Osseous Transformation with Facial Feminization Surgery: Improved Anatomical Accuracy with Virtual Planning

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Background: Facial feminization surgery entails a series of surgical procedures that help the transwoman pass as their affirmed gender. Although virtual surgical planning, with intraoperative cutting guides, and custom plates have been shown to be helpful for craniomaxillofacial reconstruction, they have not yet been studied for facial feminization surgery. The authors used cadaveric analysis for morphologic typing and to demonstrate the utility of virtual surgical planning in facial feminization surgery procedures.

Methods: Male cadaveric heads underwent morphologic typing analysis of the frontal brow, lateral brow, mandibular angle, and chin regions (n = 50). Subsequently, the cadavers were split into two groups: (1) virtual surgical planning intraoperative cutting guides and (2) no preoperative planning. Both groups underwent (1) anterior frontal sinus wall setback, (2) lateral supraorbital recontouring, (3) mandibular angle reduction, and (4) osseous genioplasty narrowing. Efficiency (measured as operative time), safety (determined by dural or nerve injury), and accuracy (scored with three-dimensional computed tomographic preoperative plan versus postoperative result) were compared between groups, with significance being p < 0.05.

Results: For frontal brow and lateral lower face, morphologic type 3 (severe) predominated; for lateral brow and chin, type 2 (moderate) predominated. For frontal sinus wall setback, virtual surgical planning improved efficiency (19 minutes versus 44 minutes; p < 0.05), safety (100 percent versus 88 percent; p < 0.05; less intracranial entry), and accuracy (97 percent versus 79 percent; p < 0.05) compared with no preoperative planning. For mandibular angle reduction, virtual surgical planning improved safety (100 percent versus 88 percent; p < 0.05; less inferior alveolar nerve injury) and accuracy (95 percent versus 58 percent; p < 0.05).

Conclusions: Preoperative planning for facial feminization surgery is helpful to determine morphologic typing. Virtual surgical planning with the use of cutting guides/custom plates improved efficiency, safety, and accuracy when performing four key craniofacial techniques for facial feminization. (Plast. Reconstr. Surg. 144: 1159, 2019.)

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A “Hot Topic Video” by Editor-in-Chief Rod J. Rohrich, M.D., accompanies this article. Go to PRSJOURNAL.com and click on “Plastic Surgery Hot Topics” in the “Digital Media” tab to watch.
importance. Facial feminization surgery involves a
series of surgical procedures aimed at feminizing
the transwoman’s face, with the goal of easing her
psychosocial burden. Facial feminization surgery
is associated with improved mental health and
quality of life.\textsuperscript{2,3}

There are numerous bony and soft-tissue dif-
fferences between the male and female face. Osse-
ous differences between the male and female face
almost universally include the forehead, lateral
supraorbital region, lateral jawline, and chin.\textsuperscript{4–6}
On frontal view, the female face is softer, more
rounded or oval-shaped, with a more pointed
chin, whereas the male face is more square and
angulated, with a strong jawline and chin (Fig. 1).
On lateral view, men traditionally have bossed
foreheads, whereas women have more gently
sloped or flat foreheads. Procedures to offer trans-
formation from a male to a female face include
anterior frontal sinus setback or recontouring,
supraorbital reduction, mandibular angle reduc-
tion, and osseous genioplasty.\textsuperscript{4–6} Other skeletal
procedures sometimes offered include the follow-
ing: orthognathic (jaw) surgery and/or zygomatic
width reduction. In addition, soft-tissue proce-
dures may be performed simultaneously, or in a
staged fashion, and include forehead shortening/
brow lift, septrhinoplasty, upper lip shortening,
fat grafting, and/or laryngochondroplasty (“trach
shave”).

