2016

Does the Marquardt mask serve as a helpful guide for facial feminization surgery?

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http://hdl.handle.net/2144/19492

Boston University
DOES THE MARQUARDT MASK SERVE AS A HELPFUL GUIDE FOR
FACIAL FEMINIZATION SURGERY?

by

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B.S., Boston University, 2016

Submitted in partial fulfillment of the
requirements for the degree of
Master of Science
2016
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ABSTRACT

A thorough literature review resulted in limited research concerning facial
feminization surgery for transgender women, specifically concerning postoperative
satisfaction. However, sufficient research referencing the historical overview of gender
recognition and evolution of facial feminization surgery into a multi-procedural process
has been completed. Studies evaluating the Marquardt mask are also scarce and none
existed regarding the application of the mask as a means of feminizing transgender
women. The proposed study intends to expand upon this current paucity of research by
photographing men ranging from the age of twenty-five to thirty-five and digitally
superimposing the Marquardt mask. The before and after images will be rated based on
masculinity and femininity in an effort to gage if the Marquardt mask is successful in
feminizing the male face. If successful, this method could be helpful in preoperative
planning in transgender women seeking facial feminization surgery.
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LIST OF ABBREVIATIONS

FFS………………………………………………………………………………Facial Feminization Surgery

GID………………………………………………………………………………Gender Identity Disorder
INTRODUCTION

Background

Transgender individuals psychologically self-identify as a gender not consistent with that of their assigned gender at birth or chromosomal makeup. This identification persists whether or not cosmetic, hormonal or surgical intervention is sought. However, female transgender individuals, those who are genetically male but identify as female, with appropriate means often seek facial feminization surgery in an effort to be recognized as the gender to which they identify and blend more seamlessly into society. As a result, these surgical procedures have shown to improve health-related quality of life in transgender women when compared to those transgender women who have not undergone facial feminization surgery.

Facial feminization surgery has evolved from the initial anthropological research by Dr. Ousterhout in the late 1980s and 1990s that allowed for surgeons to target the facial anatomy discovered to be vital in determining gender. Facial feminization surgery is now commonly a group of procedures, which in turn has increased the risk of both physical and mental complications. Surgeons manage this issue delicately often scheduling multiple consultations prior to surgery for counseling and preoperative planning. During these visits patients are typically photographed and the images are digitally transformed to give the patient and surgeon potential aesthetic outcomes of surgery.

Those advancements inspired by Dr. Ousterhout are not isolated innovations. The Marquardt mask is another installment resulting from analyzing facial structure and
symmetry. The Marquardt, or phi, mask was developed using mathematical ratios specifically investigating symmetry and its correlation with femininity and/or attractiveness. The mask is based on the golden ratio originally derived by cutting a line ABC such that AB/AC = BC/AB, first described by ancient Greeks. This ratio appears commonly in nature in structures such as leaves, flowers, seashells and even the human mandible. This ratio can be used to construct pentagrams of varying sizes that together form a mask that represents a symmetrical, model face. Specifically for this study, it is important to mention that Marquardt’s original mathematically derived mask was calculated using white, female fashion models as subjects to construct a method to objectively measure attractiveness.

Figure 1: Marquardt mask from Marquardt (published in patent: Marquardt, S. R. Method and Apparatus for Analyzing Facial Configurations and Components, in U.S. Patent and Trademark Office, 1997)²
Statement of the Problem

The approach to facial feminization surgery can vary markedly. A current technique utilized by plastic surgeons involves altering patient photographs with computer software prior to surgery until the surgeon and patient reach an achievable desired outcome. This technique employs the surgeon’s experience, trained eye and often CT imaging to gain insight into the actual limitations of surgery. Such limitations involved in preoperative planning include measuring the frontal sinus with cone-beam CT to assess the extent to which forehead contouring is attainable. Another potential approach this study intends to explore utilizes the Marquardt mask, given its claims of model features and ratios. This strategy may be of value as the Marquardt mask was developed using women’s faces in an effort to objectively rate attractiveness. Therefore, would applying these ratios and alterations to transgender female patients undergoing facial feminization surgery serve as a useful technique to guide the set of surgical procedures? To explore this idea further, this study will assess the effectiveness of feminizing the male face using the ratios of the Marquardt mask.

Hypothesis

The female Marquardt mask applied to pictures of men will make the subjects appear more feminine.

