

New Concept for Severely Burned Ear Reconstruction: Grafting of the Frame Using Banked Ear Cartilage Combined with Costal Cartilage

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Background: Damage and loss of ear cartilage can easily occur in a burned ear accompanied by severe extensive burns due to exposure of the cartilage or chondritis. Deformity can also occur due to later development of scar contracture despite minimal damage to the ear cartilage when the injury occurred. We have developed a new technique for treatment of a deep burn in the whole ear.

Methods: In the new technique, the ear is amputated, and soft tissues are denuded. The cartilage is banked in a subcutaneous pocket in the chest and later regrafted in combination with costal cartilage.

Results: Although techniques for regrafting banked ear cartilage have been reported, the reconstructed ear cannot acquire a good shape because of absorption of the cartilage or lack of intensity to sustain the outline of the ear. Meanwhile, when we tried to reconstruct an ear by only using costal cartilage, we found it difficult to fabricate a frame because most patients are adults in whom the costal cartilage is too rigid and fragile to be shaved or combined. In our technique, the frame has both the advantages of sufficient intensity in costal cartilage and a smooth curved surface together with elasticity in the ear cartilage. Ears reconstructed by our technique have a natural appearance.

Conclusion: Our technique can be used for cases in which treatment for another large area of the body surface needs to be performed first to save the patient's life. (*Plast Reconstr Surg Glob Open* 2021;9:e3058; doi: [10.1097/GOX.0000000000003058](https://doi.org/10.1097/GOX.0000000000003058); Published online 17 February 2021.)

INTRODUCTION

In an ear with a deep dermal burn, the cartilage may still remain intact immediately after the injury, even if there has been a severe damage to the skin.¹ In this situation, we should consider salvaging the cartilage by promptly covering it with tissue that has sufficient blood supply.² However, most patients who have suffered a burn to the entire ear also have severe extensive burns on other large areas of the body.³ In such cases, skin grafting to reduce the injured body surface area should be prioritized to save the patient, and treatment for the ear can be delayed. Even in an ear with a superficial burn, gradual exposure of the ear cartilage, necrosis, or chondritis can occur due to insufficient care or repeated external

irrigation.^{4,5} Consequently, there are some cases in which the ear cannot be saved.⁶

We have therefore developed a new surgical technique for the treatment of a deep dermal burn of the ear. In this new technique, the ear is amputated, soft tissues are denuded, and then the cartilage is banked in a subcutaneous pocket in the chest. The cartilage is later regrafted, after about 6 months, in combination with costal cartilage.

METHODS

Our technique is used for patients who have severe extensive burns and for whom it is difficult for the ear to be carefully treated. Another criterion for use of our technique is that the ear cartilage is intact or only slightly damaged, but the covering skin has a deep burn or a superficial burn that is predicted to become worse later.

The first operation should be performed promptly before the cartilage becomes exposed, preferably within a few days after the injury. In the operation, the injured ear is totally amputated. In cases in which the conchal skin is intact, the conchal area can be left. One surgeon can perform sequential procedures for the ear in an area away from the patient, whereas other surgeons can

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simultaneously perform debridement for other body parts. All soft tissues are removed from the amputated ear, and the degree of damage to the cartilage is examined. After confirming that there has been no damage or only slight damage to the cartilage, a skin incision is made in a noninjured area of the body, such as the anterior chest or abdomen, and the cartilage is undermined subcutaneously and banked.

Wound closure and treatment for severe subsequent complications should then be performed. In these processes, the release of the contracture or recovery by a flap using intact skin around the ear should also be performed. Subsequently, ear reconstruction can be started. The banked ear cartilage is removed from the subcutaneous pocket. The area of ear cartilage that can be used for reconstruction is confirmed, and an appropriate amount of the costal cartilage is harvested according to the deficit. Because there are generally severe extensive burns in adults, the cartilage is hard and fragile, making it difficult to connect 2 pieces of cartilage by using a wire. Therefore, a large piece of cartilage that can be used for total reconstruction should be harvested. The costal cartilage is fabricated as a base frame to sustain the ear cartilage from behind and to make up for the deficit with as small amount as possible. It is important to ensure that intensity in the helical forms is rigidly maintained and deformity due to scar contracture is prevented. Then, the costal cartilage frame is combined behind the ear cartilage and fixed by wires or suture materials at minimal points. For the skin to cover the cartilage frame, the entire scar tissue with poor extensibility is removed and replaced by a temporoparietal fascia flap and skin grafting.

