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Objective Measuring Social Attention of Thyroid Neck Scars and Transoral Surgery Using Eye Tracking

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OBJECTIVE: Measure the social attention of thyroid neck scars and transoral surgery using eye tracking.

METHODS: Observers viewed images of patients with thyroid neck scars, control patients with no scars, and patients who underwent transoral thyroidectomy as an eye-tracking monitor recorded their eye movements. Hotelling's multivariate analysis, followed by planned posthypothesis testing, were used to compare fixation times for the central triangle (CT), peripheral face, and neck between the three groups. To assess if these gaze patterns would normalize with transoral surgery, a two-sample t test was done to assess for differences in neck fixations between control and transoral patients and between transoral and traditional thyroidectomy.

RESULTS: One hundred and thirty participants completed the eye-tracking experiment (mean age 24.3 years, 65 females). Observers directed the majority of their attention to the CT in both control and scar patients. Observers paid more attention to the neck (103.72 ms, P < .0001, 95% confidence interval [CI] [55, 152] ms) and less to the peripheral face (115.50 ms, P = .01, 95% CI [19, 211] ms) in patients with neck scars than in control patients. Furthermore, transoral surgery eliminated this attentional distraction wherein there was no difference in the fixation time to the neck (−39.198 ms P = .16, 95% CI [−93.978, 15.5816] ms) between controls and those who underwent transoral surgery.

CONCLUSION: Observers directed their gaze away from the face and toward the neck in patients with thyroid neck scars. Furthermore, this distraction was eliminated with tranoral surgery. These findings shed light onto the altered observer perceptions of patients with thyroid neck scars.

KEYWORDS: Thyroid neck scar, thyroid surgery, transoral thyroidectomy, eye tracking.

LEVEL OF EVIDENCE: NA

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INTRODUCTION

Thyroidectomy is a commonly performed procedure that has rapidly evolved over the past decade. The traditional approach to thyroidectomy involves an anterior incision that is typically 2 to 8 cm in length, with variances in scar severity.1 This approach has led to high success rates; however, it results in a notable scar on the neck, an area of the body that is frequently exposed. Visible scars represent one of the most frequently reported concerns following thyroidectomy.2 Further, they cause significant cosmetic problems, leading to a psychosocial burden.3

From a patient perspective, Choi et al. demonstrated that patients with thyroidectomy neck scars have an overall decreased quality of life (QOL), which was associated with the presence of the scar itself regardless of scar severity.4 From a casual observer perspective, Nellis et al. demonstrated that neck scars significantly penalize observer ratings of neck appearance, overall attractiveness, and perceived QOL.5 Given the prevalence of thyroid disease and the young patient age at diagnosis, cosmetic outcomes have emerged as an important concern in the field of thyroid surgery. Further, it has served as the impetus for alternative approaches such as remote access and minimally invasive thyroidectomy techniques.6

Minimally invasive procedures primarily focus on the size of the incision, with most agreeing that remote access is not the same as minimally invasive.7–12 Remote access thyroidectomy involves moving the incision from the visible portion of the neck and placing it in a more discrete location.13–15 Of multiple remote access approaches that have been employed at our institution and elsewhere, the transoral endoscopic vestibular approach thyroidectomy (TOETVA) has become preferred due to the short learning curve and broad indications.6,16–19 Not only do these remote access approaches improve neck scar aesthetics, but they also improve QOL.6 Because a primary goal of these novel approaches is improved neck scar cosmesis and restoration.
to perceived normalcy, being able to objectively measure visual attention is vital in assessing outcomes of these procedures.

In this study, we used eye tracking to objectively measure social attention. Eye movements are an established proxy for visual attention, and previous studies have shown that casual observers view faces in a highly conserved manner. When viewing normal faces, observers direct the majority of their attention to the central triangle (CT) of the face. Deviations from this pattern suggest an abnormality of the face and induce an attentional bias to the deformity itself. This was seen for defects such as a crooked nose, Mohs lesions, and facial paralysis. Further, these eye movement aberrations correlated with changes in observer perception in the domains of attractiveness, QOL, and affect. We can correlate these findings to thyroid neck scars, where understanding the basis for why observers perceive patients with thyroid neck scars differently on social metrics of attractiveness, QOL, and overall neck appearance requires a clearer understanding of where observers direct their attention when making these assessments.