Over the past 10 years, craniomaxillofacial
reconstruction has used virtual surgical plan-
ning with computer-aided design (CAD) and
computer-aided manufacturing (CAM) for intra-
operative cutting guides to enhance efficiency,
accuracy, predictability, and reproducibility of
osseous procedures.\textsuperscript{7,8} In orthognathic and
mandibular reconstruction, virtual surgical planning
and CAD/CAM have been shown to decrease the
risk of nerve injury.\textsuperscript{9,10} It has also been shown
to enhance accuracy of frontal sinus reconstruc-
tion.\textsuperscript{11} Virtual surgical planning has not been well
studied in facial feminization surgery, despite the
need for multiple craniofacial techniques to modi-
fy the facial skeletal. We used cadaveric analysis to
determine male face morphologic types for anat-
omical regions that need to be altered in facial
feminization surgery: (1) frontal brow, (2) lateral
brow, (3) mandibular angle, and (4) chin. In addi-
tion, we studied cadaveric operative techniques
to evaluate virtual surgical planning and CAD/
CAM manufacturing preoperative planning for
efficiency, safety, and accuracy in the four main
osseous procedures of facial feminization surgery:
(1) anterior frontal sinus wall setback, (2) lateral
supraorbital recontouring, (3) mandibular angle
reduction, and (4) osseous genioplasty.

METHODS

Male cadaveric heads underwent computed
tomographic imaging and craniofacial operative
procedures for osseous facial feminization
\((n=50)\). Imaging was used to assess male anat-
omical morphology of four facial regions that are
known to need modification for facial feminiza-
tion: (1) frontal brow, (2) lateral brow, (3) man-
dibular angle, and (4) chin. Imaging was also used
postoperatively to assess the accuracy of the proce-
dures. In addition, 10 female three-dimensional
computed tomographic scans were used as refer-
ences. Abnormal skulls were excluded from this
study (e.g., skulls with significant facial asymme-
try, trauma, or congenital deformities).

Morphologic types were designated for each
of the four anatomical regions based on previous
experience. The number of cadaver heads with
each morphologic type was recorded indepen-
dently by three separate senior plastic surgeons
(Tables 1 through 4). Frontal brow morphology
was separated into type 1, mild bossing only, small
or no frontal sinus, and thick anterior wall; type
2, moderate bossing, normal frontal sinus, and
flatness in midforehead; and type 3, significant
masculine bossing and large projection. Although
type 4 has been previously described, we did not
see this type in our cadaveric skulls.\textsuperscript{12} Lateral brow
morphology was separated into type 1, no or mini-
mal overhang of supraorbital bar; type 2, moder-
ate overhang of lateral supraorbital bar; and type
3, significant overhang of lateral supraorbital bar
extending down the lateral orbital wall. Mandibu-
lar angle morphology was separated into type 1,
mild lower face width/angular projection; type
2, moderate lower face width/angular projection;
and type 3, significant angular projection with acute
mandibular angle. Chin morphology was separated
into type 1, mild chin width; type 2, moderate
chin width; and type 3, significant chin
width and increased lower face height.

Operative techniques are tailored to the mor-
phologic types for each region. For the frontal
brow procedures, type 1 (mild bossing, no sinus/
thick anterior wall) underwent recontouring
with a side-cutting burr; type 2 (moderate bossing,
normal frontal sinus) underwent limited bur-
ring, and midforehead hydroxyapatite or fat graft-
ing; and type 3 (significant bossing) underwent
anterior frontal sinus wall setback with resorbable
plate (Resorb x; KLS Martin, Jacksonville, Fla.)
or wire fixation and peripheral burring (Fig. 2). For lateral brow procedures, type 1 (no overhang) underwent no procedure; type 2 (moderate overhang) underwent side-cutting burr recontouring; and type 3 (significant overhang) underwent ostectomy with reciprocating saw. For mandibular angle procedures, type 1 (mild lower face width) underwent partial masseter resection (and would undergo serial botulinum toxin type A injections every 6 months); type 2 (moderate lower face width) underwent limited mandibular angle burring and partial masseter resection; and type 3 (significant lower face width, acute angle) underwent mandibular angle resection (Fig. 3). For chin procedures, type 1 (mild chin width) underwent lateral chin burring; type 2 (moderate chin width) underwent osseous genioplasty narrowing/advancement; and type 3 (significant chin width, increased lower face height) underwent osseous genioplasty narrowing, shortening, and advancement (Fig. 4). For the comparative study, the male cadaver skulls were separated into two

