Facial Feminization Surgery: Key CT Findings for Preoperative Planning and Postoperative Evaluation

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Facial feminization surgery is an increasingly performed component of gender affirmation surgery for transgender women. Preoperative facial CT is performed to plan the adjustment of the patient’s masculine characteristics to feminine and to plan operative navigation around specific readily identifiable anatomic structures. In the upper face, surgery is performed to reduce the prominence of the brow and increase the nasofrontal angle; the radiology report should indicate the frontal sinus and supraborital foramen anatomy. In the midface, rhinoplasty is performed to increase the nasofrontal and nasolabial angles; the radiology report should indicate the presence of a dorsal hump and septal deviation or spurring. In the lower face, the prominence of the chin and squareness of the jaw are adjusted via genioplasty and mandible contouring, respectively; the radiology report should describe the location and potential anatomic variations of the inferior alveolar nerve and mental foramina as well as the presence of dental abnormalities that directly inform the surgical approach. CT may also be performed if there is clinical suspicion for postoperative complications such as hardware fracture or osteotomy through the supraorbital or mental foramen. Familiarity with these findings will facilitate improved communication between radiologists and surgeons, thereby contributing to the care of transgender women.

Transgenderism is increasingly recognized in the United States, and national surveys estimate a growing U.S. transgender population size [1]. Gender dysphoria is a feeling of distress as a result of a mismatch between the gender that a person is assigned at birth and the gender with which the person identifies [2]. Treatment options for gender dysphoria include counseling, sex-hormone therapy, and gender-affirming surgery [3]. Medicare coverage has been available for gender-affirming surgery since 2014, and utilization of these surgeries is increasing [4, 5].

Facial feminization surgery (FFS) is a component of gender-affirming surgery and includes facial procedures designed to adjust masculine facial secondary sex characteristics. Secondary sex characteristics of the face represent part of the complex pattern of visual cues that humans use to ascribe gender. Facial structures that most strongly contribute to gender discernment include the supraorbital ridge, particularly its relationship to the nose, as well as the prominence of the jaw and chin [6, 7]. FFS aims to alter these anatomic characteristics (Fig. 1). A systematic review of 1121 patients who underwent FFS reported in the literature concluded that FFS is safe and satisfactory for patients [8].

Routine preoperative assessment of a patient undergoing FFS, as well as postoperative imaging assessment if needed, involves unenhanced facial CT, which provides greater anatomic detail and improved 3D characterization of the face than radiography. Given the increasing frequency with which FFS is performed, radiologists will increasingly be expected to interpret these examinations. This article describes how a radiologist may add value to this interpretation by reviewing the operative components of FFS, the anatomic targets for surgical change, and the role of pre- and postoperative CT in the care of these patients, with attention to commonly observed CT findings of interest to surgeons.

Keywords
CT, facial feminization surgery, gender dysphoria, surgical planning, transgender

References
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Imaging Protocol

CT acquisition should target the complete face and orbits, with coverage extending from above the frontal sinuses through the entire mandible. Intraoperative image-guided surgical navigation software is usually not used unless specifically requested, and thus whole-head imaging is generally not required. Preferred acquisition parameters include a helical thickness of 0.625 mm, tube voltage of 120 kV, and tube current ranging from 100 to 250 mA. This low range of tube current settings is advised to adequately delineate the relevant structures, given the focus on skeletal anatomy, while maintaining the lowest possible radiation dose, which is of particular importance in the young patient population undergoing FFS. The CT acquisition should be reconstructed using bone kernels in axial, sagittal, and coronal planes. Three-dimensional volumetric reconstructed images are created on a separate workstation using commercially available scanner-specific software and are subsequently exported to a PACS for visualization by the radiologist and surgeon.

The Supraorbital Foramina

The Ousterhout classification system groups frontal sinus types by their associated surgical approach [11] (Fig. 3). A type 1 sinus is characterized by a thick outer table with minimally pneumatized air cells. A type 2 sinus is characterized by a thin outer table with moderately pneumatized air cells and moderate anterior projection of the supraorbital rims. A type 3 sinus is characterized by a thin outer table with a hyperpneumatized sinus and a large anterior or projection of the supraorbital rims. The radiology report should describe the degree of aeration and thickness of the outer table of the frontal sinus (Fig. 4). If a large frontal sinus is present (Ousterhout type 2 and type 3), frontal bone setback is performed. If a thick outer table and a minimally aerated frontal sinus is present (Ousterhout type 1), contouring alone is performed. The presence of significant frontal sinus mucosal disease or opacification should also be described preoperatively, and these findings should be addressed before or during surgery (Fig. 4).

