Cryptotia refers to a deformation of the auricle in which the upper part of the auricle is flexed and buried subcutaneously in the temporal region. Nonsurgical corrective measures can be applied during infancy; while the auricular cartilage is plastic. After this period, surgical treatment may be required.

Many methods of surgical treatment have been reported for cryptotia, including skin grafting and local flaps. Of these, we prefer to use either the cat’s-ear flap method or the square flap method. Our recent finite-element analysis showed that the former is particularly suitable when the posterior auricular groove is shallow after the hidden helix is pulled out, whereas the latter is suitable for other cases.

However, the complicated 3-dimensional (3D) structure of the auricle in different cases means that the most appropriate surgical method can still be difficult to select.

Here, we describe how we were able to obtain 3D auricular models in a noninvasive manner using a 3D camera and printer. The models were subjected to simulated surgery using the 2 flap methods, allowing identification of the most suitable method for this specific case. Indeed, the actual surgery with the selected method achieved good results.

CASE

The patient, a 7-year-old girl, had been born with left cryptotia (Fig. 1). Before surgery, we photographed the affected ear with a 3D camera (VECTRA H1; Canfield, Parsippany, N.J.) and used the photographs and dedicated 3D image analysis software to construct a virtual 3D model. This 3D model was converted to stereolithography (STL) data, and loaded into slicer software (Ultimaker Cura, Utrecht, the Netherlands). The model was then sliced into 322 layers, including the foundation (layer height, 0.1 mm;
wall thickness, 1.5 mm). The model was then printed using a popular and inexpensive 3D printer (nozzle temperature, 220°C; bed temperature, 40°C; printing speed, 30 mm/s; Creality 3D-10s; Bonsai Lab., Tokyo, Japan) from thermoplastic elastomer filaments (PolyFlex yellow 1.75 mm; Polymaker, Tokyo, Japan). The model was life-sized and accurately represented the ear deformation. The soft material used for the model allowed deformation by hand.

We then 3D-printed 2 identical models. One was subjected to cat’s-ear flap incisions with scalpel or scissors, whereas the other underwent square flap incisions. The flaps were then sutured with 5-0 nylon thread, as would occur during the actual surgical procedure. After comparing the 2 models, we considered the cat’s-ear flap as the best method for this case (Fig. 2). (See Video [online], which displays the 3D models of the cryptotic ear were created using a 3D camera, 3D printer, and elastomer material. This model could be bent, incised, and sutured like human skin during an operation. Another model was subjected to simulated square flap surgery, allowing comparison of esthetic outcomes between the 2 methods for this particular case.

Surgery was performed under general anesthesia. The cat’s-ear flap was designed with the simulation model as a guide. After skin incision, the oblique auricular and transverse auricular muscles were transected. The flap was raised, remodeled, and sutured (See Video [online], which displays the 3D models of the cryptotic ear were created using a 3D camera, 3D printer, and elastomer material. This model could be bent, incised, and sutured like human skin during an operation. Another model was subjected to simulated square flap surgery, allowing comparison of esthetic outcomes between the 2 methods for this particular case.). External bolster fixation was applied for a week. At the 6-month follow-up, the auricle retained a satisfactory form and the patient was now able to wear glasses and masks (Fig. 3).

DISCUSSION

Cryptotia and Its Treatment

Cryptotia is attributed to deformation of the auricular cartilage, poor development of the intrinsic muscles of the ear, and/or quantitative deficiencies of the upper ear skin. Noninvasive interventions with splints during the early postnatal period can eliminate the need for surgery or facilitate subsequent interventions.4 However, approximately 5 months after birth, the plasticity of the
ear cartilage decreases and surgery may become necessary. Because patients with cryptotia can have functional disorders, surgery is often performed between the age of 5 and 7 years, once the auricle shows a size closer to that of an adult. The main objective of such surgery is to fill any skin deficiencies and/or modify any cartilage deformation. Moreover, because cartilage deformation is generally due to abnormal muscle adhesion, this adhesion must sometimes be released.5 Many techniques have been reported, including skin grafts,6 Z-plasty,6 transposition flaps,7 rotation flaps,6 and V-Y flaps.6 We prefer to use either the cat’s-ear or square flap because these flaps do not require a skin graft, are effective, result in minimal wounds, and do not require the use of unsuitable (hairy) skin. The present study showed that making 3D models of the cryptotic ear from flexible material and then simulating the options for flap surgery helped us choose the optimal method. The cat’s-ear flap method was selected, as likely to yield a more natural appearance similar to the healthy side after the flap components were sutured together. This was confirmed by the results of the actual surgery.

Advantages of Simulation with a 3D Camera and 3D Printer

Computed tomography and magnetic resonance imaging are often used to create images for preoperative simulations, but carry the risks of radiation exposure and sedation. These issues are particularly concerning in pediatric cases. Recently, 3D cameras have increasingly been used for 3D structural analyses, follow-up, and simulations in the fields of facial and breast surgery and cases of microtia.10 However, the use of 3D cameras to analyze cryptotia has not been reported previously. We show here that a 3D camera and a 3D printer helped easily and non-invasively analyze the shape of a child’s ear during outpatient treatment. The 3D printer generated an accurate full-scale model of the ear. Moreover, because 3D printer technology is continuously improving, we were also able to create ear models from a soft material with a relatively inexpensive 3D printer. Although the extensibility seen in human skin was lacking, this actually made it easier to see potential skin distortions and dog ears that could arise when a flap method was applied. This in turn aided in selection of the most appropriate method.

CONCLUSIONS

We created 3D ear models in a case of cryptotia, from an elastic material using a 3D camera and 3D printer. By subjecting the models to simulated surgery with 2 flap methods suitable for cryptotia, we were able to select the best surgical method for this case. This approach may thus be useful for selecting between methods of cryptotia reconstruction.

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Fig. 3. Six months postoperative image of the patient after surgery. At this time, the patient was able to wear glasses and masks.