Objectives and specific aims

Societal acceptance and normalization have allowed for more female transgender patients to seek surgical intervention causing a rapidly expanding surgical specialty. With
this increase in female transgender patients electively undergoing facial feminization surgery, continuing research regarding the optimal approach would be beneficial. The Marquardt mask was developed to exemplify model features and female attractiveness.² This study will analyze the effectiveness of using the Marquardt mask to guide pre-operative planning and design for facial feminization surgery by applying the Marquardt mask to faces of men and evaluating the degree of feminization.

• Rate the femininity score of male faces before and after digital alteration using the Marquardt mask.

• Measure inter-rater reliability among those participants grading the before and after photographs.
REVIEW OF THE LITERATURE

Overview

Transgender individuals, or those with gender dysphoria, psychologically identify as a gender different than that of their genetic sex. Medically, DSM-IV defines the condition as discordance between the birth sex and psychological gender, or gender identity disorder (GID).\(^3\)\(^5\) Although it is becoming more commonplace as acceptance increases and societal norms shift, the true prevalence is difficult to estimate for a variety of reasons. Many societies still consider transgenderism cultural taboo, religious sin or simply not the societal norm. These increased rates of discrimination hinder trans individuals from coming forward with their identification and has ultimately led to increased risk of depression and suicide within the community.\(^6\) An international meta-analysis performed including 12 studies capable of providing adequate data revealed the prevalence for transsexualism is 4.6 in every 100,000 individuals. The study also concluded that transwomen are nearly four times as prevalent than transmen at 6.8 in 100,000 and 2.6, respectively.\(^7\) Information within the United States, however, is scarce as federal surveys or census material does not include questions regarding gender identity. Two population-based surveys with specific questions concerning gender identity have provided some insight, including the Massachusetts Behavioral Risk Factor Surveillance Survey and the California LGBT Tobacco Survey. The 2007 and 2009 Massachusetts surveys revealed 0.5% of adults from 18-64 proclaimed to be transgender while the 2003 California survey disclosed that within the LGBT community, 3.2% identified as transgender (3.2% of adults in California claimed to be LGB). Therefore,
approximately 0.1% of adults in California are transgender. These survey values are in line with estimates achieved in a study by Olyslager and Conway assessing the percentage of the adult population that has begun the transition into a gender different than that of their sex at birth.\textsuperscript{8,9}

The initial evaluation and diagnosis of GID is largely based on persistence of incongruity between genetic sex and mental identification but also requires the patient not have an underlying intersex disorder and must have clinical indications of struggle with occupational or social operations.\textsuperscript{3} The management for individuals diagnosed with gender dysphoria is multifaceted. Those without financial means or medical access may oftentimes live their preferred gender simply by changes in clothing and cosmetics. However, a large proportion will seek treatment with hormones, surgery or both. One study showed 86% of transgender individuals were already using or planned to use hormone therapy, 39% had undergone some form of surgery and only 12% were living without hormonal or surgical intervention.\textsuperscript{6,10} These statistics help demonstrate that integrating into society with appropriate recognition is of utmost importance to transgender persons. In fact, according to a report generated interviewing 314 transgender females in San Francisco, even when access to medical care is limited an estimated 49% of transgender women disclosed taking hormones not written for by a medical provider.\textsuperscript{11}

Specifically, transgender women take hormones that either suppress testosterone or increase estrogen levels. Common hormones include estradiol, analogues of gonadorelin, cyproterone for its anti-androgenic properties and spironolactone given its ability to suppress testosterone.\textsuperscript{4} For those women seeking surgery as a component of
their GID management, focus is routinely placed on facial alterations as it is key in
gender recognition on a day-to-day basis. This increasing prevalence of transgender
women and the emphasis on facial surgery has influenced the growing area of research
focusing on gender identification and facial feminization surgery.

Historically, many advances have allowed for surgeons and scientists alike to
identify the key features involved in recognizing one gender over another. In the 1980s
and 1990s Dr. Douglas Ousterhout surveyed and analyzed hundreds of human skulls to
gain an appreciation for the differing features between male and female skulls. His
research gave valuable insight as to which particular facial structures can be surgically
altered in order to give a more feminine appearance and in turn lead to further research
that would become beneficial for facial feminization surgery. It has since been discovered
female faces are commonly rounder than that of their male counterparts, have more
arched eye brows, smaller noses with narrower bridges, fuller upper lips and shorter,
tapering chins. The multitude of differences between the male and female facial anatomy
influenced facial feminization surgery so that now it is often a group of procedures.
Common procedures include reshaping the hairline by advancing the scalp, lifting the
brow, forehead reduction, rhinoplasty and mandible angle reduction.

