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The impact of chest contouring aesthetics outcomes: a pilot eye tracking study

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ABSTRACT

Eye-tracking technology was used to assess aesthetic surgical outcomes in transgender and gender diverse patients who are assigned female at birth and who seek gender affirming chest surgery. Post-surgery, observers focused more on scars than on the nipple-areolar complex. Ratings for similarity to cis-male chests significantly increased. This series highlights the objective evaluation of visual perception and masculinity assessments using eye-tracking.

Introduction

In the United States there is approximately 1.3 million adults identify as transgender, accounting for 0.5% of the country's population [1]. Specifically, in the state of Minnesota, there is an estimated 26.000 individuals, making up 0.6% of the state's population [1]. To cater to the healthcare needs of this community, Minnesota implemented Medicaid programs in 2016 that cover gender-affirming treatments, including surgery. As a result of increased awareness and legal validation, there has been an exponential surge in surgical procedures performed to address gender dysphoria [2]. For transgender and gender diverse (TGD) individuals who were assigned female at birth (AFAB) presenting with Gender Dysphoria (GD) and identify along the masculine spectrum, the cornerstone of gender-affirming (GA) surgery is chest contouring or chest wall masculinization, i.e. mastectomy [3]. This procedure is often the first, and sometimes the only, surgical procedure during the transition [4]. It has been associated with positive outcomes such as improved social interactions, mental health, and an overall better quality of life [5,6]. To ensure satisfactory outcomes, plastic surgeons should carefully consider the anatomical differences between cisgender males and females in terms of the chest and nipple-areolar complex (NAC), adjusting their techniques accordingly [7].

While there are existing methods to evaluate the aesthetic outcomes of GA chest contouring surgery, such as patient-reported outcomes scales (PROs), like the chest module of the BODY-Q scale and the BREAST-Q, they were not specifically developed with the inclusion of TGD patients [7–9]. Efforts are underway to develop a GENDER-Q scale exclusively designed for these patients [10]. However, these traditional methods do not provide objective appraisals of how observers perceive the results of chest contouring surgery.

In recent years, the application of Artificial Intelligence (AI) and deep learning has introduced eye tracking technology (ETT), which can track the gaze patterns and areas of interest (AOI) for observers. By analyzing the subconscious visual preference of observers, ETT offers and objective assessment of aesthetic outcomes, which can serve as a proxy for our collective preferences and aversions [11]. Its use in plastic surgery has gained popularity over the last decade as it provides valuable insight into the observer's visual preferences. Building upon this principle, our study aims to assess how aesthetic outcomes of GA chest contouring surgery via mastectomy are perceived by tracking gaze patterns or subconscious visual

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preferences. This analysis will shed light on to the anatomical features that are most salient to observers when evaluating patients undergoing this procedure. By measuring visual preferences and masculinity likeness as perceived by observers, we can gain deeper understanding of the subjective concept of chest attractiveness or masculinity. This understanding can contribute to the development of new evaluation methods for mastectomy outcomes in trans masculine individuals, potentially improving patient-reported outcomes and post-reconstructive surgery experience.

Currently, the existing body of research on the use of ETT for assessing breast and chest aesthetic outcomes remains limited. Few studies have specifically investigated the application of ETT in evaluating post-mastectomy female breast attractiveness [12,13]. Additionally, there are two studies that examine male preference for female breasts [14,15] and only one study that explores how gender identity influences the assessment of GA chest surgery outcomes for TGD both AFAB and assigned male at birth (AMAB) [4]. However, none of these studies exclusively focus on assessing the aesthetic outcomes of AFAB presenting with GD and seeking for GA chest contouring. As a result, there is a significant research gap regarding the objective assessment of gaze patterns in masculinized chests following GA chest surgery using ETT.

Our study uses the term 'attractiveness' in the context of assessing aesthetic outcomes through ETT. Unlike the everyday connotation of 'attractiveness' implying positive desirability, we use it to refer to visual preference. We aim to understand which features draw an observer's gaze, without inherently implying a positive or negative judgment. 'Attractiveness' can be influenced by individual preferences, cultural factors, and personal experiences, making it a subjective concept. Using ETT, we examined the early stages of visual processing in subjects as they observed images of chest contouring, objectively measuring the aspects of a masculinized chest that capture visual attention.

