INTRODUCTION

Cryptotia is an auricular muscle abnormality that causes the superior and posterior auricular area to be buried under the temporal skin. The deformity is considered to be the result of an anomaly of the intrinsic transverse or oblique auricular muscles. However, the various forms of cryptotia remain to be classified and the mechanisms that lead to this defect are poorly understood.

At present, cryptotia can be effectively treated by surgery or a nonsurgical method employing a stent. The conservative therapy with a stent is most beneficial if it is applied within 5 months after birth. With regard to surgical treatment, many methods have been reported,1–7 namely, Z-plasty and various local flaps, including the VY, advancement, rotation, and transposition flaps. Some cases also require complicated procedures with a skin graft or cartilage/muscle modification. Because the criteria for using one or the other operative procedure have not yet been clearly elucidated, the choice is often guided by surgeon preference. We prefer 2 types of local flap methods for treating cryptotia, namely, the Square flap method and the Cat’s Ear flap method. Although the choice between the 2 is made on a case-by-case basis, both involve small skin excisions, do not require skin grafts, and yield good results. Interestingly, the shape of the Square flap method after the flap components are sutured together is similar to the design of the Cat’s Ear flap method (Fig. 1).

In the present study, we treated 2 typical cases of cryptotia with either the Square flap method or the Cat’s Ear method. The aim was to help surgeons select the most appropriate surgical procedure on a case-by-case basis.

Methods: Two typical cryptotia cases were treated with the Square or Cat’s Ear flap method. Finite element analysis was performed with ADINA v8.9 software, a PC (Windows 7, CPU: Core i7, Memory: 8 GB), and a hyperelastic skin model (skin diameter 20 cm; thickness 2 mm). The model scales were about 500 nodes and 500 elements (tetrahedron).

Results: The Square flap method involved advancing the square flap between the two triangular flaps. Switching then generated dog-ears that created a big valley. In the Cat’s Ear flap method, the two triangular flaps were rotated in the same direction, whereas a square flap was advanced slightly on the opposite side. This created a large dog-ear.

Conclusions: This study suggested that the Cat’s Ear flap method may be particularly useful for cryptotia patients whose posterior auricular groove is shallow when the buried helix is pulled out. The Square flap method may be suitable for other cases because it effectively extrudes the buried helix with comparatively small excision. (Plast Reconstr Surg Glob Open 2019;7:e2315; doi: 10.1097/GOX.0000000000002315; Published online 25 July 2019.)
Their clinical results are presented here. Computational modeling with finite element analysis was also performed to evaluate the three-dimensional morphological changes that were induced by each surgical procedure. This finite element analysis study sought to determine the characteristics and differences of the two flap techniques, with the aim of helping surgeons to select the most appropriate surgical procedure on a case-by-case basis.

MATERIALS AND METHODS

Two typical cases of cryptotia that we deemed to be suitable for the Square flap and the Cat’s Ear flap methods, respectively, were selected for the study. The design of each flap method is shown in Figures 1 and 2. These cases were analyzed by finite element analysis by using a PC (Windows 7, CPU: Core i7, Memory: 8 GB), a hyperelastic skin model, and the analytical software called ADINA v8.9 (ADINA R&D, Watertown, MA, USA). A skin model that was 20 cm in diameter and had a thickness of 2 mm was used for this study. The design of each flap method was drawn in the center of the skin model and the movement of the flaps and the sizes of the resulting dog-ears were simulated. The scales of the model were about 500 nodes and 500 elements (tetrahedron). We have described the details of this simulation technique previously.8,9

RESULTS

Presentation of Cases

Case 1: Correction of Cryptotia with the Cat’s Ear Flap Method

A 6-year-old girl presented with right cryptotia. Excess flexion of the helix toward the back side of the ear was observed. This deformity was corrected by performing the Cat’s Ear flap method. After surgery, the ear was protruded correctly. By 12 postoperative months, the wounds had healed uneventfully (Fig. 3).

Case 2: Correction of Cryptotia with the Square Flap Method

A 5-year-old boy presented with insufficiency of the left retroauricular fold skin. It was treated by performing the Square flap method. A retroauricular fold could be made 6 months after the operation (Fig. 4).

Finite Element Analysis

The fine three-dimensional computer simulation results showed that in the Square flap method, the single square flap was advanced between the 2 triangular flaps. Switching of the flaps then created dog-ears that generated a big valley. In the Cat’s Ear flap method, the 2 triangular flaps were rotated in the same direction while the square flap was advanced slightly from the opposite side. This created a large dog-ear (See Video 1, [online], which displays the square flap method. The single square flap was advanced between the 2 triangular flaps. Switching of
the flaps then created dog-ears that generated a big valley) (See Video 2, [online] which displays the Cat’s ear flap method. The two triangular flaps were rotated in the same direction while the square flap was advanced slightly from the opposite side. This created a large dog-ear).