Fig. 1. Morphologic gender skull differences as originally described by Doug Ousterhaut. (Above, left) Male skull (frontal view) demonstrating bossed forehead, low supralateral brow, wide lower face, and wide chin. (Above, right) Female skull (frontal view) demonstrating flat forehead, contoured supralateral brow, narrow lower face, and pointy chin. (Below, left) Male skull (lateral view) demonstrating bossed forehead, supralateral brow hooding, acute mandibular angle, and large chin. (Below, right) Female skull (lateral view) demonstrating recessed forehead, low supralateral brow, soft curved mandibular angle, and small chin.
equal groups: group 1, virtual surgical planning and CAD/CAM preparation before performing the operative techniques; and group 2, no preoperative planning. Because type 1 cases required no surgery or minor procedures, types 2 and 3 were added so that the comparative groups each had 25 specimens. The specimens were separated randomly into groups and age was recorded. For group 1, virtual surgical planning and CAD/CAM had cutting guides and custom plates made (KLS Martin, Jacksonville, Fla.). Cutting guides were made for frontal brow, lateral brow, mandibular angle, and chin. Movements were based on existing three-dimensional computed tomographic scan morphology and desired change for each region. Custom plates were made for the frontal brow and osseous genioplasty. Surgery was performed on fresh cadavers with soft tissues attached to mimic in vivo procedures.

Group 1 (virtual surgical planning and CAD/CAM) was compared to group 2 (no preoperative planning) for efficiency, safety, and accuracy. Efficiency was based on operative time per region; we did not include preoperative planning time. Safety was based on inadvertent entry into the cranial space or dural injury (for the forehead and lateral supraorbital regions) and sensory nerve injury (for mandibular angle and chin regions). Accuracy was based on volumetric analysis comparing the preoperative to the postoperative three-dimensional computed tomographic scans for each region. Measurements were calculated as percentage accuracy, as follows: 

\[
\text{Percentage accuracy} = \frac{\text{Absolute value of expected volumetric change} - \text{Actual volumetric change}}{\text{Expected volumetric change}} \times 100
\]

Prevalence (%)

<table>
<thead>
<tr>
<th>Frontal Brow Type</th>
<th>Defining Features</th>
<th>Techniques for Transformation</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mild bossing, no or minimum frontal sinus, thick anterior wall</td>
<td>Burring</td>
<td>3/50 (6)</td>
</tr>
<tr>
<td>2</td>
<td>Moderate bossing, midforehead flattening</td>
<td>Burring plus fat filling</td>
<td>4/50 (8)</td>
</tr>
<tr>
<td>3</td>
<td>Significant bossing, large projection</td>
<td>Anterior frontal sinus wall setback</td>
<td>43/50 (86)</td>
</tr>
</tbody>
</table>

*aType 3 requiring an anterior frontal sinus wall setback is the most common.

RESULTS

For morphologic types, 93 percent were recorded identically by the three independent reviewers for all regions. The remaining 7 percent with discrepancies among reviewers were re-reviewed and reclassified. Mean cadaveric age was 54.3 ± 4 years.