The Supraorbital Ridge

The prominence of the brow and its relationship to the nose appear to confer the greatest discernment of male-versus-female gender identity [6]. Accordingly, the supraorbital ridge and nose represent major anatomic targets for FFS, and the radiologist has a distinct role in alerting referring clinicians to the relevant morphologic findings of these regions. The relationship of the supraorbital ridge to the nose can be quantified by the nasofrontal angle (NFA) and by the distance from the frontal prominence to the mid sella. The NFA is assessed by measuring the angle formed by lines tangent to the glabella and the nasal bridge, meeting at the nasion to form its apex. The frontal prominence–to-midsellar distance is measured by drawing a line from the outer table of the frontal sinus to the mid sella (Fig. 2).

In the female face, the NFA is considerably more obtuse and the anterior prominence of the frontal bone is reduced, which is manifested by a shorter frontal prominence–to-midsellar distance [9]. In a series by Noureai et al. [9], the NFA changed from 141.6° ± 6.0° (mean ± SD) preoperatively to 150.5° ± 5.5° postoperatively. In a study by Capitán et al. [10], the frontal prominence–to-midsellar distance decreased from an average of 85.9 ± 2.7 (SD) mm preoperatively to 77.3 ± 2.1 mm postoperatively.

Frontal Sinus Anatomy

To increase the NFA and reduce the prominence of the brow, osteotomy with fixation of the anterior table in a new position and/or contouring is performed to the frontal bone [11]. Thus, the anatomy of the frontal sinus directly informs the surgical approach: a frontal sinus that is minimally pneumatized may require only superficial bone contouring without osteotomy, whereas a heavily pneumatized frontal sinus will require osteotomy and setback with fixation to achieve the appropriate feminine proportions.

The Ousterhout classification system groups frontal sinus types by their associated surgical approach [11] (Fig. 3). A type 1 sinus is characterized by a thick outer table with minimally pneumatized air cells. A type 2 sinus is characterized by a thin outer table with moderately pneumatized air cells and moderate anterior projection of the supraorbital rims. A type 3 sinus is characterized by a thin outer table with a hyperpneumatized sinus and a large anterior or projection of the supraorbital rims. The radiology report should describe the degree of aeration and thickness of the outer table of the frontal sinus (Fig. 4). If a large frontal sinus is present (Ousterhout type 2 and type 3), frontal bone setback is performed. If a thick outer table and a minimally aerated frontal sinus is present (Ousterhout type 1), contouring alone is performed. The presence of significant frontal sinus mucosal disease or opacification should also be described preoperatively, and these findings should be addressed before or during surgery (Fig. 4).

The Lower Face

In the lower face, the width of the jaw and shape of the chin are the primary determinants of visual gender discernment: a
feminine face tends to have a less square jaw and a more pointed chin [13]. Depending on the patient’s existing facial proportions, in general, the goal of FFS is both to reduce the anterior prominence of the chin via genioplasty and to decrease the lateral width and general prominence of the jaw via mandibular ostectomy and/or contouring [14] (Fig. 7).

The Chin

In genioplasty, the mental region is narrowed and advanced or is set back as needed. The genioplasty segments are plated for construct stability and are contoured to minimize stepoff and to taper the chin.

During surgical access, the mental foramen is identified and dissected to protect its neurovascular bundles, which contain terminal branches of the inferior alveolar nerve. Because of the inferior course of the nerve on its exit from the foramen, the superior extent of the genioplasty ostectomy must be at least 0.5 cm inferior to the mental foramen [15]. Additionally, the intramandibular course of the nerve must be assessed before genioplasty to avoid nerve damage. Usually, the mental foramen is positioned between the first and second premolars, although variant positioning can occur. Moreover, the mental foramen can be duplicated or triplicated [16] (Fig. 8). The radiology report should describe these features (Fig. 4).

The Jaw

Mandibular angle ostectomy and/or contouring is performed in patients for whom the squareness of the jaw contributes to an overall masculine appearance. The CT depiction of the contribution of the mandibular angles to overall jaw squareness is best shown by 3D reformatted images viewed in the coronal plane and is part of the rationale for routine CT 3D postprocessing (Fig. 7).

The degree of mandibular angle contouring varies on a per-patient basis because the visual relationship of the squareness of the jaw to masculinity or femininity can be culturally influenced [13]. If mandible ostectomy is performed, the mandibular angle is accessed via intraoral incisions, and the flared portions of the mandibular angles are resected and adjusted. The mandible is then contoured as desired from the angle anteriorly to the genioplasty segment to smooth the jawline. In some cases, an ostectomy and resection of the inferior border of the mandible are performed. This procedure requires identification of the inferior alveolar nerve course and can benefit from virtual surgical planning with cutting guides; the use of personalized 3D models during virtual planning can maximize the safety of resection [17, 18]. Finally, the presence of unerupted mandibular molars and/or periodontal cysts can in some cases inform the approach for mandibular ostectomy and should be described in the radiology report (Figs. 4 and 9).