Preoperative planning for FFS tends to be very individualistic and often extensive
due to the complexity and number of procedures executed. Those seeking plastic surgery
in the general population typically favor a more enhanced look but still desire to be
recognized as themselves. Subjects being consulted for facial feminization surgery aspire
to look drastically different which requires thorough counseling to psychologically
prepare for the changes, as well as developing sensible expectations. It is the job of the surgeon to identify key structures on the patient’s face that are contributing to the masculine appearance and target those areas for surgical alteration. However, there are developments that claim to objectify beauty and femininity that may be useful in taking some of the extensive, patient-centered planning out of facial feminization surgery. As mentioned above, the Marquardt mask was developed by Steven Marquardt in an effort to create the ideal facial archetype. Given the mask has been designed to represent the exemplary female face based on attractiveness and femininity, would applying this mask to patients seeking facial feminization surgery serve useful? This study will review past and current advancements in facial feminization surgery, the development of the Marquardt mask and investigate whether it can be used as a helpful guide for FFS by applying the mask to biological males and rating the level of feminization.

**Existing research**

Transgender individuals have a spectrum of experiences that lead them to realizing their identification and mixed experiences in social support following. Their psychological well-being is not only largely dependent on their ability to integrate into society as their preferred gender, but also influenced by the support of family, friends and intimate partners. Davey et al examine this theory in a study comparing the psychological well-being of transgender participants compared to a control group of the same age and gender. A scoring system from one to seven is used to rate the level of support provided by friends, family and significant others and used to compare the perceived level of support received. Other demographic information collected includes employment status,
marital status, living situation and surgical status. A main aim of the paper was successfully demonstrating that transwomen do in fact have the perception of decreased social support. Of note, the clinical sample of transgender individuals consisted of 103 participants but of those only seventeen had received surgery.\textsuperscript{13} Perhaps this is insight into the potential benefits of surgery in the multifarious approach for overall well being for the transgender community.

Research among the transgender community is limited. Many existing studies focus on postoperative satisfaction following gender reassignment surgery but few expand upon their degree of contentment and examine their overall quality of life. The analysis becomes even narrower when considering the psychological effects of facial feminization surgery. A 2010 study by Ainsworth and Spiegel, however, specifically determines the mental health quality of transgender women compared to females in the general population as well as the potential psychological health improvements following facial feminization surgery. A thirty-six question standardized questionnaire evaluating both mental and physical components of health was used to comprise a score rating overall well-being. A separate evaluation ranging from 0-4 was used to study the fulfillment of facial feminization surgery, seen in Figure 2 below.\textsuperscript{3}
Mental health quality of life, as scored from the questionnaire, was significantly lower in transwomen who had not received any gender confirming surgery when compared to women in the general population. Interestingly, no significant difference in mental health scores was observed between females amongst the general population and those transwomen who had gender reassignment surgery, facial feminization surgery or both. The results scaling satisfaction and quality of life following facial feminization surgery revealed a significant \( P < 0.01 \) difference between those individuals who had undergone facial feminization surgery and those who had not. The mean for postsurgical patients following FFS was 76 with a standard deviation of 17.7 compared to 44 (standard deviation of 15.7) for those without surgical alteration. According to the study,
these results indicate that facial feminization has a positive impact, not only concerning social integration and operation, but a broader quality of life.  

Although gender reassignment surgery may appear to be a vital procedure in helping the mind and body feel congruent in those with gender identity disorders, facial feminization surgery serves as a vital step in the public recognition of the gender to which they identify.  

It is commonplace for transgender women to prioritize the need to incorporate into society and be publicly recognized as their proclaimed gender. Facial recognition is a vital component to this integration. Historically, gender recognition studies have allowed for surgeons to establish targets for facial feminization surgery. It has been shown that despite cosmetic products, length or style of hair, adornments and other identifiers of gender sex can still be recognized with an accuracy of 96%.

