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F-Chin/Feminizing the Chin: A Genioplasty Technique with Virtual Planning for Male-to-Female Transgender Patients

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Abstract
The chin is an essential structure in facial harmony and an important gender marker. Advancing a receding chin is fundamental to improve the facial appearance, particularly in male-to-female transgender patients. However, in patients with microgenia and/or retrognathia, desiring a more feminine appearance, a chin advancement can result in a wider, square shape; an undesirable effect. Genioplasty is a versatile procedure used in facial feminization surgery that allows modifying the natural anatomy of the chin in all three spatial dimensions. The technique herein described proposes a simple genioplasty procedure for feminizing the chin (F-chin genioplasty) in transgender patients where anteroposterior advance is required. Virtual planning was used to establish the landmarks for an anteroposterior advancement with transverse reduction in the chin. A perpendicular line to the Frankfurt plane passing through the incisal edge of the upper central incisor was used to plan the anteroposterior movement, and two vertical lines on the outer wall of the nasal cavity for the chin transverse measurement. The authors present three case reports with the F-chin genioplasty transgender technique with satisfactory results, ensuring a more feminine facial appearance.
Level of Evidence V This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Genioplasty · Chin repositioning · Feminization · Transgenders · Gender reassignment procedure

Introduction

The aesthetics of the human face can be based on three main elements: proportion, symmetry, and skin texture [1]. The lower third significantly impacts each individual's profile [2]. Effective techniques for gender affirmation surgery were developed by enhancing knowledge about facial distinctions between genders. A systematic anatomical analysis reveals noticeable phenotypic differences between male and female faces. The male upper third of the face typically features an M-shaped hairline and a more prominent, elongated, and sloping forehead. Conversely, the female hairline is positioned lower, resembling an inverted V shape, while the forehead exhibits a gentler incline [3, 4]. The three-dimensional position of the chin is an essential factor in establishing visually pleasing facial proportions since, together with the nose and forehead, the chin significantly influences facial aesthetics [2]. The evaluation of its position is complex and should be done in the anteroposterior, transverse, and vertical planes. The deformities observed in the chin are macrogenia, microgenia, and asymmetry, which can occur in one or more of

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these planes [5]. Surgical corrections of these deformities are complex and require highly precise planning adapted to the anatomical structure of each patient. In recent years, virtual surgical planning systems have been developed that allow the design of custom-made surgical guides and improve the safety and precision of surgeries [6, 7]. Nevertheless, surgical planning frequently relies on the surgeon's expertise, needing more consensus regarding the reference guides to apply.

Genioplasty is the surgical procedure to correct deformities of the chin area and adjust the facial profile. It can also be indicated in cases of feminization, either in cisgender or transgender patients, to ensure a shape and morphology more in keeping with the female gender [8]. Different techniques and modifications have been described to respond to varying types of deformities [9–13].

After previous experiences, the authors observed a wider aspect of the mandible in microgenia cases where a chin advancement was performed, an unwanted characteristic in male–female transgender cases. Therefore, the authors propose an innovative procedure for feminizing the chin in transgender patients where anteroposterior advance and transverse reduction are necessary. Virtual planning was adopted to establish the guidelines for an anteroposterior advancement with a transverse reduction in the chin. Three cases of transgender patients were described. The index of orthognathic functional treatment need (IOFTN) was used to confirm that the patients only required aesthetic correction through genioplasty and did not need orthognathic surgery to correct occlusion [14–17].

