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IDEAS AND INNOVATIONS

Reconstructive

Simplifying Facial Feminization Surgery Using Virtual Modeling on the Female Skull

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Summary: Osseous work in facial feminization has been largely developed by comparing the qualitative and quantitative anthropometric differences between male and female cadaveric skulls. While virtual surgical planning has allowed for improved accuracy and ease in osteotomies and recontouring procedures in facial feminization, ultimately, a subjective decision-making process is still required. In this work, we describe a novel method of simplifying facial feminization by virtually modeling all osseous surgical maneuvers for facial feminization with a reference female skull. *(Plast Reconstr Surg Glob Open 2020;8:e2618; doi: 10.1097/GOX.0000000000002618; Published online 20 March 2020.)*

INTRODUCTION

Facial feminization surgery (FFS) is one of the most important and dramatic surgical transitions for the treatment of gender dysphoria. With the recent improvement in insurance coverage for FFS procedures, more patients are seeking FFS in the United States, leading to more craniofacial surgeons offering and performing these procedures. Due to the extensive anatomic analyses of Ousterhout, concepts of precise clinical examination including measurements and cephalometric analyses translating to osseous surgical maneuvers have been well described.[1–4] However, similar to skeletal maneuvers of the craniofacial region, relative relationships are key to the success of a balanced and harmonious facial skeleton. Unlike congenital craniofacial reconstructive techniques focused on the restoration of normal anatomy, facial reconstruction for gender affirmation is focused on the conversion of normal masculine skeletal relationships to that of normal feminine relationships or vice versa.[5,6] Thus, the margin for error is particularly narrow.

Using virtual modeling is now mainstream within the craniofacial community, typically for planning symmetrical osteotomies or designing custom implants.[7] In the context of FFS, the female skull is the perfect template. Thus, a powerful method of eliminating subjective guesswork in facial gender affirmation surgery is utilizing such a template to plan all surgical maneuvers. In this work, we describe a method of simplifying FFS by virtually modeling surgery on a female skull.

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METHODS

Male-to-female transgender patients (n=8) undergoing primary FFS planned using virtual modeling on a female skull between 2018 and 2019 were included (UCLA IRB#11-000925).

Decision Making for Osseous Maneuvers

The clinical examination of the patients included measurements of the forehead length and the sagittal distance between the anterior globe and the most anterior portion of the forehead. Fine-cut computed tomographic (CT) scans with a section thickness of 0.6 mm were obtained preoperatively in all patients. VSP services were provided by 3D Systems (Rock Hill, S.C.). During the virtual planning session, patient skulls were superimposed on a female reference skull, which typically required proportional enlargement to the size of the patient's skull (Fig. 1 and Video) (**see video [online]**, which displays virtual modeling for FFS). Surgical maneuvers to correct discrepant skeletal areas between the patient and reference skull were then planned virtually. Custom cutting guides were 3D printed in preparation for the operation.

Operative Details

A pretrichial incision extending into the hairline laterally was carried out to expose the forehead. The anterior table of the frontal sinus was osteotomized and precision forehead recontouring with reduction of the superior orbital rims occurred using virtually planned guides. The

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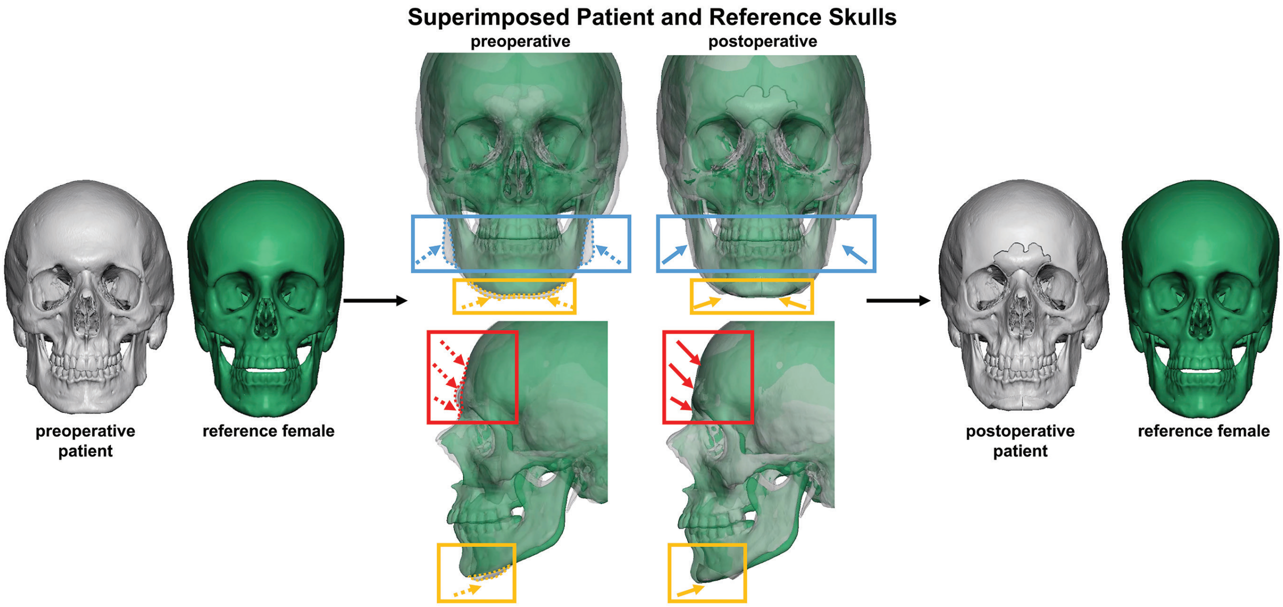