The aim of the present study was to objectively measure the attentional distraction of thyroid neck scars using eye tracking, with an overarching goal of understanding why observers rate patients with neck scars differently on social metrics. We hypothesized that thyroid neck scars provoke a measurable attentional distraction whereby observers fixate on the neck rather than other areas of the face. Furthermore, we explored whether transoral thyroidectomy would have any impact on visual attention in the neck. Taken together, we hope that by objectively measuring the impact of thyroid neck scars on visual attention, we can better understand social perceptions and establish whether there is a role for improving the appearance of the standard thyroidectomy incision.

**MATERIALS AND METHODS**

**Participants**

The Johns Hopkins University Institutional Review Board approved this study. One hundred and thirty participants were recruited (65 males, 65 females) from public areas in Baltimore, Maryland, and Ecuador. Participants were excluded if they were younger than 18 years of age, had eye movement disorders, or were self-reported to have an affective psychiatric condition such as schizophrenia or autism due to the differences in how these individuals direct their attention toward a face. Subjects were naive to the purpose of the study.

**Eye-Tracking Stimulus Material**

Frontal images of 18 unique patients (15 females, age range 19–77; Fitzpatrick skin types 1–5) were obtained: eight patients with a conventional thyroidectomy neck scar, eight control patients with no neck scar, and two patients who underwent transoral thyroidectomy. The thyroidectomy neck scar patients were at least 6 months after surgery, with the majority being 1 to 2 years after surgery. We used photographs with a wide spectrum of scar severity, as rated by an expert thyroid surgeon in effort to provide a heterogeneous sample. No keloid scars were used in this study. All control patients were selected to demographically match the neck scar patients for age. All patients provided written informed consent that their pictures may be used for research purposes.

**Procedure**

Prior to beginning the study, participant observers were given a brief online survey via Qualtrics (Qualtrics, Provo, UT) to collect demographic information and obtain informed consent. Participants were informed that they would be viewing 18 images and instructed to gaze freely on the images. The participants’ eye movement recordings were calibrated using a 9-point calibration task. They viewed life-size facial images at a viewing distance of approximately 60 cm. Images were randomly presented for 10 seconds on a 17-inch LCD screen (resolution 1280 × 1024 pixels).

**Eye Tracking**

Visual scan paths were recorded using an SMI iView X RED (SensoMotoric Instruments, Needham, MA) eye-movement monitoring system, which uses an infrared sensor to capture eye movements while an observer looks at each image. Eye position was recorded with x and y values as if the subject were examining a two-dimensional grid in the plane of the image. These coordinates, as well as pupil diameter, were sampled at a rate of 60 Hz. From this data, we extracted fixations and saccades for each face.

**Data Analysis**

Using the SMI BeGaze v3.0 analysis software (SensoMotoric Instruments), visual fixations from the participants were superimposed on each of the facial images. Fixations were defined as those where the x and y coordinates remained fixed within 0.5 degrees for >200 ms. The fixations and saccades between them constituted a scanpath for each face. Predetermined areas of interest (AOIs) were outlined for each face, which included the CT, neck, and peripheral face. The duration and number of fixations in each AOI were measured. The CT AOI was composed of the eye, nose, and mouth subunits. The peripheral face AOI incorporated all fixations on the face exclusive of the CT. We used the Hotelling’s T²-test to determine if fixation times in control and thyroid neck scar patient differ between the three AOI. We then performed planned Student t tests to study each AOI separately. Next, we determined if the fixation times lost by the peripheral face AOI and gained by the neck AOI in thyroid scar patients were significantly different using contrasts of marginal linear predictions of a multivariate regression. This was followed by a pilot analysis using a two-sample t test to assess for differences in neck fixations between control and transoral patients and transoral and traditional thyroidectomy.

For our pilot study, we set our experiment wide alpha = 0.1 and corrected for multiple comparisons using Hochberg’s procedure. Statistically significant differences are marked by an asterisk. Statistical analysis was processed in Stata 12 SE (Stata Corp., College Station, TX).

**RESULTS**

**Demographics**

One hundred and thirty participants completed the eye-tracking experiment. The observer population included 65 men and 65 women with age ranges from 18 to 67 years;
mean age was 24.3 years. This population was also heterogeneous with regard to race, marital status, level of education, occupation, and annual household income.

**Eye-Tracking Data**

Figure 1 is a heat map of visual fixations indicating the areas of greatest attentional focus on a control patient and a patient with a thyroid neck scar. For both groups of patients, observers spent the majority of time gazing at the CT. Outside of the CT, observers spent more time looking at the peripheral face (face-CT) and the least amount of time gazing at the neck in control patients. These relationships were perturbed in patients with thyroid neck scars: observers gazed at the neck longer and less at the peripheral face in patients with thyroid neck scars compared to control patients. Figure 2 is a focus map from the perspective of a casual observer illustrating areas of focused attention and the altered visual attention given to patients with thyroid neck scars.