Operative Technique

Virtual Surgical Planning

Before surgery, the genioplasty was projected and designed using the surgical planning software—Freeform Plus. An axial computed tomography (CT) scan was performed for digital planning. In the software, the tomography is oriented according to the natural head position, and anatomical structures, such as the tooth roots and the mental nerve bilaterally, were identified (Fig. 1a). Reference lines for chin movement are marked: the facial midline enables the symmetry of the two hemi-faces, a line perpendicular to the Frankfurt plane passing through the incisal edge of the upper central incisor determines the anteroposterior movement of the chin, and two vertical lines on the outer wall of the nasal cavity bilaterally orient the transverse measurement of the chin (Fig. 1b). However, the skeletal and anatomical variability of each patient does not allow standard measurements to be determined. The authors encourage that in a facial feminization process, the transverse dimension of the chin should always be near these two vertical lines. Three lines were defined for the osteotomy: one horizontal line (horizontal osteotomy) separating the chin from the mandible, and two vertical lines (vertical osteotomy) were demarcated on this fragment. The horizontal osteotomy line is drawn considering the proximity relationship with the identified anatomical structures and the degree of anteroposterior movement. Next, two vertical lines are drawn for the vertical osteotomy, defining the medial fragment. The desired movement is planned and performed virtually (Fig. 1c). The chin is positioned in the anteroposterior direction at a variable distance of 10 to 12 mm between the pogonion and the vertical line of the maxillary incisor. The chin is then reduced transversely between the two vertical lines, with the facial midline determining the midpoint of the chin and, in turn, the symmetry between the two bone fragments. Subsequently, a bone-supported or dental-supporting cutting guide was designed and printed on a 3D printer (Fig. 1d). If it was dental-supported, the *.stl* file resulting from the impression of the lower dental arch should be inserted in the software. Under the post-surgical position of the chin, the customized fixation plate was designed, and a *.stl* file was generated and subsequently printed on a titanium printer.

Surgical Procedure

The surgery is performed under general anesthesia with nasotracheal intubation. The chin area is infiltrated with lidocaine solution with adrenaline. An intraoral incision with a #15 blade in the lower lip mucosa, 5 mm above the buccal vestibule, is made from canine to canine. The incision of the muscular plane follows in the direction of the bone. The tissues are detached by blunt dissection to a subperiosteal plane aiming to keep the periosteum intact. The subperiosteal dissection allows the exposure of the entire mandibular symphysis and the mental foramen's emergence bilaterally (Fig. 2a). The customized cutting guide is fixed. Holes are drilled for subsequent fixation of the screws of the chin surface (Fig. 2b). With a piezoelectric tool, the horizontal osteotomy and two vertical osteotomies are performed following the cutting guide (Fig 2c). The horizontal osteotomy is extended posteriorly. Edges of the osteotomies are smoothened to avoid a bone step that could be felt on external palpation, following the *chin wing* technique reference proposed by Cordier, Sigaux [18]. The cutting guide is then unscrewed, and the osteotomies are performed crossing the cortex. With an osteotome, the bone parts are separated. The medial bone fragment is removed, and the lateral fragments are mobilized to the planned position. The customized osteosynthesis plate is fixed with screws (KLS Martin) (Fig 2d).

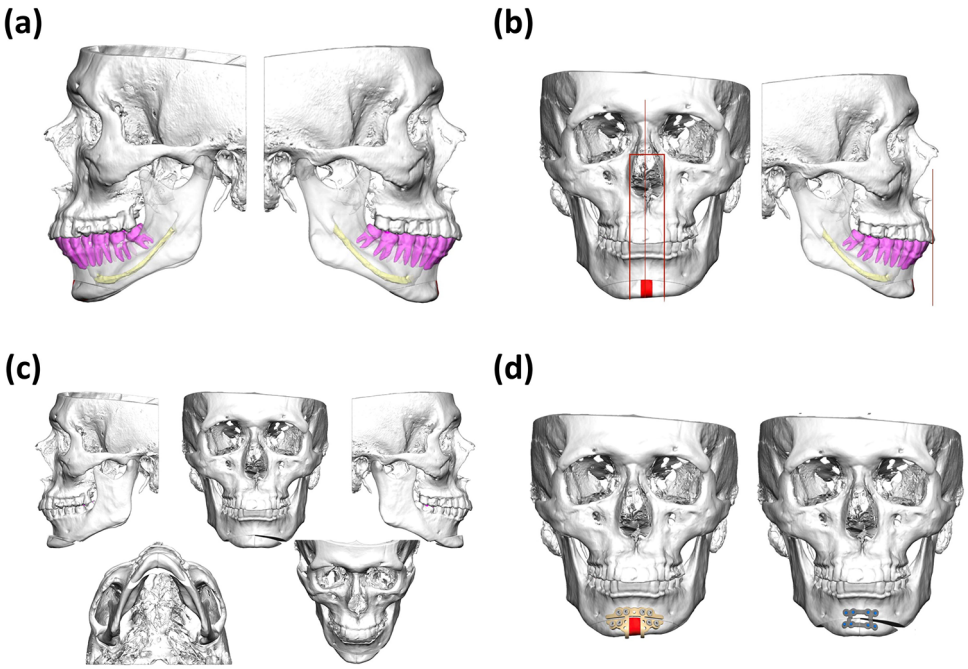

Fig. 1 Virtual surgical planning. Anatomical structures identified. Dental roots—purple; mental nerve—yellow (**a**); vertical lines pass through the outer wall of the nasal cavity; in the sagittal plane, a line perpendicular to the Frankfurt plane passes through the edge of the upper central incisor (**b**); chin movement (**c**); customized cutting guide and fixation plate (**d**)