Fig. 1. Modeling osseous maneuvers on a female skull. Preoperative planning of the osseous maneuvers of facial feminization surgery was performed using a standard female skull as a reference. On the left, 3D CT scans of the patient's skull and the skull of the reference female are shown. These were subsequently superimposed to identify the precise areas of reduction at the forehead (red dotted line), gonial angles (blue dotted line), and chin (yellow dotted line).

radix was also reduced using a burr. The frontal sinus cavity and nasofrontal ducts were inspected carefully to ensure patency before reconstruction of the anterior frontal sinus. Then, the anterior table of the frontal sinus was contoured and set back to the level of the newly contoured forehead.

Two-piece reduction genioplasties and reduction of the gonial angles were approached intraorally through gingivobuccal incisions. For the genioplasty, subperiosteal dissection was performed inferior to the mental fold and extended laterally to the inferior border of the mandible just below the mental foramina bilaterally. 3D printed cutting and positioning guides were used for the horizontal osteotomy and the central wedge excision. For the mandible, cutting guides were also designed to mark the amount of angle reduction. When necessary, bony step-offs were addressed with bone rasping or further resection.

Table 1. Patient Characteristics

Total no. patients (n)	8
Mean age in years (SD)	32.3 (11.5)
Procedure types, n (%)	
Anterior table setback/reduction of Superior orbital rim/hairline Lowering/brow lift	8 (100)
Reduction rhinoplasty	6 (75.0)
Fat grafting	7 (87.5)
Reduction genioplasty	6 (75.0)
Bilateral gonial angle reduction	4 (50.0)
Upper lip shortening	2 (25.0)
Tracheal shave	3 (37.5)
Operative time in hours (SD)	8.7 (1.6)
Length of hospital stay in days (SD)	1.5 (0.5)
Length of follow-up in days (SD)	115.3 (107.8)
Time of HRT before surgery in years (SD)	5.1 (3.9)

RESULTS

Eight patients underwent virtual modeling using a female skull for planning and execution of FFS (Table 1 and Fig. 2). The mean age of the patients at the time of surgery was 32.3 ± 11.5 years, and the mean operative time was 8.7 ± 1.6 hours. The mean length of the patients' hospital stay was 1.5 ± 0.5 days, and the mean follow-up period was 115.3 ± 107.8 days. All patients received a setback of the anterior table of the frontal sinus (mean 4.3 ± 1.6 mm), 75.0% (n = 6) received reduction genioplasties, and 50.0% (n = 4) received bilateral gonial angle reductions. Of the nonosseous procedures, fat grafting was performed in 87.5% of patients, primarily for the temporal and malar regions and 75.0% of patients received reduction rhinoplasties. One patient demonstrated delayed healing of the scalp incision which was treated with local wound care and all others healed uneventfully.

DISCUSSION

In this work, we present a novel method of planning osseous maneuvers in FFS using virtual modeling on a female skull. Virtual modeling essentially unites the concepts derived from anthropometric comparisons between the male and female skulls with modern virtual surgical planning.[8] Unlike traditional planning and VSP alone, virtual modeling on a female skull eliminates subjectivity in the amount of skeletal reduction and positioning of skeletal segments. In addition, the secondary benefits of achieving accurate symmetrical skeletal relationships (ie, setting the midline) also contribute to the power of this technique. Interestingly, in our experience of 8 patients, the estimated anterior table setback based on clinical examination was nearly identical to the virtually planned

Fig. 2. Preoperative and postoperative FFS results planned using virtual modeling on a female skull. Lateral preoperative (A) and postoperative (B) photographs of an FFS patient who underwent anterior table setback and forehead recontouring, hairline lowering, fat grafting to temple and malar areas, open reduction septorhinoplasty, two-piece reduction genioplasty, bilateral gonial angle reductions, and tracheal shave.

setback based on the female skull (4.4 ± 1.7 versus 4.3 ± 1.6), confirming the accuracy of Ousterhout's initial measurements and descriptions.

One of the limitations of this technique, which is also present in traditional planning, is that the osseous movements are based on reference skulls that might not accurately reflect the patient's ethnic background, age, or other individual characteristics. Further refinement of this technique could involve using a normalized average of many female skulls, rather than a single female skull. Such normalized models have been created by some groups,[9,10] though a centralized database was not available for the purposes of this study. Other avenues for future exploration could be comparing patient outcomes and operative times FFS without VSP, as well as virtually planning soft tissue volumes based on female facial anatomy and performing volume replacement based on these observations. These studies are underway in our group.

CONCLUSIONS

The use of a reference female skull as a template to virtually model FFS simplifies and reduces subjective guesswork for osseous maneuvers. Given both the relative ease of the technique and the common sense of this approach, we suggest that this technique should be the dominant method for surgical planning of facial gender affirmation surgery.

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