In an initial study, Roberts and Bruce divided and covered the face into various regions in an effort to identify key features used in gender identification. This study proposed that the eyes did not play a pivotal role in sex recognition but instead the nose was a key feature. However, further review of their technique revealed their cover of the eyes did not hide the eyebrows yet the cover of the nasal structures did conceal part of the eyebrows. Following recognition of the mistake a succeeding study was performed that included the eyebrows in the concealed eye area. Results showed, in fact, the eye region is the most noteworthy anatomy for gender recognition. This is consistent with another study performed by Spiegel et al that digitally altered different regions of the face, including the upper third, of study participants to be more feminine. The images were compared to other feminized areas of the face and individuals were asked to determine the most
feminized. Alteration of the upper face was selected 83% of the time by study participants, while the middle and lower face were only selected 13% and 3%, respectively.\textsuperscript{16}

Gender recognition and those features that contribute to it largely began in the late 1980s. Featured in the May 1987 edition of \textit{Plastic and Reconstructive Surgery}, “Feminization of the Forehead: Contour Changing to Improve Female Aesthetics” was an earlier study by Dr. Douglas K. Ousterhout, D.D.S, M.D. with the goal of demonstrating masculine characteristics in women and highlighting the treatment targeted for each patient based on their degree of supraorbital bossing and/or forehead concavity just superior to the orbital ridge. The study placed 26 male and female patients into three different groups based on the prominence of their supraorbital bossing and the surgical intervention was tailored accordingly.\textsuperscript{18} Group 1 patients demonstrated only minor supraorbital bossing and surgical intervention merely involved reducing the size of the bone with a burr. Group 2 patients also had minimal supraorbital rims. However, due to reduced thickness of the overlying bone, treatment involved reducing the size with a burr, as in group 1 patients, as well as alteration of the concavity atop the anterior supraorbital projection with methyl methacrylate contouring.\textsuperscript{18} Group 3 patients, strictly men, were those with severe prominence of the supraorbital rim. Treatment for this group involved a sinus osteotomy, back setting of the supraorbital rim and additional contouring.\textsuperscript{18}

Ousterhout reported no complications within 9 years of continued patient follow up and stated that no patient was “even slightly dissatisfied with the results.”\textsuperscript{18} Of note, five patients included in the study identified as female transgender patients seeking a
more feminine appearance. Although small, this study highlighted the potential for the success of facial feminization surgery for the transgender population and may have begun the development of what would eventually become the group of procedures it has evolved into today.\textsuperscript{18} Since Ousterhout’s groundbreaking study, forehead contouring has remained a staple procedure for facial feminization surgery and has continued to evolve with emerging advanced surgical techniques. Capitan et al discuss such techniques in a 2014 study. The publication also contains powerful before and after photos showing the effectiveness of reducing supraorbital bossing and shaping the forehead to a more feminine profile, including the image below.\textsuperscript{19}

**Figure 3: Profile view prior to forehead reconstruction (left) and profile view 6 months after forehead reconstruction (right)**\textsuperscript{19}

![Image](image.png)

Frontal bone contouring is often concomitant with brow lifting and scalp advancement. A higher forehead and receding hairline has been determined to be a masculine characteristic involved in gender recognition so focus has been placed on these
areas for surgically feminizing the face. A case report by Cho and Jin discusses a transgender woman who underwent forehead reshaping with simultaneous brow lift and scalp advancement. It is explained within the study that it is necessary to visualize the frontal bone to perform the frontal sinus reshaping. It is visualized after making a coronal incision approximately 5mm behind the hairline then creating a forehead flap. Following the forehead contour, the flap can then be pulled superiorly and anchored in place with sutures to raise the brow. Next, advancing the scalp towards the brow and removing the excess skin can reduce the size of the forehead. Below is a picture showing this process. Note the two medical sutures anchoring the raised brows and lateral sutures for advancing the scalp. Of note, the authors chose to use the pronoun ‘he’ for the patient throughout the case report. This is a rare instance in recent research where appropriate pronouns were not used.

Figure 4: Forehead flap revealing raised brow and advanced scalp

Surgeons have expanded the concept of gender identification and facial feminization surgery to include surgical alterations of other facial anatomy.
Facial Plastic Surgery publication from 2007 focuses on nasal feminization and its role in gender reassignment surgeries. Nouraei et al. evaluated 12 patients that received rhinoplasty specifically to feminize their appearance and objectively measure the feminization of the individual’s nasal profiles.22 The study states bone structure of women’s noses are smaller and have a more obtuse nasolabial and nasofrontal angle.22 These angles were measured before and after surgery and the values were used to calculate the numerical difference between male and female nasal structure. The results were significant and of the 12 patients evaluated, each had a more feminine nasal profile following surgery.22 Nostril form is another aspect of nasal anatomy that must be considered during facial feminization surgery rhinoplasties. A 2008 publication by Etoz et al evaluates the morphometric nasal profiles of both men and women and further divides nostril forms into four distinct groups: teardrop, heart shaped, round and triangular. Significant variations in nostril forms were observed, solidifying that nostril form and its relation to other nasal anatomy is an important consideration in routine rhinoplasty. Pertinent to facial feminization surgery, the authors call attention to feminization of the male nose during routine rhinoplasty, reporting it as a not uncommon complication. Although it is not a specific aim of the study to highlight techniques for feminizing male nasal anatomy, it does highlight that nostril form does contribute to a masculine or feminine nose.23