To quantify the significance of this observation, we performed a Hotelling’s multivariate t test to test the hypothesis that there are differences in the fixation times of these areas of interest between patients with neck scars and controls. Results demonstrated significant differences in the distribution of attention between control and patients with thyroid neck scars ($T^2 = 32.1; F(3,1668) = 10.6892, P < .001^*$). Next, we performed three separate t tests to determine which of the three AOI differed between control patients and neck scar patients. These data show that observers attended significantly more to the neck (103.7 ms, 95% confidence interval [CI] [55.4, 152.1] ms, $P < 0.001^*$) and less to the peripheral face (115.5 ms, 95% CI [19.7, 211.3] ms, $P = 0.018^*$) in patients with thyroid neck scars than in control patients. Meanwhile, there was no significant difference in time spent gazing on the CT (218.7 ms, 95% CI[−51.8,489.3], $P = 0.113$). We tested to see if the attention times gained by the neck differed from the time lost by the peripheral face in scar patients and found this not to be different ($F(1,1670) = 0.04, P = 0.842$); thus, we concluded that casual observers redirected their attention away from the peripheral face and toward the neck in patients with thyroid neck scars.
With the knowledge gained from these previous analyses and knowing that there were differences in the way observers viewed patients’ necks with thyroid scars compared to controls, we performed a pilot study to test the hypothesis that transoral surgery would eliminate the attentional distraction of thyroid neck scars. A two-sample t test was done to assess for differences in neck fixations between control and transoral patients and between transoral and patients who underwent traditional thyroidectomy. We found that there were no significant differences in the time spent gazing at the neck between patients who underwent transoral thyroidectomy and control patients who underwent no surgery (39.2 ms, 95% CI [15.6, 94.0] ms, \( P = 0.16 \)), but there were significant differences between patients who underwent traditional thyroidectomy compared to transoral surgery wherein observers gazed longer at the neck in patients who underwent traditional thyroidectomy (142.9 ms, 95% CI [65.4, 220.4] ms \( P < .001^* \)). These data suggest that transoral surgery eliminated the attentional distraction of thyroid neck scars wherein there was no difference in the fixation times in the neck for control patients and those who underwent transoral surgery.

**DISCUSSION**

In this study, we objectively measured for the first time the attentional distraction caused by a thyroid neck scar as compared to patients with no neck scars. The results support our initial hypothesis that thyroid neck scars would lead to a measurable difference in visual attention.

This study, much like previous work on objective measurements of social perception, utilizes eye movements as a proxy for attention. To our knowledge, this is the first time that we can begin to quantitatively describe social attention to patients with thyroid neck scars. A recent study by Nellis et al. demonstrated that patients with thyroid neck scars were perceived as less attractive, having a worse neck appearance, and having a decreased QOL. Furthermore, casual observers were willing to pay on average $10,116 to avoid having a neck scar, suggesting that society highly values avoiding a neck scar. The correlation between the objective eye movement findings from this current study and previous data about social perceptions suggests a relationship between observer perceptions and aberrant attentional distribution. Whereas our study did not look specifically investigate whether this distraction directly results in negative social perceptions, it does suggest that they may be associated. Our objective findings provide insight into why observers rate patients with thyroid neck scars differently with respect to subjective metrics and suggest areas to direct reconstructive efforts or initial therapy.

For both control and neck scar patients, observers allocated the majority of attention to the CT area of the face comprising of the eyes, nose, and mouth. This was not surprising because the CT face is one of the key features where the observer gains valuable information about the identity and emotional state of the individual. Gaze fixations in this region are highly conserved as a result of top-down visual processing. In top-down processing, attention is allocated in a goal-directed manner under the influence of preexisting expectations, in this case, with the goal of ascertaining information about the individual at hand. This is in contrast to bottom-up visual processing wherein attention is allocated based on unique or abrupt features of a stimulus that attract attention. Presumably, bottom-up selection drives attention to deformities. It is generally accepted that in our everyday interactions these two processes interact such that attention is allocated based on unique properties of the stimulus and the nature of the viewing task itself. This balance, however, can be tipped in favor of one mechanism over the other, depending on the properties of the stimulus.