Forehead brow morphology in a large majority of specimens was type 3, with significant masculine bossing and large projection (86 percent). Type 2 (moderate bossing) and type 1 (mild bossing) made up only 8 and 6 percent, respectively (Table 1). The forehead brow type 3 cases required an anterior frontal sinus wall setback. The mean amount of setback was 6.2 ± 2 mm from maximal projection. For group 1 (virtual surgical planning) cadavers, cutting guides were designed within the exact border of the frontal sinus, and the location of the septum was marked. A surgical drill was used to precisely cut the anterior frontal sinus wall out, a reciprocating saw was used to horizontally cut the bone removed, and custom plates were used for fixation in a posterior position (Fig. 2). Of note, 88 percent of cases had a septum present requiring an osteotomy to take off the anterior frontal sinus wall in one piece. Group 2 (no preoperative planning) had a window made in the anterior frontal sinus wall, bone was removed as multiple individual pieces, and wire and miniplate fixation of bone with degree of setback was determined on the table. Group 1 (virtual surgical planning) resulted in improved efficiency with decreased operative time compared to group 2 (no preoperative planning) (19 ± 3 minutes versus 44 ± 5 minutes; \( p < 0.05 \)). Although operative times were consistent throughout group 1 (virtual surgical planning) cases, for group 2 (no preoperative planning) cases, there was a learning curve, with slower times for the initial one-third of cases (58 minutes) and faster times...
Fig. 2. Virtual surgical planning for the brow region. (Above) Cutting guide for frontal brow (central) for osteotomy of the anterior frontal sinus wall and cutting guides for the lateral brow (lateral) for ostectomy of the lateral supraorbital bar. (Center) Custom resorbable plate fixation after anterior frontal sinus wall horizontal sectioning (for contouring from convex to flattened) and setback; borders are contoured with a burr (arrow). (Below) Right lateral side view of brow demonstrates frontal sinus wall setback. Gray outline shows original convex contour and colored bones show new flat contour.
for the last one-third of cases (37 minutes). There also was improved safety with group 1 (virtual surgical planning) cases, with no complications, compared to group 2 (no preoperative planning), with four inadvertent intracranial entries (safety, 100 percent versus 88 percent; \( p < 0.05 \)) (Table 5). Finally, group 1 (virtual surgical planning) had improved accuracy compared with group 2 (no preoperative planning) (97 ± 4 percent versus 79 ± 3 percent; \( p < 0.05 \)).
Lateral brow morphology in a majority of cases was type 2 with moderate supraorbital overhang (66 percent) (Table 2). Type 3 (significant supraorbital overhang) and type 1 (no supraorbital overhang) made up only 18 percent and 16 percent, respectively. Type 2 cases required lateral brow burring, with a cutting guide used for group 1 (virtual surgical planning) cases. When comparing group 1 to group 2 cases, there was similar efficiency (18 ± 2 minutes versus 20 ± 3 minutes), similar safety (100 percent versus 96 percent), and similar accuracy (94 ± 4 percent versus 88 ± 5 percent) (Table 5).

Mandibular angle morphology had a majority of cases with type 3 or with significant lower face width (66 percent) (Table 3). Type 2 (moderate lower face width) and type 1 (mild lower face width) made up 24 percent and 10 percent, respectively. Type 3 cases required mandibular angle resection; for group 1 (virtual surgical planning) cases, a cutting guide based on occlusal reference was used to protect the nerve and gain symmetry (Fig. 3). When comparing group 1 cases to group 2 cases (no preoperative planning), there was similar efficiency (18 ± 2 minutes versus 20 ± 3 minutes; p < 0.05); however, group 1 was superior with regard to safety (100 percent versus 88 percent; p < 0.05) (less inferior alveolar nerve injury) and accuracy (95 ± 4 percent versus 58 ± 2 percent; p < 0.05) (Table 6).

Chin morphology had the most cases with type 2 or with moderate chin width (74 percent). Type 3 (significant chin width and lower face height) and type 1 (mild chin width) made up 20 percent and 6 percent, respectively (Table 4). Type 2 cases required osseous genioplasty narrowing; for group 1 (virtual surgical planning), a cutting guide based on occlusal reference was used, with the amount of central narrowing marked for resection (Fig. 4). When comparing group 1 cases to group 2 cases (no preoperative planning), there was similar efficiency (18 ± 2 minutes versus 24 ± 3 minutes), similar safety (100 percent versus 92 percent), and similar accuracy (95 ± 4 percent versus 88 ± 5 percent) (Table 6).