The mandibular angle in males is yet another feature associated with a more masculine appearance. The mandible of males tends to be more pronounced secondary to a sharpened angle and increased masseter volume. The face of men often appears longer
in profile view and square in frontal aspects as a result of the masculine mandible anatomy.\textsuperscript{14,4} To reduce this angle, surgeons use drills to shave and remove the bone with an intraoral approach in the area of the first molar. The angle can be further minimized through resection of the antero-medial masseter muscle. Atrophy of the masseter has also been observed following mandible angle reduction. This is a desired result as it further reduces the square-faced effect of a masculine face.\textsuperscript{4}

The afore mentioned studies focus on the importance and efficacy of recognizing and feminizing specific facial anatomy such as the supraorbital ridge, nose and jaw. Alterations of each of these are individually reviewed and summarized in a study discussing facial feminization surgery as a group of surgical procedures. \textit{Facial feminization surgery: current state of the art} first introduces the process of forehead reduction followed by brow lift. The study explains the female brow is typically superior to the orbital ridge while the male brow tends to overlie the ridge itself. Therefore, lifting the brow gives a more feminine appearance. Scalp advancement is another aspect of facial feminization surgery discussed within the study. The male hairline commonly sits higher on the forehead with regression along the lateral edges so that when the scalp is advanced it more closely resembles a feminine scalp pattern. As mentioned before, rhinoplasty is a procedure often utilized to feminize the face. Specifically, reducing the prominence of a dorsal hump if present, narrowing the nasal bridge and reducing the size of the nostrils.\textsuperscript{4}

Female faces commonly have a triangular shape with the cheeks serving as the base and the chin as the apex.\textsuperscript{4} To achieve this effect cheek implants are often utilized,
giving the lower two thirds of the face a more feminine appearance. Various sizes of implants exist and surgeons often place them through pockets created within the mouth. Genioplasty, or surgical alteration of the chin, is another procedure described within the study. Female chins are often more slim and tapered while male chins can be wide with sharp angles. The goal of a successful genioplasty in transwomen is to round the sharp corners if present while reducing the overall length. This largely contributes to the feminization of the lower two thirds of the face. Despite studies showing the upper one third of the face as most crucial in gender identification, if the lower two thirds of the face is overtly masculine, procedures feminizing the upper one third of the face may not be sufficient for patient satisfaction or the consistent public recognition that the patient desires.\textsuperscript{4,16}

**Figure 5: Chin before genioplasty (left) and chin 3 month after genioplasty (right)**\textsuperscript{4}

This study again demonstrates the evolution of identifying the contrasting facial anatomy of males and females, science of gender recognition and summarizes the technique of combining these advancements to a group of procedures for the male to female transgender population.

This idea of performing multiple procedures has provided optimal patient satisfaction but with the additional surgical procedures comes further preoperative
planning. Given the Marquardt mask provides a template for the entire face, using the mask’s preset ratios could allow surgeons to more quickly digitally feminize images, targeting those anatomic features to be operated on during facial feminization surgery.

Even with substantial Internet and television exposure, the Marquardt mask has been subjected to minimal scientific analysis examining his theory of objectifying attractiveness. In an attempt to achieve the same, Bashour et al put forth a model to test the accuracy of Marquardt’s claims. Thirty-seven male and thirty-five female faces where photographed and rated based on attractiveness by random Internet viewers. Thirty-one faces of each sex were then digitally altered to match the preset ratios of the Marquardt mask and then rated. The delta of the attractiveness values was used, along with multiple points on the face as points of reference to measure the deviation between the before and after photos. Using these two methods comparing the before and after photos it was determined that divergence from the mask has a direct correlation with attractiveness, ranging from 25 to 75 percent dissimilarity. The study later discusses that the Marquardt mask is, at a minimum, an initial tactic towards creating an objective system for evaluating attractiveness.