Materials and methods

The study obtained ethical approval from the Mayo Clinic Institutional Review Board, and written informed consent was obtained from the patients whose images were included in the study. The participant group consisted of eight trans masculine individuals who underwent double incision mastectomy with free nipple grafts (DIFNG), with a mean age of 25.13 ± 4.59 years (range, 21–36 years) (Figure 1). To provide a comparative assessment, standardized digital images of the chest in the anteroposterior view (AP) were retrospectively collected, both pre- and post-operative (Figure 2). Additionally, seven AP standardized digital images of cisgender male chests were obtained for control purposed. All photographs underwent individual manual processing, utilizing predetermined landmarks to divide into six symmetric AOIs: (1–2) NAC, (3–4) surrounding chest (defined by borders: clavicle, sternum midline, anterior axillary line) and (5–6) scars (in post-operative photographs only) (Figure 3).

Forty participants, with a mean age of 43.63 ± 11.61 years (range, 20–64 years), 23 females and 17 males (Figure 4), were recruited as observers. Written consent was obtained from the observers prior their participation in the study. They were instructed to visually evaluate the overall aesthetic outcomes of the
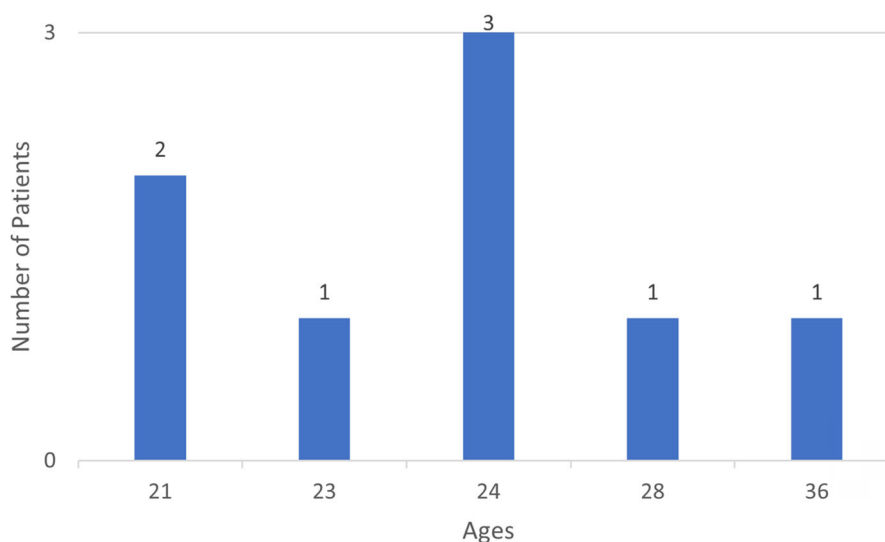

Figure 1. Patient's age.

Figure 2. Pre- and post-op photos of the eight trans male patients that underwent gender-affirming top surgery. Ages ranged from 21 to 36 years old.
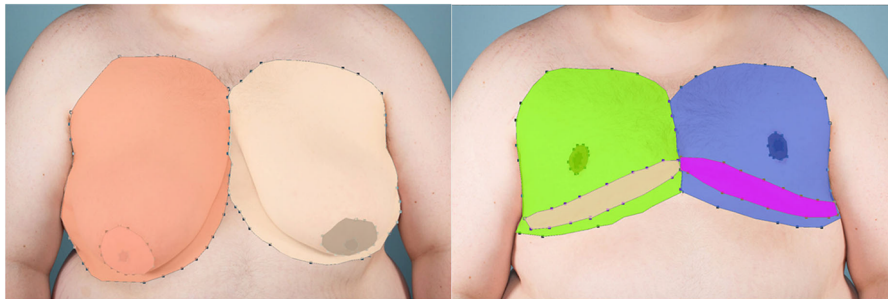

Figure 3. Study images examples of trans male patient's chest (a) pre and (b) post-DIFNG. All images were processed individually by hand, using predetermined landmarks, to assign 6 symmetric AOIs based on key breast.

photographs without being given specific aesthetic features to focus on.