**DISCUSSION**

Facial features are extremely important for a transgender person trying to present in public as a member of the desired gender. As such, transgender individuals seeking confirmation surgery often seek facial feminization surgery even before top (breast) or bottom (genitalia) surgery. Douglas Ousterhout studied differences between the male and female face and the male and female facial skeleton. Using knowledge of facial differences between the sexes, effective transformational facial feminization surgery procedures were devised.

On systematic anatomical analysis, phenotypic difference between the male and female face become apparent. The male upper third face begins with an M-shaped hairline and has a more prominent, longer, sloping forehead. The central brow above the nasal radix is bossed from the underlying frontal sinus. The male lateral brow arch tends to be flat or only slightly arched. By contrast, the female hairline is set lower and resembles an upside-down V shape, and the forehead has a milder slope.

**Table 2. Lateral Brow (Supraorbital Rim) Types and Indicated Corrective Techniques**

<table>
<thead>
<tr>
<th>Lateral Brow Type</th>
<th>Defining Features</th>
<th>Techniques for Transformation</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No or minimal supraorbital overhang</td>
<td>No surgery</td>
<td>8/50 (16)</td>
</tr>
<tr>
<td>2</td>
<td>Moderate supraorbital overhang</td>
<td>Burring</td>
<td>33/50 (66)</td>
</tr>
<tr>
<td>3</td>
<td>Significant overhang; extending down lateral orbital wall</td>
<td>Ostectomy</td>
<td>9/50 (18)</td>
</tr>
</tbody>
</table>

*Type 2 requiring burring of the overhanging bone is the most common.

**Table 3. Mandibular Angle (Lower Face Width) Types and Indicated Corrective Techniques**

<table>
<thead>
<tr>
<th>Lower Face Width Type</th>
<th>Defining Features</th>
<th>Techniques for Transformation</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mild lower face width</td>
<td>Masseter resection serial botulinum toxin type A</td>
<td>5/50 (10)</td>
</tr>
<tr>
<td>2</td>
<td>Moderate lower face width</td>
<td>Angle burring, masseter resection</td>
<td>12/50 (24)</td>
</tr>
<tr>
<td>3</td>
<td>Significant lower face width/acute angle</td>
<td>Mandibular angle resection</td>
<td>33/50 (66)</td>
</tr>
</tbody>
</table>

*Type 3 requiring mandibular angle resection is the most common.
narrower, smoother dorsum and supratip break; and greater tip rotation. The male lip is longer than the female lip. In the lower third of the face, the male jaw is square, angulated, and appears wider because of lateral ridging/lipping of the mandibular angle and a bulkier masseter. By contrast, the female lower face is triangular. The male mandibular angle and a bulkier masseter. By contrast, the female lower face is triangular. The male face has a wider, longer, and often more protruding chin, whereas the female chin is shorter and more narrow.15 Previous studies suggest that the male chin may be as much as 20 percent longer than the female chin.16

Despite these general descriptive differences, our anatomical cadaveric study showed variation and gradation of masculine features. These variations were separated into morphologic types. Preoperative skeletal analysis with the use of computed tomographic imaging allowed for regional morphologic typing. In our cadaveric study, we found that for each of the four regions, there was one morphologic type that predominated. For the frontal brow and lateral lower face width regions, type 3 predominated, and for the lateral brow and chin regions, type 2 predominated. Thus, in the majority of cadavers, the brow, lateral supraorbital, mandibular angle, and mental regions were significantly “masculine” enough to warrant modification of the craniofacial skeleton. Both type 2 and type 3 required craniofacial osteotomy techniques.