Despite Marquardt’s claims of identifying an ideal archetype for attractiveness, studies exist with intent to show this is in fact false. E. Holland explores the perils of depending on the phi mask for assessing attractiveness in a 2008 study published in *Aesthetic Plastic Surgery*. Facial landmarks were defined using a prior study by Hennessy et al that attempts to define those points on the face important in determining masculinity and femininity. Procrustes and thin-plate spline analysis was then used to
demonstrate how well the Marquardt mask preset ratios meet masculine and feminine features of Northern European populations. Note that researchers analyzed both frontal and profile views using these landmarks. 3D images were constructed using phi mask ratios and used to compare to a more standard feminine face of the same type of 3D image. Figures 2 and 3 demonstrate this comparison. Riemannian distances were used to calculate results and compare the 3D images to Marquardt’s mask and average northwestern European faces. It was concluded that the frontal view matched more of a masculine appearance for the average citizen in northwestern Europe while the profile view matched a more average face, neither hyper masculine or feminine. Holland later discusses evidence suggesting that very feminine features are in fact preferred for attractiveness and that Marquadt’s mask is not compliant with creating this idyllic face given the more masculine Riemannian distances observed.

Figure 6: Landmarks used to compare face samples from “Marquardt’s Phi Mask: Pitfalls of Relying on Fashion Models and the Golden Ratio to Describe a Beautiful Face”
Figure 7: Frontal view of 3D approximation of Marquardt’s mask (left) and a 3D image of a more widely accepted feminine face (right)

Subtle differences exist between the two images. In the frontal view the 3D composite of the Marquardt mask appears to have more severe frontal bossing given the shadow banded across the forehead and highlight beneath the brow. The nasal ridge

Figure 8: Profile view of 3D approximation of Marquardt’s mask (left) and a 3D image of a more widely accepted feminine face (right)
appears wider and the chin more pronounced when compared to the image on the right. This brings attention to potential confounding factors, such as the influence of lighting on the images and whether or not it is uniform as this could accentuate features commonly considered masculine.
METHODS

Study design

This will be an efficacy trial rating the degree of feminization in male subjects when the Marquardt mask is digitally applied to a photograph of the participants.

Study population and sampling

Individuals included in the study will be white men ranging from 25 to 35 years old. The proposed sample size will be 32 subjects with a standard deviation of 0.5 ($\mu_A=1.25$ and $\mu_B=1.75$), alpha of 0.05 and power being 0.8. These numbers were generated considering studies showing the accuracy of the public in recognizing gender. Male subjects will be recruited to represent masculine features rather than female transgender individuals seeking facial feminization surgery as often many have been living as female for many years. This introduces many potential confounding variables including longer hair, tweezed eyebrows or other cosmetic procedures that could influence gender appearance. The age of the subjects will be restricted to 25 to 35 years old to avoid any interference with the alteration of the photographs and potential influence on gender identification by those rating the photographs as the facial anatomy of women tends to progress to a more masculine appearance during the aging process. As mentioned above, the Marquardt mask was developed with the influence of white, female fashion models. Therefore, this study will focus simply on analyzing the efficacy of applying the Marquardt mask to Caucasian men.
**Treatment (or intervention)**

Those subjects that meet inclusion criteria will be digitally photographed using a Nikon D5000 DSLR camera. Participants will be without facial hair or adornments and hair off the forehead in an effort to neither contribute to nor distract from their evaluations of gender. Each subject will also have their head placed in a standardized frontal position for the photograph with their mouth closed and neutral expression. There will be a common background for each image and the photographs will be taken with uniform lighting. Finally, the images will be cropped, removing the influence of hair, neck anatomy and ear size as these structures will not be applicable to the study.²

Using Adobe Photoshop 8.0, each photograph of the subjects will then have a composite image created by placing the Marquardt mask atop the original images and altering the facial structures to meet the preset mask ratios.² Prior to superimposing the mask on the images, it will be best fitted to each subject’s face using Marquardt’s proposed method matching the distance between the upper and lower lip to the mid-pupillary line.¹

**Study variables and measures**

Participants in the study will be required to submit their age, ethnicity, eye and hair color as each of these may influence results. BMI will also be measured considering its potential to increase subject’s facial roundness, cheek fullness or other facial anatomy that could influence gender recognition. The Femininity Rating Scale below will be used to assess both the before and after images.
Table 1. Femininity Rating Scale

5  Female with certainty
4  Female with some masculine features
3  Androgynous (mix of masculine and feminine features)
2  Male with some feminine features
1  Male with certainty

Reliability scores will be calculated to assess inter-rater reliability.