To track the visual gaze, the EyeTech TM4 desktop-mounted system (EyeTech Digital Systems, Mesa, AZ) was utilized. This system incorporated a near-infrared LEDs light and an eye-tracking camera capable of detecting corneal light reflections at a binocular data tracking rate of 30 Hz. The system accurately measures *minute* eye movements and connects the eye position data to the pre-assigned AOIs on the computer screen displaying the photograph. The precision of this eye tracker model is less than half a degree (0.5°) of visual angle, corresponding to a circle with a radius of 0.5 cm in the monitor, which displays the image at a viewing distance of 63.5 cm. To ensure stability, a chin and forehead rest with adjustable height and straps were used to support the observer's head (Figure 5). A standardized protocol was implemented

for the distances between the camera, observer's chin, monitor stand, camera-monitor, monitor-to-chin, and table-to-bottom chin which remained consistent throughout the experiments. Prior to each experiment, the infrared camera runs a 16-point calibration on the observer's eye. The GazeTracker Full 10.0 software was employed for the analysis of the eye-tracking data.

After each experiment, the observers rated each postoperative photograph based on similarity to a cisgender male chest, using a scale of 1–7, with 7 indicating the highest similarity to a cisgender male chest and 1 indicating the highest similarity to a cisgender female chest.

Results and discussion

One of the primary goals of chest contouring surgery is to enhance body image and self-esteem in TGD
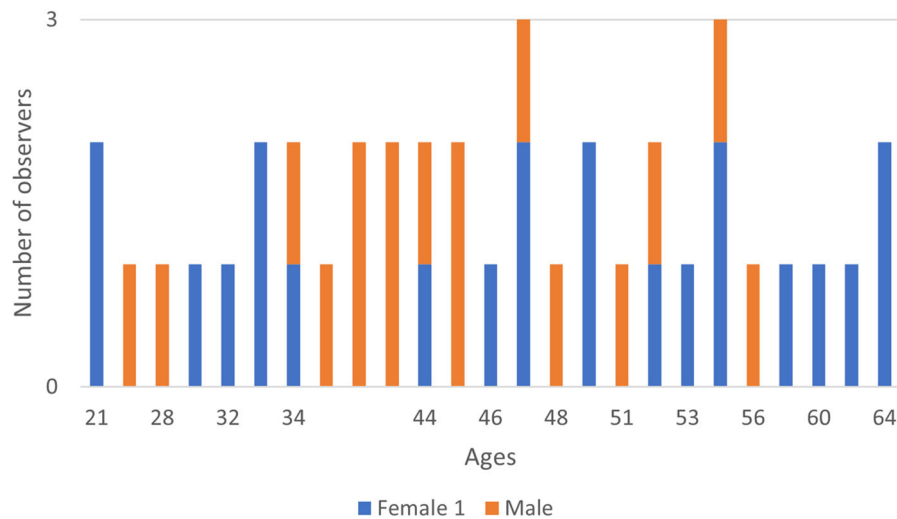
Figure 4. Observer's age and the distribution according to their age.

Figure 5. Our ET setup: viewing the subject's face seated on a chin rest, and the near-infrared ET device aiming at the subject's eyes as he observes the monitor. The ET detects movements of less than half a degree of visual angle.