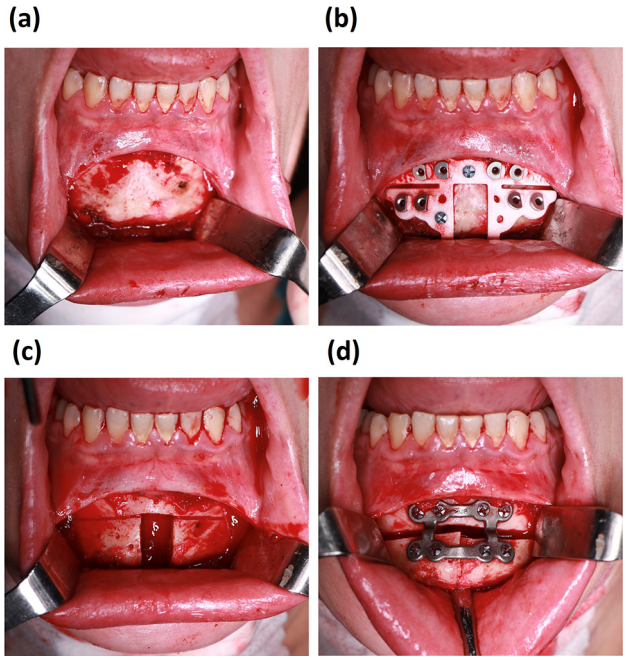

Fig. 2 Osteotomy is performed with a customized cutting guide. Exposure of the entire mandibular symphysis (**a**); customized cutting guide attachment (**b**); osteotomy performed with piezoelectric (**c**); customized fixation plate (**d**)

After confirming the final position of the chin, the surgical area is irrigated with povidone-iodine and saline solution. Hemostasis is checked, and the operative wound is closed by layers with 3-0 vicryl suture; the muscle tissue is sutured with single stitches, followed by the mucosa with continuous suture. In the postoperative period, a neuromuscular kinesio tape is placed to prevent edema and ptosis of the soft tissue. After the third day, the tape is removed.

Clinical Cases

Case 1 Transgender patient, in the process of feminization, 25 years old, straight facial profile, hypodivergent and brachyfacial, class II malocclusion (Fig. 3). An initial distance between a pogonion line and the central incisor teeth is 12.8 mm (Fig. 4a, d). A genioplasty with a 1 mm advancement and asymmetric transverse reduction in 7.5 mm (3.5 mm reduction to the right and 4 mm reduction to the left of the facial midline) was planned (Fig. 5a, d). IOFTN score was 1.14, without indication for orthognathic treatment.

Case 2 Transgender patient, in the process of feminization, 33 years old, convex facial profile, dolichofacial with enlargement of the lower third of the face (Fig. 3). An initial distance between pogonion line and central incisor teeth is 14.3 mm (Fig. 4a, d). Genioplasty was planned with a 4 mm advancement, symmetrical 10 mm transverse reduction (5 mm reduction to the right and 5 mm reduction to the left of the facial midline), and 2 mm impaction (Fig. 5b, d). IOFTN score was 3.3 (Reverse overjet $\geq$ 0 mm and $<$ 3 mm with no functional difficulties).