Recruitment

Male subjects to be photographed will be recruited from Boston University faculty, staff and student body. Initially five male and five female participants will be used for rating the photographs. A kappa score will be calculated to measure inter-rater reliability. If heterogeneity is achieved, an additional five male and five female raters will be recruited. The kappa will be recalculated until inter-rater reliability is acceptable.

Data collection

The original and transformed images will be compiled and rated by an equal mix of male and female college students. The rating scale for each image will range from 1 to 5 with 5 being recognized as female with no uncertainty to 1 being identified as male. Please refer to Table 2 for full description. The images will be shuffled so that each participant rating the image scores both the before and after picture and to avoid any potential “before and after” effect of the altered and non-altered photographs. The rating scores for all images will then be compiled for data analysis.
A simple form will be given to participants to be photographed just prior to the study with spaces to provide the variables mentioned earlier. Height and weight will also be requested on the form and BMI will be calculated independently.

**Data analysis**

Of the variables collected, age and BMI will be analyzed through mean and standard deviation. Results will also be stratified to control for potential confounders within ANOVA to analyze for variance. The mean rating score of both the before and after images will be termed the Feminization Quotient and used to compare the mean ratings of the before and after photographs using a paired T-test\(^2\) (with unknown variance). Significant results will be defined as a minimum of 0.5 points on the Femininity Rating Scale. A Kappa statistic will be calculated to assess significant difference between individual raters and assure each photograph is being evaluated in a similar fashion.

**Timeline and resources**

Necessary equipment for the study will include a MacBook Pro with Adobe Photoshop 8.0 software for all digital editing. Photographs will be taken using a Nikon D5000 DSLR camera. A statistician will be hired for the calculation of the Feminization Quotient and Kappa statistic for inter-rater reliability. A primary investigator will be responsible for project oversight while two hired research technicians will be hired for recruitment, photographing participants and data collection. A graduate student may participate, working alongside the research technicians and observing the primary
investigator. An employed specialist in photo editing software will perform the digital edits necessary for superimposing the Marquardt mask.

**Institutional Review Board**

The study protocol will be submitted for to the IRB for an expedited review for educational studies to the Boston University Medical Campus IRB. The study will be considered minimal risk with only photographic intervention, no procedural involvement or medical identifiers revealed. The average turnaround times from to final decision are published on a monthly basis on the Boston University Medical Campus IRB website [http://www.bumc.bu.edu/irb/bumcirb/irb-review-time/]. At the time of this proposal they are listed as 9 days for an expedited review.
CONCLUSION

Discussion

Despite limited research among the transgender community, it has been shown that transgender women often experience incredible hardship and desolation before and during the transition process. These misfortunes are not limited to loss of employment, rejection from friends or family and increased risk of depression or suicidal ideations. To minimize this effect of incredible social influence, proper public recognition becomes paramount. Facial feminization surgery serves as a vital step during this integration. The benefit is often so impactful that facial feminization surgery is often sought prior to other gender reassignment surgeries, such as breast augmentation and genitalia alteration.

As mentioned earlier, many advances have been made in identifying the facial anatomy involved in gender recognition and procedures of facial feminization surgery. In the short period of time between Ousterhout’s initial studies and more current advances FFS has evolved into the discussed group of procedures. Meanwhile, the Marquardt mask has been developed to help demonstrate female beauty using preset ratios of the entire facial anatomy. Fixed ratios of the forehead, eye brows, nose, cheeks, jaw and chin are all included. Given the knowledge gained of the differences between male and female facial structures and the evolution of FFS to involve nearly the entire face, the mask may serve useful in helping guide the alteration of masculine features to more feminine ones. If the proposed hypothesis is correct and the mask does feminize the male face, applying this to female transgender patients could give plastic surgeons at a minimum a template to
approaching FFS. This would reduce the amount of preoperative planning and potentially
the patient specific nature of consultation currently being practiced.12