AFAB, ultimately alleviating their GD [4]. However, our understanding of the perception of breast attractiveness and expectations among individuals who have undergone mastectomy primarily relies on studies conducted with cisgender female patients [16]. This highlights a significant gap in the current literature. Furthermore, existing studies employ self-assessment scales and questionnaires as measurement tools, leading to considerable discrepancies among the results [12,17,18]. As a result, there is lack of knowledge specifically regarding the objective assessment of visual preferences as proxy of attractiveness for masculinized chests after GA chest surgery. The subjective concept of 'attractiveness' in this context stems from Pietrusky's observation that the area capturing the observer's initial fixation during the evaluation of breast aesthetics and symmetry tends to be referred to as 'attractive'. Therefore, it was coined to describe the area that attracts the observer's attention first and longest fixation times. While 'attractiveness' is often associated

with positive desirability in everyday language, our research employs it to denote visual preference. The first study of ETT of breast reconstruction on cisgender female oncoplastic patients, conducted 12 years ago, established that the observers tend to spend most time fixating on AP photographs. Making it the preferred view for this study [19]. Subsequently, a study involving conscious assessment by cisgender male of naive cisgender female breasts found that medium to large breasts size and darker or medium areolar pigmentation were considered more attractive characteristics than small breasts with light areolae [14]. However, ETT revealed that observers' subconscious gaze pattern did not differ significantly based on these morphological traits, indicating a disparity between conscious and subconscious assessment [14]. Building upon this knowledge, our study aimed to assess the success of chest masculinization by comparing average ratings provided by the observers' for pre- and post-surgical photos. The results showed a significant

increase in the similarity to a cisgender male chest rating from 2.69 pre-operatively to 5.61 post-operatively ($p < 0.05$) Figure 6.

The goals of a mastectomy in a TGD patients differ significantly from those in a cisgender female, and this could potentially lead to different gaze patterns. However, given the scarcity of studies that utilizes ETT assessment in the context of chest contouring for TGD, preliminary evidence with this technology, primarily involving cisgender female patients, provides a point of reference and comparison. Currently, three studies have assessed ETT on specific AOIs on breasts before and after surgery [4,12,14]. Overall, a detailed analysis of gaze patterns has shown that NAC attracts the most attention with the longest fixation time [4,12,14]. However, the classification of gaze patterns pre- and post-operative photos varies among studies (Table 1). Some indicate that the NAC remains the AOI preoperatively [4,13], while others show that the lower quadrants of the chest receive most attention (25.58% right and 28.62% left) [12]. Postoperatively, that same study by Pietruski found that the NAC was the primary AOI, which aligns with the findings of another study [4] that focus on TGD individuals. However, in the cisgender group, a greater emphasis was placed on scars. This observation is consistent with the group in the study conducted by Cai et al. that had incomplete reconstruction (without NAC). Notably, when patients underwent complete reconstruction with NAC, the attention is almost the same between NAC (27.5%) and scars (27.7%) [20]. In our study, observers spend the most time fixating on the surrounding chest area (40.51%), followed by inframammary fold (IMF) scars (8.16%), and finally the NAC (6.34%), which overlaps with the scar (Figures 7 and 8). This variation in results can be attributed to the different populations included in the studies (cisgender females vs. transgender males) and the lack of studies specifically focusing on the perceived aesthetic outcomes of masculinized chest through GA surgery. The average photographic follow up in our study before the surgery to after was 259.43 days (range 59–632 days). The average photographic follow up from surgery to post-operative period was 108.75 days (range 32–316 days). Further research is needed in the transgender male and gender diverse population to gain better understanding of perceived aesthetic outcomes using ETT.

Table 1. AOIs with longer fixation's summary from ETT studies for breast surgery aesthetic outcomes.

AOIs/study	Our study			Martin4-assessing GA chest surgery outcomes: does gender identity alter gaze?		Pietruski 14-the impact of mastectomy on women's visual perception of breast aesthetics and symmetry: a Pilot ET Study		Cai-13 where do we look? Assessing gaze patterns in breast reconstructive surgery with ETT	
	2023			2021		2020		2018	
	Control (%)	Pre-op (%)	Post-op (%)	Pre-op (naive)	Post-op	Pre-op (control)	Post-op	Pre-op	Post-op (%)
NAC	5.67	7.47	6.34	Trans (802 ms) >cis (495 ms)	Trans	25.58% (R) 28.62% (L)	25.11% (R) 24.22 (L)	40.2%	27.5
Surrounding chest	37	38.4	40.51						
Scars (NAC present)			8.16		Cis: IMF and lateral				27.7
Scars (no NAC)									53.9
Lower outer quadrant						25.75% (R)	24.57% (R) 21.88% (L)		
Lower inner quadrant						26.68% (L)			