Traditionally, the amount of recontouring and reduction of bony prominences performed was based on artistic insight and experience. However, with that traditional approach, underresection, overresection, or unequal (side-to-side) resection are possible. In our study, the traditional approach (i.e., no-preoperative planning group) was less accurate compared with the virtual surgical planning group in facial feminization surgery that used surgical cutting guides. For all four regions operated on, there was less accuracy without the use of virtual surgical planning when the virtual plan was compared to the actual three-dimensional computed tomographic outcome. This was particularly true for the frontal brow region with an anterior frontal sinus wall setback and for the lower facial width region with mandibular angle reduction. Most importantly, the virtual surgical planning group demonstrated improved safety with regard to reduced intracranial injury

### Table 4. Chin Types and Indicated Corrective Techniques*

<table>
<thead>
<tr>
<th>Chin Type</th>
<th>Defining Features</th>
<th>Techniques for Transformation</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mild chin width</td>
<td>Burr</td>
<td>3/50 (6)</td>
</tr>
<tr>
<td>2</td>
<td>Moderate chin width</td>
<td>Osseous genioplasty narrowing</td>
<td>25/50 (46)</td>
</tr>
<tr>
<td>3</td>
<td>Significant width, increased lower face height</td>
<td>Osseous genioplasty narrowing; vertical shortening</td>
<td>10/50 (22)</td>
</tr>
</tbody>
</table>

*Type 2 requiring osseous genioplasty narrowing and advancement is the most common.

### Table 5. Comparative Outcomes of Facial Feminization Surgery with Virtual Surgical Planning versus No Preoperative Planning for Forehead and Lateral Brow*

<table>
<thead>
<tr>
<th>Regions for Transformation</th>
<th>Forehead</th>
<th>Lateral Brow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Efficiency (min)†</td>
<td>Safety†</td>
</tr>
<tr>
<td>VSP</td>
<td>19 ± 3</td>
<td>25/25 (100%)</td>
</tr>
<tr>
<td>No preoperative planning</td>
<td>44 ± 5</td>
<td>21/25 (88%)</td>
</tr>
</tbody>
</table>

VSP, virtual surgical planning; EVC, expected volumetric change; AVC, actual volumetric change.

*Facial feminization surgery with VSP was more accurate and efficient in the forehead region. Efficiency = procedure time (min); safety = avoidance of inadvertent intracranial injury or sensory nerve injury; accuracy = absolute value of (EVC × AVC) × 100/EVC. †p < 0.05.

### Table 6. Comparative Outcomes of Facial Feminization Surgery with Virtual Surgical Planning versus No Preoperative Planning for Lower Face Width and Chin:

<table>
<thead>
<tr>
<th>Regions for Transformation</th>
<th>Lower Face Width</th>
<th>Chin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Efficiency (min)†</td>
<td>Safety*</td>
</tr>
<tr>
<td>VSP</td>
<td>34 ± 3</td>
<td>25/25 (100)</td>
</tr>
<tr>
<td>No preoperative planning</td>
<td>37 ± 3</td>
<td>22/25 (88)</td>
</tr>
</tbody>
</table>

VSP, virtual surgical planning; EVC, expected volumetric change; AVC, actual volumetric change.

*Facial feminization surgery with VSP was more accurate and efficient in the lower face width (mandibular angle region). Efficiency = procedure time (min); safety = avoidance of inadvertent intracranial injury or sensory nerve injury; accuracy = absolute value of (EVC × AVC) × 100/EVC. †p < 0.05.
(with the frontal sinus osteotomy) and decreased nerve injury (with the mandibular angle osteotomies). As surgeon experience increases, the likelihood of these safety mishaps are less likely, but with virtual surgical planning, they can be minimized altogether. Also, the virtual surgical planning group had greater efficiency with decreased operative times compared with the no-preoperative planning group. This benefit of efficiency using virtual surgical planning likely decreases with increasing experience. Also, additional time is spent by the surgeon for preoperative virtual surgical planning.