Both the anterior and posterior surfaces of the frame should be covered by the temporoparietal fascial flap completely. This procedure can prevent infection and makes it easy to elevate the ear at a later stage. For grafted skin, full-thickness skin harvested from an area such as the supraclavicular or anterior chest is better, although split-thickness skin from the scalp can also be used. The redundant cartilage block is banked again.

Ear elevation is performed after an interval of >6 months. The cartilage frame is elevated with the posteriorly

covered temporoparietal fascia. The banked cartilage is removed again and grafted posteriorly to sustain the ear elevation angle. It is covered by a mastoid fascial flap, and the posterior raw surface is totally covered by a skin graft.

CASE REPORT

The patient was a 47-year-old man who had suffered from a burn injury to 30% of his total body surface area, including his face, scalp, neck, both upper limbs, anterior chest, and back, caused by flames from ignited kerosene. Almost all burns were deep dermal burns. Both ears also had deep burns, except for the concha areas that had superficial dermal burns. The concha areas could be treated conservatively, although it was predicted that the cartilage of other areas would soon become exposed due to necrosis of the covering skin. The degree of damage to the cartilage itself was unclear (Fig. 1).

The first operation was performed on the day after the injury. The anterior chest and neck were debrided, and our technique was applied simultaneously. Both ears were amputated, except for the concha areas. Subsequent procedures for the ears could be performed in any area away from the patient by one doctor. All skin and soft tissues were removed from the amputated ear, and the degree of damage to the cartilage was examined. There was little damage to the cartilage (Fig. 1C). A skin incision was then made in the noninjured right anterior chest, and the cartilage was undermined subcutaneously and banked in a space surrounded by fat tissues.

For wound closure of the entire injured body area, 3 operations for debridement and skin grafting were performed. Additionally, 7 operations for release and reconstruction for future scar contracture in the neck, axilla, and digits were necessary. When the neck contracture was released, scars in the caudal and posterior areas of the ears were removed simultaneously. These areas were reconstructed using large latissimus dorsi musculocutaneous flaps. The patient's visible impression looked very strange because of the loss of the ears.

Reconstruction of the right ear was started 1 year and 8 months after the injury. The concha area had healed