*AOIs: areas of interest; NAC: nipple-areolar complex; (R): Right; (L): Left.
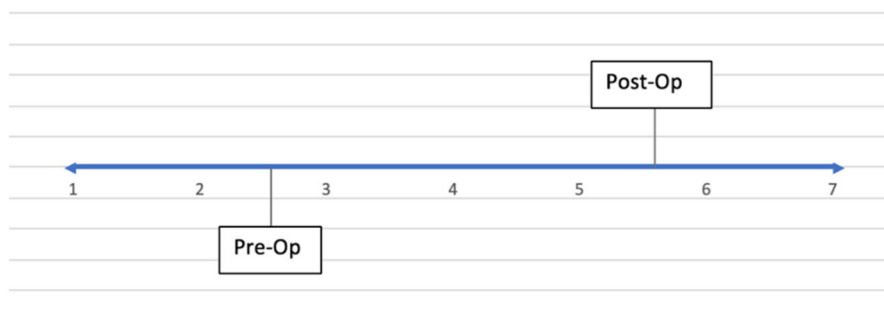

Figure 6. Average observer ratings of pre-and post-operative gender-affirming chest surgery with 7 being the most similar to the ideal male chest and 1 being the most similar to the ideal female chest.
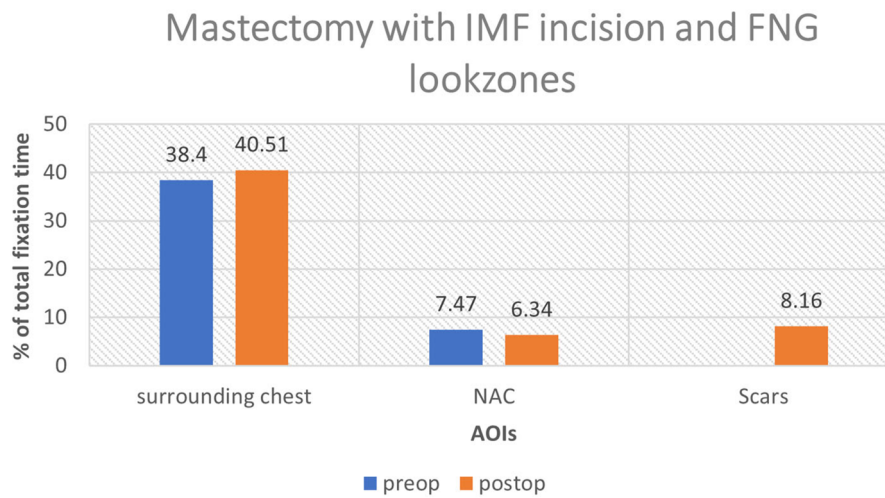
Figure 7. Observers were found to have the greatest percentage of gaze fixation on the left and right chest regions compared to the nipple-areolar complex both pre-and post-operative.
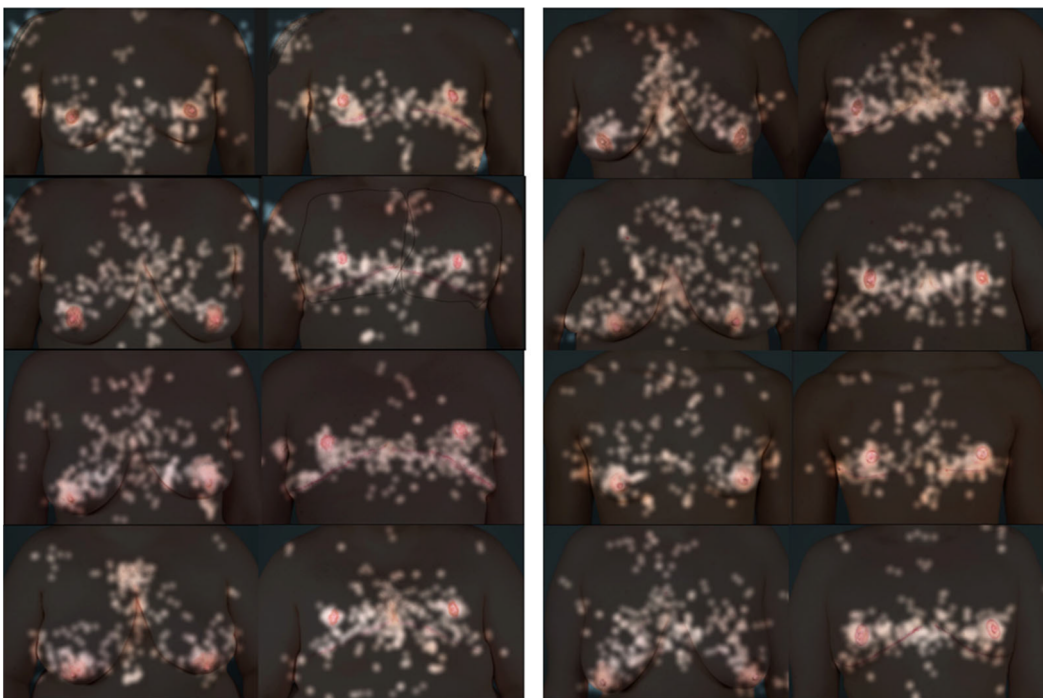