For the frontal brow region, the anterior frontal sinus wall setback had the greatest decrease in comparable operative time (group 1, 19 minutes; group 2, 44 minutes). This is likely attributable to greater surgeon confidence and control of the resection margin while using the cutting guides for anterior sinus wall removal. In addition, the frontal sinus wall was taken in one piece, sectioned horizontally, and fixed with a custom plate, and the borders were contoured to create a flat forehead (Fig. 2). This expedited technique was faster than the no–preoperative planning group, with piecemeal removal of the anterior sinus wall followed by wiring of the individual bony segments. Virtual surgical planning for the frontal brow minimized the need for intraoperative revisions and adjustments. These decreased operative times with virtual surgical planning were seen from the very first virtual surgical planning cases. With no preoperative planning, there is a learning curve with long operative times for the first several cases and then a slow decrease in operative times as one gains experience. For the lateral brow region, the virtual surgical planning group showed only small improvements with efficiency, safety, and accuracy that were not significant compared with the no–preoperative planning group.

Injury to the inferior alveolar nerve is a considerable concern during mandibular angle resection. In our study, the virtual surgical planning group had fewer inferior alveolar nerve injuries and better side-to-side symmetry following resection. Although injury to molar tooth roots has been reported in mandibular angle reduction, we did not see that in any cases. The authors feel that for type 2 and 3 morphology (90 percent), an angle resection with simultaneous limited maseteric reduction is superior to rasping. For the chin, the virtual surgical planning group showed only small improvements with efficiency, safety, and accuracy that were not significant compared to the no–preoperative planning group. Interestingly, the time necessary to place the cutting guides did not adversely affect the operative time despite this being an added step.

A theoretical advantage to using virtual surgical planning (not studied here) is the positive aspect of involving the facial feminization surgery patient with treatment decisions preoperatively. Candidates for these procedures are very involved with their health care decision-making. Preoperative information given in the right way to these patients may reduce perioperative anxiety and improve overall patient experience. We also recognize that it will not be valuable to involve some patients in planning cutting guides, as they will have a poor understanding of how surgical technique translates into clinical outcomes.

This cadaveric study allowed us to standardize the methodology for facial feminization surgery and control for many variables; however, there were limitations. This study did not represent a true operative environment with considerations for bleeding and anesthesia. There is a need for in vivo intraoperative reproducibility. Perioperative concerns including surgical-site infections, reaction to foreign body, and bone healing could also not be assessed. Most importantly, before one could suggest superiority of one method over another, a comparative study on patient-reported outcome measures and clinical safety would be necessary. This is warranted to help validate these new techniques for this patient population that is willing to accept significant social, psychological, and medical risk to achieve their health goals. One limitation of using virtual surgical planning is that the result is only as good as the preoperative plan at the time of virtual planning. This study does not attempt to comment on the skill of the planner as it pertains to the final result. Previous reports document that forehead surgery may be safely performed in experienced hands. Finally, age of patients requesting facial feminization surgery may be younger than the mean 54.3 years of our cadaveric group.

In summary, this cadaveric study demonstrated improvement in efficiency (time), safety (less injury), and accuracy (ability to replicate surgical plan) with the use of virtual surgical planning for regional facial feminization surgery techniques of the forehead, lateral lower face, and chin. Use of virtual surgical planning in dealing with the heterogeneity of facial features and the difficult nature of craniofacial contouring procedures improves a plastic surgeon’s chance of achieving ideal results for the facial feminization surgery patient. Otherwise, without virtual surgical planning, only the expert with immense experience, precise technical skill,
and immense visuospatial perception will be able to achieve aesthetically satisfying results with low complications. In addition, the transwoman undergoing gender confirmation surgery of the face, should be involved in the preoperative planning. Virtual surgical planning allows for transwomen to have a role in creating the final appearance of femininity.

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REFERENCES