Some may dispute Marquardt’s claims of creating the ideal female face based on
attractiveness. However, the purpose of FFS is often not to create a more youthful or
aesthetically pleasing face, it is simply to surgically alter facial structures to give a more
womanly appearance.4 So, despite the findings in Holland’s study that Marquardt’s mask
may generate a more masculine female face and therefore not as attractive, the mask may
still be an effective template to feminize the male face or faces of transgender women.1 In
fact, because it does produce a more masculine female face, would using the mask to help
guide surgery demonstrate more realistic goals, especially in those individuals with
excessive masculine features such as prominent supraorbital bossing and large, square-
shaped jaws? It has also been studied that the faces of women tend to become slightly
more feminized as they age. The average age for transgender women who have
undergone FFS is from 45-50, so could this also be an advantage to using the Marquardt
mask and its proposed technique of creating a slightly more masculine face in this
population.3,16

The proposed method of superimposing the Marquardt mask to male faces for the
benefit of transgender women is a novel concept with no existing research. This study
would be the first to compile a historical assessment of gender recognition and facial
feminization surgery combined with a review of the Marquardt mask and its potential
benefits concerning FFS. However, expected limitations are indisputable. The Marquardt
mask was developed using the faces of Caucasian fashion models so application of the
mask to other ethnicities would likely not result in that specific population’s idea of attractiveness or femininity.\textsuperscript{1} Another potential limitation to using the Marquardt mask for preoperative planning is the digital modifications could exceed surgical feasibility. The aforementioned cone beam CT imaging commonly used to assess the degree of supraorbital bossing for forehead contouring surgery, for example, may prove some digital alterations are beyond surgical viability.\textsuperscript{4} A further restriction takes into account goodness of fit when superimposing the Marquardt mask on a patient’s face. Marquardt suggests matching the distance between the upper and lower lip and the mid-pupil level prior to applying the mask to the photograph while Bashour’s study utilized the horizontal distance between pupils. In either case, both of these distances are not consistent amongst the general population and make the idea of goodness of fit difficult to analyze and apply appropriately.\textsuperscript{1}

The male subjects participating in the study will be without facial hair or other masculinizing features, however, a large proportion of women in the general population and transgender woman alike tweeze their eyebrows, wear make up and perform other cosmetic alterations that allow them to appear more feminine. This may prove to be an obstacle faced by the subjects rating gender before and after the Marquardt mask is applied. Should this method be successful in feminizing the male face, the typical cosmetic practices of transgender women could enhance the results even further.
Summary

A comprehensive review of gender identification studies, facial feminization surgery and the Marquardt mask has lead to a profound understanding of each topic. From Ousterhout’s foundational studies in recognizing gender and forehead feminization to current techniques utilized in facial feminization surgery the accomplishments have been remarkable. However, given increasing social acceptance and subsequent patient comfort in identifying as transgender, the field is rapidly growing and could benefit from further research regarding optimal approaches to surgery, maximizing aesthetic results and further improving mental health. One such improvement is proposed within this study, a method to objectively feminize the faces of transgender women prior to surgery using the Marquardt mask.

Clinical and/or public health significance

Should application of the Marquardt mask feminize masculine features with statistical significance the potential clinical applications are numerous. Many surgeons require multiple consultations with patients to allow for the full breadth of physical and social risks involved in surgery to be fully realized. Although the social and psychological implications for FFS would likely remain unchanged, there is potential for a reduction in the number of clinic visits required and hours spent on digital alterations prior to surgery. This would allow for more efficient appointment times and potentially an increase in patient volume.

As discussed thoroughly within the literature review, the potential for quality of life improvements for transgender women patients who undergo facial feminization
surgery is substantial. Should the Marquardt mask prove helpful in guiding FFS, it could aid surgeons with preoperative planning and potentially maximize patient satisfaction.
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REFERENCES


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EXPERIENCE

2010-2011  Medical assistant
Fast Access Healthcare
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As a medical assistant my responsibilities included verification of insurance, training of all new front office employees, triaging patients, inventory of clinic supplies, medical records and testing for common pathogens using standard laboratory techniques

2009-2010  Sleep technician
Advanced Center for Sleep Disorders
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During day shifts, my responsibilities included verification of all insurance, field marketing, taking vitals, CPAP machine hook-ups and patient schedule organization. Working as a sleep technician on night shifts at ACSD I was responsible for sleep study preparation and data analysis in diagnosing a variety of sleep disorders
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Working under the guidance of Dr. Ethan Carver, I introduced plasma DNA to zebrafish embryos using standard microinjection techniques in an attempt to conceive a transgenic organism. Other research projects included genetic transformation of bacteria using standard PCR techniques and introducing GFP into developing embryos.

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