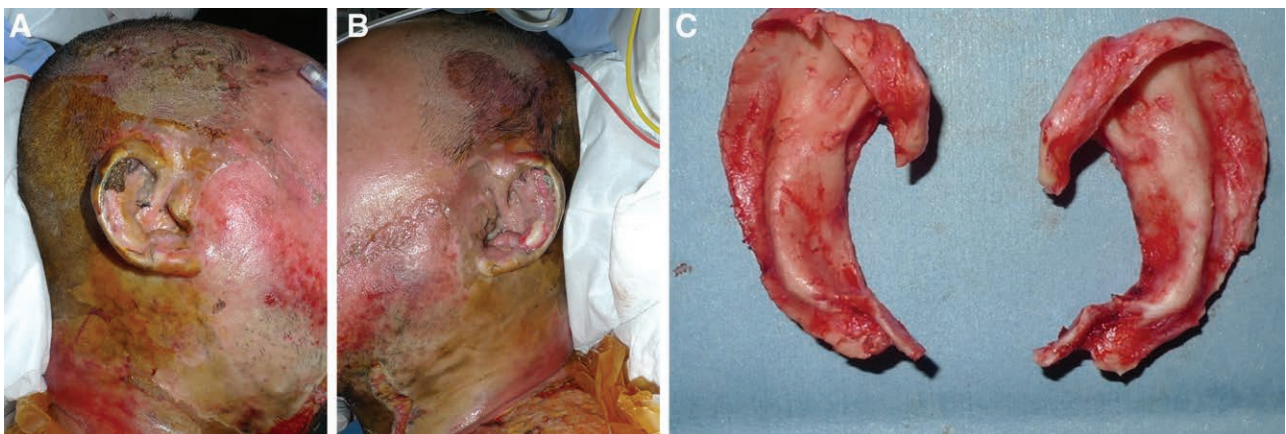


Fig. 1. One day post-burn injury. A and B, Preoperative appearance of the patient. Both ears had deep burns except for the concha areas. C, Both ears were amputated, and soft tissues were all removed and banked in the chest subcutaneously. There was little cartilage damage.



Fig. 2. One year, 8 months post-injury. Appearance of the patient before reconstruction of the ears. A, right-side view; B, left-side view. The caudal skin areas of both ears were replaced by back skin.

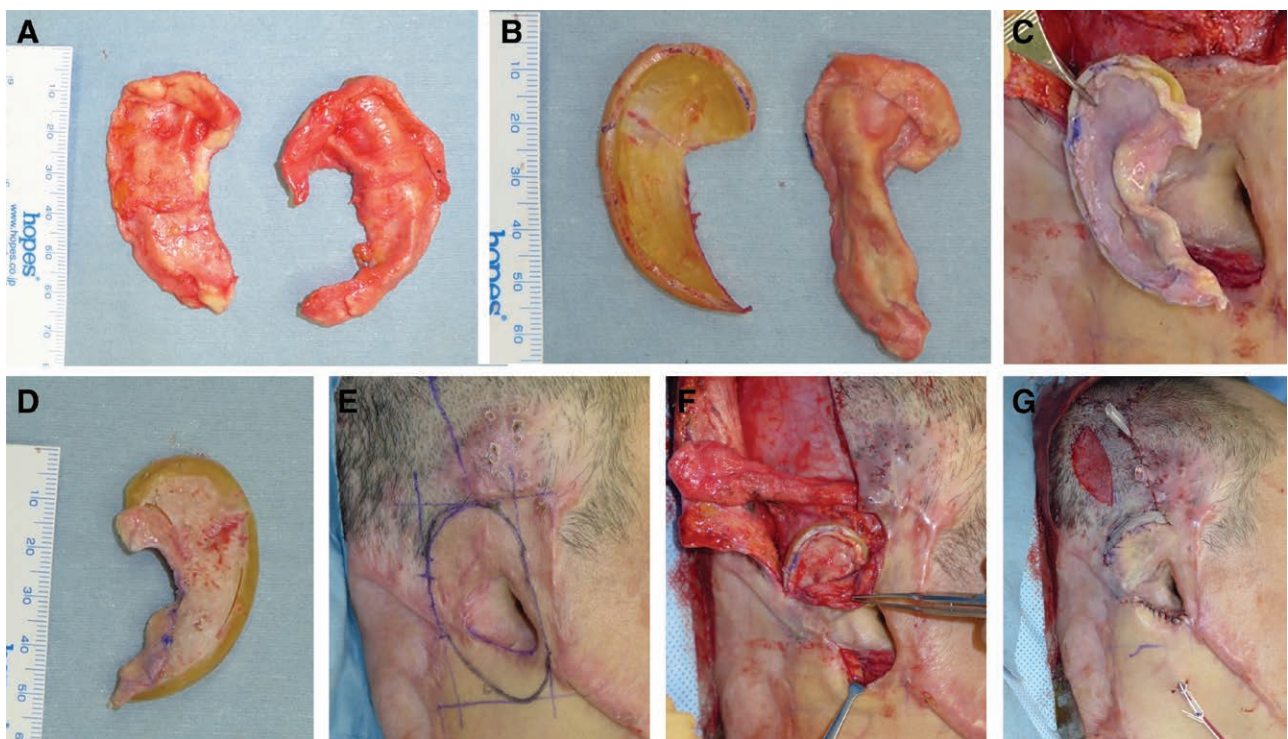


Fig. 3. Costal cartilage grafting. A, The banked cartilage had maintained a rigid structure but showed partial absorption and deformity. B, The ear cartilage could be remodeled to a good shape by creating an antihelix (right). The base frame was created from the seventh costal cartilage (left). C and D, Completed cartilage frame using banked ear cartilage combined with costal cartilage. E, A skin incision was made on the caudal and conchal margin, and a subcutaneous pocket was created. F, The temporoparietal fascia flap was elevated to cover the cranial parts of the frame. G, Appearance when the operation was finished.

