A Proposed Method for Measuring the Esthetic Outcome of Head Surgery

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Abstract

The human face plays a central role in social interaction and, through its rich repertoire of facial expressions and gestures, can be regarded as the primary interface of human communication. Consequently, alterations of the human face – or, more broadly, the human head – may negatively affect an individual's social interactions, potentially imposing a significant psychological burden on the affected person. [3]

Based on these considerations, it is evident why, in head and neck surgery, it is of paramount importance to develop surgical procedures that result in only minimal changes to the patient's head. During surgery, scar lines and certain deformities may appear on the head, which can affect the natural symmetry of the head. In this paper, we focus on deformities that influence head symmetry and arise as a consequence of surgical interventions.

In order to enable a quantitative comparison of the extent of head-related deformities resulting from different surgical procedures designed to achieve the same clinical objective, we developed a semi-automatic image processing method. The results produced by this method can be incorporated into a comprehensive evaluation framework that also takes into account the patient's subjective perception, thereby supporting the aesthetic assessment of surgical outcomes.

It is well established in the literature that head deformity – specifically, the degree of change in symmetry relationships – is an important metric for evaluating aesthetic outcomes. [2] During the development of our method, a key consideration

was that the data acquisition device used for head scanning should be based on a widely available LiDAR sensor, such as those found in some modern mobile phones (in our case, an iPhone 16 Pro Max was used). Owing to its easy accessibility, this choice enhances the potential for widespread adoption of the proposed method.

The method we propose for analyzing 3D head scan data is specifically designed to identify the cephalometric midline (median plane) of the head and to evaluate facial symmetry. The method can be divided into three main logical components: ROI Selection, Midline Fitting, and Symmetry Calculation. The ROI selection step, which can be partially automated, aims to define the region of the head that may have been affected by the given surgical intervention. This allows us to avoid unwanted influences from prior surgeries or other pre-existing asymmetric regions that could bias the evaluation results. The goal of the Midline Fitting step is to determine the orientation of the head and to identify the facial symmetry line based on facial landmarks (e.g., the nasal bridge, the midpoint of the line connecting the eyes, etc.), as illustrated in Figure 1. This bisecting line forms the basis for dividing the head into left and right halves using a plane, thereby enabling the interpretation of symmetry as the difference between the summed distances of points on each side from the midplane.
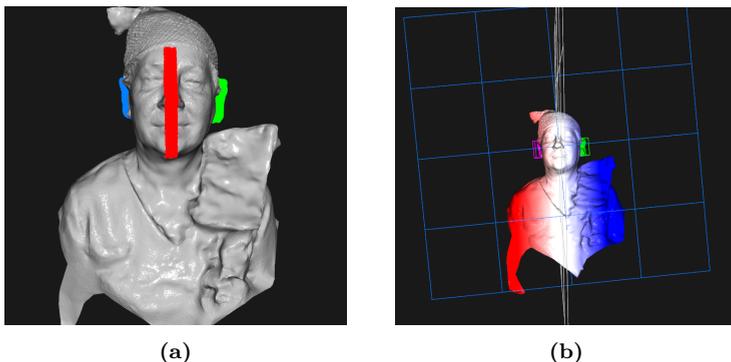

(a)   (b)

Figure 1. The red points shown in (a) represent the feature points used to determine the plane required to divide the head into two parts. (b) The heat map shows the distances of surface points from the midplane. The ROIs are highlighted in purple and green.

We evaluated our method by comparing two surgical procedures used for parotid gland removal [1] (a visual comparison of the results of two procedures is provided in Figure 2).

For this purpose, we constructed a small dataset consisting of data from five individuals, organized as shown in the Table 1. The scan quality was intentionally set to a low level, and visible artifacts can be observed in the resulting 3D models. The purpose of this choice was to test the method on data of the poorest possible quality, which can be acquired quickly and without extensive training by virtually anyone.
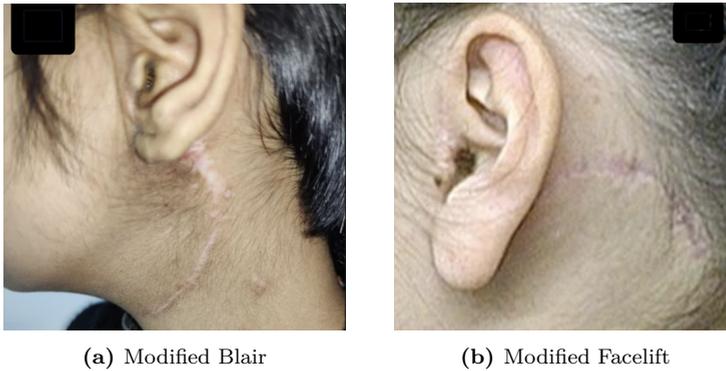
(a) Modified Blair

(b) Modified Facelift

Figure 2. Surgical procedures for parotid gland removal under our investigation

Table 1. For the patients included in the study, the symmetry metrics determined by our method and the corresponding rankings based on these metrics.

ID	Type of Surgery	Global Symmetry	ROI Symmetry	Total Symmetry	Doctor's Ranking	Method's Ranking
Patient #1	Modified Facelift	4.29	4.72	0.43	1	1
Patient #2	Modified Blair	-0.44	3.92	4.36	3	3
Patient #3	Modified Blair+	0.69	6.05	5.36	2	4
Patient #4	Modified Blair	0.84	4.77	3.93	4	2
Patient #5	None	1.55	0.00	1.55		

The same table also illustrates the relationship between the results produced by our algorithm, the subjective ranking provided by the operating surgeon, and the ranking derived from sorting the outputs of our method. The initial experimental results support the hypothesis that there is a detectable difference, in aesthetic terms, between the two surgical procedures under investigation. The initial results are encouraging; therefore, the next steps include further refinement of the method and the execution of validation experiments on a larger and more comprehensive dataset.

References

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