Postoperative Assessment

Postoperative CT may be performed when there is clinical suspicion for an operative complication. As with any postoperative imaging examination that is performed after hardware fixation, the hardware should be scrutinized for surrounding lucency or fluid collections, which may suggest the presence of an infection (Fig. 10). The presence of hardware fracture or discontinuity should also be assessed.

In addition to hardware and soft-tissue scrutinization, the postoperative CT assessment should include inspection of the osteotomy lines to ensure that surrounding structures have not been violated. For example, if the genioplasty ostectomy is too close to the inferior wall of the alveolar nerve canal, the risk of postoperative lip numbness is increased (Fig. 11). Similarly, the frontal bone ostectomy should not contact the supraorbital foramina. These features should be reported in a standardized fashion (Fig. 4).

Discussion

Gender identity refers to one’s innermost concept of self as male, female, or neither. One’s gender identity can be the same or different from one’s sex assigned at birth. “Cis-gender” is a term used to describe a person whose gender identity aligns with the sex assigned at birth. “Transgender” and “gender diverse” are umbrella terms used to describe people whose gender identity and/or expression is different from cultural expectations based on the sex assigned at birth. These terms also describe gender nonconforming, nonbinary, and gender queer individuals (e.g., a person whose gender identity may not be confined to a binary male or female understanding of gender) [19].

The transgender and gender-diverse population accounts for approximately 1.6 million adults in the United States [20]. This population faces substantial health care disparities, including an increased risk of suicidality, substance abuse, and cancer [21, 22]. The 2015 report from the National Center for Transgender Equality revealed that 28% of transgender and gender-diverse patients, fearing intimidation, were forced to postpone medical care, 30% experienced harassment in the medical settings, and 20% were refused care altogether [23].

A number of solutions have been proposed to achieve more equitable health care for transgender and gender-diverse patients. These include expansion of gender-related education of medical personnel across all ranks, creation of an inclusive physical environment that provides gender-neutral bathrooms and changing rooms, and modernization of the electronic medical record and PACS to address gaps in gender-sensitive information [24–26].

A recent systematic review by Kennedy et al. [27] revealed a marked paucity of published transgender-related radiology research, highlighting the need for greater awareness by radiologists of how the specialty may contribute to the care of the transgender community. Accordingly, in this article, we have described the radiologist’s role in an important aspect of the care of gender-diverse patients—namely, preoperative FFS planning. This builds on previous work by Doo et al. [28] that provided a broader overview of imaging findings for a range of gender-affirming surgeries.

We have focused on the skeletal aspects of preoperative FFS planning. Soft-tissue modifications—for example, brow lift, hairline adjustment, and malar enhancement—are not assessed on facial CT but remain important tools in the surgeon’s ability to adjust masculine features to feminine. We have not explored the potential use of MRI in preoperative planning, which has been shown to be beneficial for planning other surgical procedures [29, 30]: for example, the use of preoperative MRI to characterize and quantify soft-tissue modifications that contribute to FFS or to facilitate augmented reality in surgical planning. Also, we have not commented on facial masculinization surgery or its radiologic considerations.
Conclusion
We describe readily identifiable CT features with a key role in FFS planning. Familiarity with these findings will facilitate improved communication between radiologists and surgeons, thereby contributing to the care of transgender women.

References
22. Sowinski JS, Gunderman RB. Transgender patients: what radiologists need to know. AJR 2018; 210:1106–1110

(Figures start on next page)
CT to Plan FFS and Evaluate for Complications After FFS

Fig. 1—Drawings show key pre- to postoperative modifications to face in frontal (top row) and lateral (bottom row) projections. Frontal bone ostectomy (dashed lines) and/or recontouring is performed to reduce prominence of brow. Rhinoplasty (dotted lines) is performed to increase nasofrontal and nasolabial angles and complement degree of frontal contouring. Genioplasty (solid red lines) is performed to decrease prominence of chin. Mandible angle osteotomy (dot-dash lines) is performed to reduce jaw squareness.

Fig. 2—CT shows nasofrontal angle (NFA) and frontal prominence–to-midsellar distance in 37-year-old transgender woman who underwent CT for preoperative planning of facial feminization surgery. NFA (angle A) is formed from line tangent to glabella and line tangent to nasal bridge with its apex at nasion (upper asterisk). Frontal prominence–to-midsellar distance (line B) is formed from line originating at anterior point of outer table of frontal sinus and terminating at mid sella. Apex of nasolabial angle (angle C) is formed by subnasale (lower asterisk), point at which lower border of nose meets outer contour of upper lip.