Case 3 Transgender patient, in the process of feminization, 34 years old, convex facial profile (Fig. 3). Presence

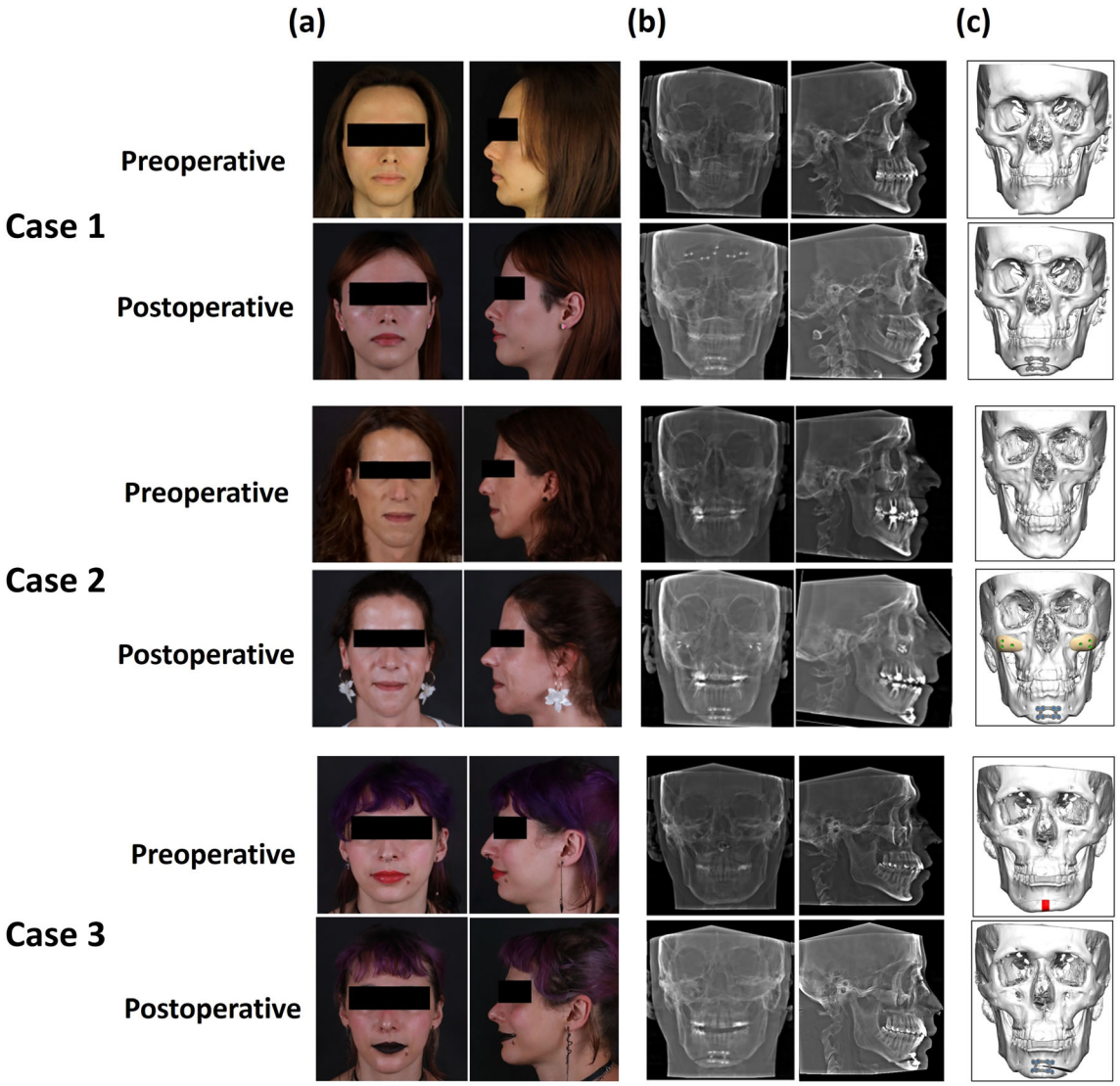

Fig. 3 Preoperative and 3-month postoperative of three transgender patients who performed transverse genioplasty with chin advancement. Facial photographs (**a**); computed tomography (**b**); 3D reconstruction (**c**)

of canting in the baseline of the chin and initial distance between pogonion and the central incisor teeth is 15.6 mm (Fig. 4a, d). Genioplasty was planned with a 5.6 mm advancement and asymmetrical transverse reduction in 8 mm (3 mm reduction to the right and 5 mm reduction to the left of the facial midline) and correction of the baseline canting by 3.5° with the fulcrum in the midline (Fig. 5c, d). IOFTN score was 0.

