (Deschamps-Braly 2018). Their augmentation or reduction is extremely requested in facial gender affirmation surgery. Finding the correct amount for augmentation and reduction can be difficult and subject to personal interpretation, complicating the outcomes (Bannister et al., 2022; Ching and Persing 2021). As the FZ-IOL uses bilateral mandibular angles as a reference, it represents a valid check-point for quantifying correct hard tissue lateral projection in both approaches (M to F and F to M): masculinization is obtained by reaching/crossing the line in its outer portion, and it is usually achieved with alloplastic implants; feminization is obtained by reduction osteotomies that bring the mandibular angle edge in the inner portion of the line, far from the reference.

4. Conclusion

The Frontozygomatic-Infraorbital Line showed excellent results in mandibular angle harmonization surgery, solving complex cases of multi-operated asymmetric patients, and satisfying aesthetic expectations. The proposed line demonstrated how establishing appropriate reference lines is crucial for the success of the surgery. The selection of reference lines should be based on the patient's anatomy, the symmetrization process's complexity, and the surgery's desired outcome. The FZ-IOL represents an adequate reference line for managing mandibular angle lateral projection, resulting useful to perform a rigorous lower third of the face symmetrization. It can also be used as a masculinizing or feminizing parameter of a face. The strengths of this baseline are the easy reproducibility and calculability, as well as the independence of the two sides analyzed. This allows great accuracy, ensuring promising results and patients satisfaction. Further studies on a larger court are necessary to validate and affirm more practice of the Frontozygomatic-Infraorbital Line.

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AI detection declaration

During the preparation of this work, the authors used "Notion AI" to achieve grammar and spell-checking. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare no conflicts of interest.

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