We saw this phenomenon in our study: outside of the CT, observers gazed longer at the neck and less at the peripheral face in patients with thyroid neck scars compared to controls. This highlights the bottom-up visual processing schema because thyroid neck scars carry obvious salient features that would take attention away from other regions. In this case, attention was taken away from the peripheral face, which we suspect may be because the peripheral face incorporates areas such as the cheeks and mandible, which are closer in proximity to the neck. In previous studies, we saw that more centrally located facial deformities such as crooked noses or facial paralysis took attention away from components of the CT itself. This may be because, when presented with a deformity, observer scanpaths direct in such a way that visual attention is hyperfocused on the area of the deformity itself; thus, fixation in one area is cause for distractions in areas most proximal to the deformity.

Building on the knowledge gained in the initial results, we hypothesized that transoral surgery would eliminate this attentional distraction. Although preliminary, our results support this hypothesis because our study demonstrated that there was no difference in the fixation time in the neck region for controls compared to those who underwent TOETVA. In other words, postoperative transoral thyroidectomy patients were regarded similarly to a patient with no neck scar.

Although the changes in fixation duration in this study seem small, they are clinically important. Observers gazed on each face for only 10 seconds, thus, even a change on the order of hundreds of milliseconds may be significant. This has important implications because one of the greatest sources of distress to patients with scars or deformities is the fear of appearing abnormal to the casual observer. One of the primary goals of the novel thyroidectomy procedures is to maintain a more normal appearance. Until now, we have not had a reliable way to measure how observers allocate attention to neck scars, which left us unable to make meaningful assessments about how to improve surgery outcomes. This research also correlates with both Western and Eastern data supporting the assertion that an incision in the central neck causes some patients to feel self-conscious and seek subsequent intervention to minimize the impact of this incision.

It is beyond the scope of this article to ascertain individual patient and observer factors that affect scar perceptions, but using eye tracking to objectively measure social attention of deformities such as neck scars can be helpful to more accurately define the characteristics of
the deformity that render it worthy of attention and the point at which it does attract attention. This can help us direct our efforts; for example, observers gazed more on the neck in patients with thyroid neck scars, suggesting that avoidance of a central neck incision may be important in reducing this distraction. This study was not intended to identify the superiority of one approach over another—or who would be an ideal candidate for one surgical intervention over another—but rather to highlight that as new thyroidectomy techniques emerge it is important to the patient, surgeon, and healthcare system to carefully assess the adequacy of these interventions to ensure that the field moves forward in an evidence-based manner that optimizes patient outcomes. This requires data that can objectively and precisely quantify changes in social perception.

**Limitations**

This study is not without limitations. First, for this study we included patient images that were mostly males, although most patients who undergo thyroid surgery are females. Future studies will be necessary with a more diverse patient pool to extend generalizability. Similarly, our images consisted of a heterogeneous patient population with varying degrees of scar severity, and it is unclear whether a threshold of scar severity exists in eliciting attentional distraction. Future studies should include more sophisticated measures for grading thyroid neck scar severity and distinguishing between these nuances. Further, as a result of the simulated nature of our study, all images were still photographs of patients, which does not reflect the dynamic setting in which we make social perceptions. Future studies should include videos of patients with thyroid neck scars to allow for observer perception in settings that are more reflective of real-life scenarios. In addition, because we found that the CT was not affected by thyroid neck scars, we did not study the individual domains comprising the CT, such as the eyes, nose, and mouth, separately to see how they were affected individually. Future studies using larger groups should investigate changes in these domains and their impact in affect display. Finally, our pilot study on transoral surgery is limited in its small patient pool because only two patient images were used for this study. Future studies will be necessary using a larger and more diverse patient population to further assess the significance of transoral surgery on social perceptions of thyroid neck scars. Importantly, the conclusions drawn in our study were dependent on the observer population that we recruited, and future studies with a larger and more diverse observer cohort are needed to investigate the cultural differences in gaze variations.

Despite these limitations, we believe that our study addresses a knowledge gap of how society objectively perceives patients with thyroid neck scars. We hope our objective data will improve this understanding to bring us closer to optimizing reconstructive modalities.

**CONCLUSION**

This study uses eye-tracking technology as a novel method to quantify social perceptions of patients with thyroidectomy neck scars. Thyroidectomy scars preferably redirected observer attention toward the neck compared to control patients and took attention away from the peripheral face. These patterns were eliminated in patients who underwent TOETVA whereby attention patterns were restored to that of control patients. These findings shed light onto the altered observer perceptions of patients with thyroid neck scars and can be used to direct surgical efforts.

**BIBLIOGRAPHY**