Discussion

Genioplasty plays an important role in achieving the best shape of the lower third of the face, in particular, the symphysis area. Thus, chin reshaping can be considered a vital step in the gender reassignment journey. Modifying the shape of the face helps transgender patients to feel more comfortable with themselves, improving their quality of life.

Several authors have described the feminization genioplasty among the general population, but a few authors describe precise techniques for the transgender population. According to Raffaini et al. [19], 100% of transgender male–female patients request a genioplasty to feminize their faces. Since 1942, several authors have used genioplasty to advance the chin [20, 21]. In 1987, Wolfe [22] described a genioplasty for altering the vertical dimensions of the chin by shortening or lengthening it. This technique was later modified and called T-osteotomy or mini V-line [2, 12].

Genioplasty procedures have been done using photographic analysis for many years due to their simplicity, not

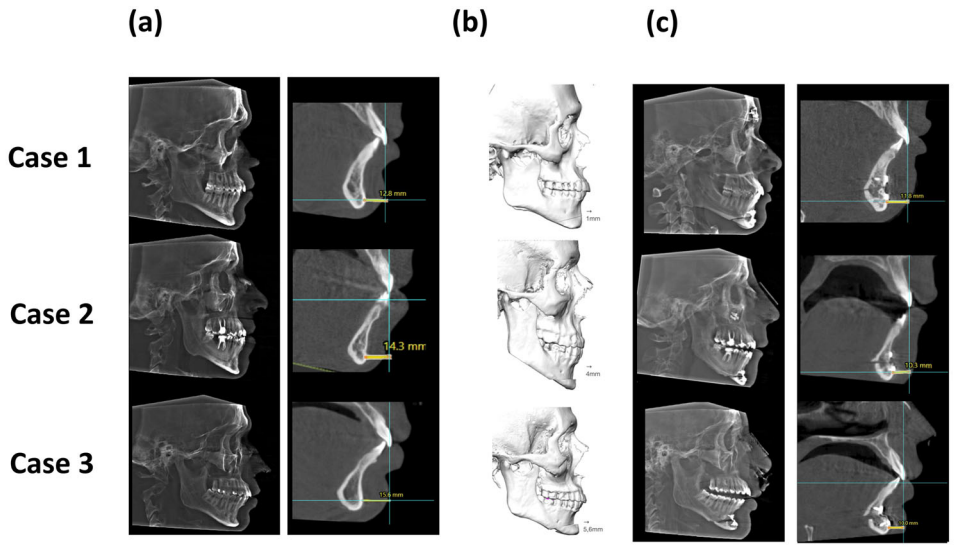

Fig. 4 Sagittal view of advancement genioplasty. Preoperative computed tomography including the measurements between the pogonion line and the central incisor teeth (**a**); virtual surgical planning of chin advancement (**b**); 3 months postoperative computed tomography including the measurements between pogonion line and the central incisor teeth (**c**); measurements (IPS case design ®, v 2.3.5.2) in millimeters (mm) of chin advancement performed (**d**)

(d)

Chin advancement

Patients	Pogonion - Central Incisor teeth (Preop)	Advancement	Pogonion - Central Incisor teeth (Postop)
Case 1	12.8 mm	1 mm	11.8 mm
Case 2	14.3 mm	4 mm	10.3 mm
Case 3	15.6 mm	5.6 mm	10 mm

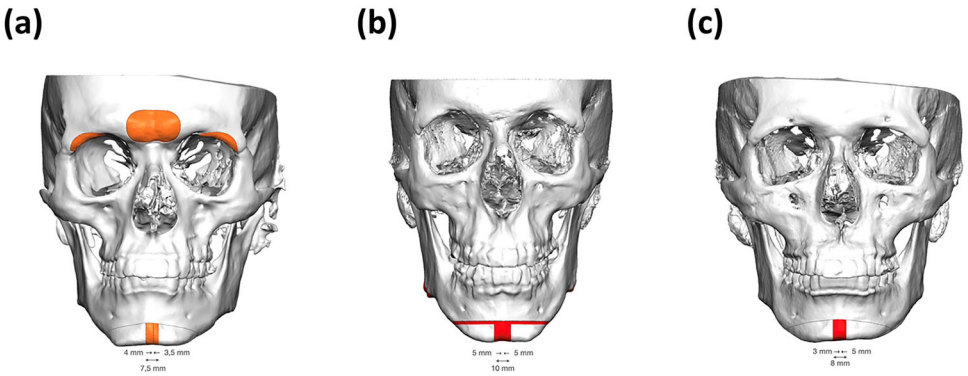

Fig. 5 Frontal view of transverse reduction genioplasty. Case 1 (**a**); case 2 (**b**); case 3 (**c**); measurements in millimeters (mm) of transverse reduction genioplasty (**d**)