Figure 8. Corresponding pre- and post-op photos of the eight patients with an overlay of the eye tracking technology demonstrating where the observers fixated their gaze.

Our study has several limitations. Inherent to the methodology is that is a small case series as a pilot study with varying BMI, breast size, and ptosis among the participants, it is important to acknowledge that these variations in body habitus may influence the results. To ensure the generalizability of the results to a broader population, it is advisable to conduct larger-scale studies with more extensive samples. Also, only AP photos were considered, while lateral or oblique photographs were excluded. Additionally, the surrounding chest area was not divided into quadrants, and sternum areas were not included, as seen in other studies involving cisgender female breast [12,19]. The rationale behind this methodology was that in a masculinized chest, the quadrants are not significantly different postoperatively, and there is no substantial projection in other views besides the AP view. However, considering these additional factors could provide a more detailed understanding of the aesthetic areas of importance and further improve surgical procedures

for both cisgender and masculinized chest. In addition, our study did not incorporate measurements such as dwell-time [19] and initial fixation AOI [13], which have been studied in previous ETT research. Furthermore, we did not take into account the gender identity [4] of the observers or their educational background [19]. There is evidence suggesting that these factors can influence AOIs [4] and aesthetic perception [19] after GA chest surgery and overall aesthetic assessment. Lastly, the experiment was performed at one point in time per patient so a change in pattern was not assessed. However, the results from the patient with the shortest photographic follow up after surgery (2 months) to the patient with the longest follow up (13 months) did not differ.

Conclusions

In conclusion, there are significant gaps in the knowledge regarding chest attractiveness and expectations among individual who have undergone mastectomy, particularly in the context of TGD patients AFAB presenting with GD and seeking chest contouring surgery. The use of ETT provides an objective means of assessing subjective concepts of attractiveness and aesthetic outcomes by analyzing observer's gaze patterns. Our study aimed to evaluate the success of GA chest contouring surgery by comparing pre- and post-surgical photos and found a significant increase in the similarity to a cisgender male chest rating postoperatively. However, more research is needed, specifically focusing in this population and utilizing ETT. Addressing limitations and incorporating additional measurements and demographic factors in future studies will contribute to advancements in the field of GA chest surgery and improve patient satisfaction and well-being.

Ethical approval

Institutional review board approval was obtained for the study. Informed consent all patients provided informed consent. The research protocol was approved by the Institutional Review Board (IRB) by Mayo Clinic, number 17-009087, in accordance with The Code of Ethics of the World Medical Association Declaration of Helsinki (June 1964) and subsequent amendments.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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