Fig. 3—Ousterhout classification of frontal sinus.
A, 32-year-old transgender woman who underwent CT for preoperative planning of facial feminization surgery (FFS). CT shows type 1 frontal sinus. Ousterhout type 1 is characterized by thick outer table with minimally pneumatized sinus.
B, 29-year-old transgender woman who underwent CT for preoperative planning of FFS. CT shows type 2 frontal sinus. Ousterhout type 2 is characterized by thin outer table with moderately pneumatized sinus and moderate anterior projection of supraorbital rims.
C, 41-year-old transgender woman who underwent CT for preoperative planning of FFS. CT shows type 3 frontal sinus. Ousterhout type 3 is characterized by thin outer table with hyperpneumatized sinus and large anterior projection of supraorbital rims.
Figure 4—Illustration shows CT measurements and checklists of pre- and postoperative CT findings for facial feminization surgery.
Fig. 5—Characterization of supraorbital foramen. A, 27-year-old transgender woman who underwent CT for preoperative planning of facial feminization surgery (FFS). Coronal CT shows supraorbital foramen is manifesting as notch congruent with supraorbital rim (arrows). B, 29-year-old transgender woman who underwent CT for preoperative planning of FFS. Coronal CT shows supraorbital foramen is distinct from supraorbital rim (arrows).

Fig. 6—41-year-old transgender woman who underwent CT for preoperative planning of facial feminization surgery (FFS) and for postoperative evaluation after FFS. A and B, Coronal unenhanced preoperative (A) and postoperative (B) CT images show medial oblique superior nasal bone osteotomies (arrows) performed to narrow nasal base and recontour nasofrontal angle.

Fig. 7—Pre- and postoperative CT of two different patients who underwent facial feminization surgery (FFS). A and B, Frontal 3D reformatted images obtained before (A) and after (B) FFS of 29-year-old transgender woman. Red dashed line in A indicates frontal bone osteotomy. Red dash-dot lines in A indicate mandibular angle osteotomies. Red solid line in A indicates genioplasty. Green arrowheads indicate superior orbital foraminal notches. Blue arrowheads indicate mental foramina.

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Fig. 7 (continued).—Pre- and postoperative CT of two different patients who underwent facial feminization surgery (FFS). C and D, Sagittal reformatted images obtained before (C) and after (D) FFS of 39-year-old transgender woman. Note Ousterhout type 1 frontal sinus. In C, red dashed line indicates frontal bone recontouring, and red solid line indicates genioplasty. Nasofrontal angle (yellow lines) is increased postoperatively (D).

Fig. 8.—Three-dimensional volumetric CT reconstruction of 41-year-old transgender woman undergoing preoperative evaluation for facial feminization surgery. Arrows indicate duplicated mental foramina, which is normal anatomic variant that can inform operative approach for genioplasty.

Fig. 9.—Sagittal CT of 37-year-old transgender woman undergoing preoperative evaluation for facial feminization surgery. Presence of impacted or partially erupted teeth, with or without any associated cystic change, should be described in radiology report because dental extraction may be required before mandibular angle osteotomy. Red dashed line indicates planned plane of osteotomy.
Facial feminization surgery (FFS) encompasses facial bony and soft-tissue surgeries aimed at adjusting masculine facial features as part of gender-affirming surgery. Radiologists play a key role in the preoperative planning for patients undergoing FFS by identifying anatomic variants and pertinent anatomic relationships of the craniofacial anatomy. This article presents a framework for analyzing the key craniofacial structures with specific attention to anatomic variants that affect the surgical approach. Additionally, the reader is presented with an anatomy-based approach to the modifications of various facial features for achieving a more feminized facial appearance.

In addition to playing a crucial role in preoperative planning, radiologists may be asked to evaluate patients for postoperative complications after FFS. The authors thus also describe postprocedural complications of FFS, which are mainly related to the integrity of hardware, the osteotomy lines, and the relationship of the osteotomy lines to neural foramina such as the inferior alveolar nerve canal and supraorbital foramina. To provide a clinically relevant postoperative report, radiologists must be familiar with the various bony and soft-tissue craniofacial surgical procedures that are undertaken as part of facial feminization, as the authors describe.

This article provides checklists and a reporting template, which offer a concise organizational framework for readers that can be easily used when evaluating patients who are planning to undergo FFS. This article adds to the growing body of literature on FFS and highlights the crucial role radiologists play in the workup and evaluation of patients undergoing FFS. With gender affirmation surgeries becoming more prevalent, it is important for radiologists to be familiar with gender-diverse imaging and gender-affirming surgical procedures.

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