(d)

Transverse reduction

Patients	Asymmetrical transverse reduction	Right transverse reduction	Left transverse reduction
Case 1	7.5 mm	4 mm	3.5 mm
Case 2	10 mm	5 mm	5 mm
Case 3	8 mm	3 mm	5 mm

requiring radiological examinations, and more costs. An expanding number of surgical teams now adopt virtual surgical planning and cutting guides for facial feminization surgeries. Gray et al. [6] demonstrated in a cadaver study that virtual surgical planning enhances the surgeon's ability to achieve optimal outcomes for patients undergoing facial feminization surgery. This approach addresses the challenges of varied facial features and complex craniofacial contouring procedures. The authors believe that virtual planning is an asset in surgical planning, even more so in cases as complex as gender reassignment. This allows custom procedures with more satisfactory results that meet patients' expectations. Moreover, patients actively participate in their transformative journey by engaging in preoperative planning alongside the surgeon. The doctor–patient relationship assumes essential significance, especially in transgender individuals who face social inequality. The authors recommend using surgical guides customized to each patient based on meticulous surgical planning. Some authors have proposed different lines of referral for advances of the chin. González-Ulloa [23] proposes a line perpendicular to the Frankfurt line passing through the nasion, while Gibson et al. [24] present a line perpendicular to the Frankfurt horizontal through the alar groove. Both authors said the pogonion must be in the same plane as this line or immediately posterior to it. However, these proposals have problems with variability with nasion and alar base size modifications. Legal et al. [25] proposed an angle to evaluate facial convexity, measured between a line traced from the glabella to the subnasal point and another from the subnasal point to the pogonion. The authors of this study consider an optimal value of 12°, which may vary from 8° to 16°. The principal disadvantage is that it does not apply to cases of maxillary hypoplasia. Silver's method recommends drawing a line perpendicular to the Frankfurt plane and tangential to the border of the mucocutaneous transition of the lower lip [26]. The pogonion should be on or up to 2 mm behind this line [26]. Since every case is unique and different, combined strategies appear to be the best approach to attaining a satisfactory outcome among the techniques described. In the authors' previous experience, advancing the chin caused a wider, square-shaped appearance. Analyzing and addressing chin alterations alongside other maxillofacial deformities is imperative, as this holistic approach ensures optimal facial proportions and a harmonious balance. The author's guideline proposed a line perpendicular to the Frankfurt plane passing through the incisal edge of the upper central incisor determines the anteroposterior movement of the chin, and two vertical lines on the outer wall of the nasal cavity bilaterally orient the transverse measurement of the chin. The authors found that passing through a dental plane shows less variability, unlike Silver's method, which uses a skin point prone to deviations/changes. In our view, when it comes to reference points, skeletal points are preferred over skin/soft tissue points.

The authors found that for an appealing aesthetic result, the distance between the pogonion and the vertical line of the maxillary incisor in anteroposterior chin advancement should be 10–12 mm. Although these values are a reference, standardization should not be made, depending on the distance between these reference lines and the patient's anatomy. In this article, the advancement values ranged from 1 to 5.6 mm. However, it was defined that the limit for advancing the chin with this technique is the contact with the base of the mandible.

This procedure presents an improvement in feminization genioplasty based on the rigorous surgical cutting guidelines planned in virtual surgery. Overall, it is a straightforward procedure that effectively meets transgender feminization needs. F-chin genioplasty yields satisfactory results, ensuring a more feminine facial appearance. Further studies on a larger population are necessary to evaluate more aspects of this new technique.

Declarations

Conflict of interest None of the authors has a financial interest in any of the products, devices or drugs mention in this manuscript.

Ethical Approval This study has been approved following the ethical norms and standards in the Declaration of Helsinki, including ethics committee approval statement and informed consent statement.

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