DISCUSSION

There is a high incidence of cryptotia in Asia: in Japan and South Korea, the incidence is one in every 400–500 births.¹⁰ By contrast, it is rarely reported in Caucasian and African American patients. In 1985, Hirose et al¹¹ classified cryptotia into 2 types on the basis of the type of antihelix deformity. They also postulated that each type was due to an abnormality of a particular intrinsic auricular muscle. Specifically, in Type I cryptotia, the superior crus and body of the antihelix are compressed together so that the upper portion becomes buried under the skin; it is thought to be due to an abnormally broad transverse muscle. By contrast, Type II cryptotia is characterized by marked contraction of the antihelix body and sharp bending of the inferior crus of the antihelix; it is believed to be due to abnormal attachment of the oblique muscle to the inferior crus. Hirose et al¹¹ suggested that the higher incidence of cryptotia in Asians reflects that fact that the transverse and oblique intrinsic muscles of Asian children are more well developed than in European children. Although cryptotia does not appear to show a marked preference for one side of the body, several studies do suggest that it may occur slightly more often on the right side. Unilateral cryptotia is more common than bilateral cryptotia.¹² Patients with cryptotia can have a functional disorder that means they are unable to wear glasses and/or put on masks. Many patients with cryptotia undergo social discrimination, including bullying at school.

The research to date suggests that there are 2 main ways of treating cryptotia, namely, by a nonsurgical operation that deploys a stent and by surgery. Although many nonsurgical techniques have been introduced and refined over time, there are still indications for the more traditional products. There are several types of stents, including the ear-hanging device that clasps the superior of the helix and the insert device that is placed on the intrahelix. Nonsurgical correction with a stent is most effective if it is applied within 5 months after birth. As the child ages, however, this approach becomes more complicated. Sur-
Surgery is normally performed when the patient is 5 or 6 years of age, which is when the auricle size approaches that of an adult. This is also a good timepoint for surgery because the child is more likely to be cooperative and has not yet entered elementary school. Various operative methods have been proposed for cryptotia, including various transposition flaps (e.g., Z-plasty, the Cat’s Ear flap, and the Square flap), V-Y advancement flaps, and full-thickness skin grafts. In some cases, cartilage transplantation may be necessary. All of these surgical techniques have consistently good outcomes. Hence, we suggest that the best choice is the technique with which the surgeon is most familiar. This is because applying an unfamiliar technique may result in other cartilage problems: this reflects the fact that people with cryptotia can have additional congenital auricular deformations, including Stahl’s ear and folded ear.

Limberg and Wolfe were the first to describe a local flap method consisting of a single square flap and two triangular flaps (30°) in his 1963 textbook entitled *The Planning of Local Plastic Operations on the Body Surface: Theory and Practice*; he referred to it as a “combination of figures of convergent triangular flaps joined along one common straight line of the middle and lateral incisions.” He stated that this flap method can be applied to many cases, including various clefts, epicanthal folds, and burn contractures. However, the 30° triangular flap is prone to blood supply problems, especially in burn scar reconstruction. Consequently, in 1987, Hyakusoku and Fumiiri presented the Square flap method: this method involved creating triangular flaps whose angles are as large as possible, namely, 45° and 90°. This flap method can theoretically lengthen a scar band by 2.8-fold. In addition, the square flap component generates a concavity when it advances between the 2 triangular flaps: the resulting commissure has a U-shape that is sufficiently deep and slopes naturally. Consequently, the Square flap method is useful for reconstructing burn contractures of the axilla, cubital fossa, and web; it is also suitable for creating an auriculotemporal groove for congenital auricular deformities. In terms of cryptotia, the rich blood flow to the face suggests that a flap method involving small-angled triangles is not likely to generate blood flow problems. However, our previous report shows that the stereometrics advantage of the Square flap method will only appear when the angle of one triangular flap is 90° and the angle of the other flap exceeds 37.5°. Therefore, we recommend that the original angles proposed for the Square flap method should be used when treating cryptotia. Also, length of a side of flaps is length needed to pull out the auricle.

In the present study, we selected the original Square flap method for one of our cases. The other case was treated by performing the Cat’s Ear flap method. The choice depended on how much the helix was buried. The first report of the Cat’s Ear flap method for treating cryptotia came from Anze. It was named the Cat’s Ear flap method because the design resembles the ears of a cat. We used finite element analysis to compare the morphological results of the Square and Cat’s Ear flap techniques. Finite element analysis involves computer simulation and is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. This analysis has many medical applications and has been used to analyze artificial joints, artificial blood vessels, skin, and soft tissues. Our finite element analysis...
showed that the Square flap method involved advancing the single square flap between the 2 triangular flaps and that switching of the flaps generated dog-ears that created a deep valley. By contrast, in the Cat’s Ear flap method, the 2 triangular flaps were rotated in the same direction while a square flap was advanced slightly from the opposite side; this created a large dog-ear. Both techniques had similar effects, namely, they tightened the auriculotemporal groove skin and relaxed the lateral side (Figs. 5 and 6). The Square flap method had the advantage that it made a valley with a long and gentle curve between the auricular and temporal regions, whereas the Cat’s Ear flap method was effective because it created a big dog-ear that resulted in the extrusion of the buried helix. In conclusion, the Cat’s Ear flap method seems to be most useful for cryptotia patients whose posterior auricular groove is shallow after the buried helix is pulled out to wear glasses and/or put on masks or compared with the normal side. The Square flap method may be suitable for most other patients because it effectively results in the extrusion of the buried helix with comparatively small excision.

In conclusion, our finite element analysis of 2 historical procedures for cryptotia showed how the dynamics of each procedure led to morphological changes that induced extrusion of the buried helix. However, because we used a plane model analysis to make it easy to understand the 3-dimensional structure of the flaps, further analyses are needed to ensure that our findings are clinically reproducible.

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