well without scarring or deformity. For the skin covering the cartilage frame, the cranial half of the area was slightly scarred but was matured and soft. The caudal half of the area was replaced by intact back skin (Fig. 2). First, the

banked cartilage was taken from the anterior chest. The cartilages had adhered well to the surrounding tissues and had also maintained a rigid structure with the same normal color after removal of soft tissues as that when they

were banked. Partial absorption was found in the helix, and the shape was deformed due to pressure from the surrounding tissues (Fig. 3A). The ear cartilage could be remodeled to a good shape by creating an antihelix using suture materials. Using a skin incision in the anterior chest, the seventh costal cartilage was harvested. The costal cartilage was very hard and fragile, although its size was sufficient to cover the whole widths of both ears. The base frame was fabricated by costal cartilage to sustain the ear cartilage from behind and to acquire the helical form and height (Fig. 3B). Then, the costal cartilage frame was combined behind the ear cartilage and fixed by wires or suture materials at minimal points (Fig. 3C, D).

A skin incision was made on the caudal and conchal margin. The area just under the skin was undermined to create a subcutaneous pocket for insertion of the cartilage frame (Fig. 3E). Then, the cartilage frame was grafted, although the cranial skin was too limited to acquire a 3-dimensional shape of the ear. An additional skin incision was then made in the scalp, and the temporoparietal fascia flap was elevated and the cartilage frame was covered completely (Fig. 3F). A split-thickness skin was harvested from the neighboring scalp skin and grafted (Fig. 3G). The redundant costal cartilage and left ear cartilage were banked again in the same pocket.

Cartilage grafting on the left side was performed 4 months after cartilage grafting on the right side. Most part of the operative technique was the same as that for the right side. However, the ear cartilage had a larger defect because of secondary banking, and the cranial half of the skin was scarred. Therefore, the costal cartilage was fabricated to create an additional area of the scapha compared with the right side. The scarred skin was entirely removed, and the full-thickness abdominal skin was grafted after

covering the cartilage frame by a temporoparietal fascia. The redundant costal cartilage block was banked again (Figs. 4–5).

The elevation of each ear was performed after intervals of >6 months. The cartilage frame was elevated with the posteriorly covered temporoparietal fascia. The banked costal cartilage was removed again and grafted posteriorly to sustain the ear elevation angle. It was covered by a mastoid fascial flap, and the posterior raw surface was totally covered by an abdominal skin graft.

Both ears healed without any complications such as skin necrosis or infection (Fig. 6A, B). At the 2-year follow-up, the reconstructed ears maintained a good shape, and the patient could wear a mask and glasses (Fig. 6C, D).

DISCUSSION

Most ears with superficial or deep dermal burns can be saved if appropriate treatment is performed promptly after the injury.⁷ Even for an ear with a deep burn, the cartilage may still be intact immediately after the injury and can be saved. However, most burned ears are accompanied by severe extensive burns in other large body areas, including the face.³ For such patients, skin grafting to reduce the injured body surface area should be performed first to save the patient, and burned ears cannot be cared for satisfactorily or left for later treatment. Since the ear is protruding, it has thin skin, and poor subcutaneous soft tissues, exposure of the ear cartilage, necrosis of the cartilage, or chondritis may occur because of repeated external stimulus.^{1,3-5}

As a primary procedure to save a burned ear, an easy technique such as skin grafting can be used when the perichondrium is intact.¹ For a more severe burn accompanied by injury to the perichondrium, a postauricular local skin flap is useful when the postauricular skin is not

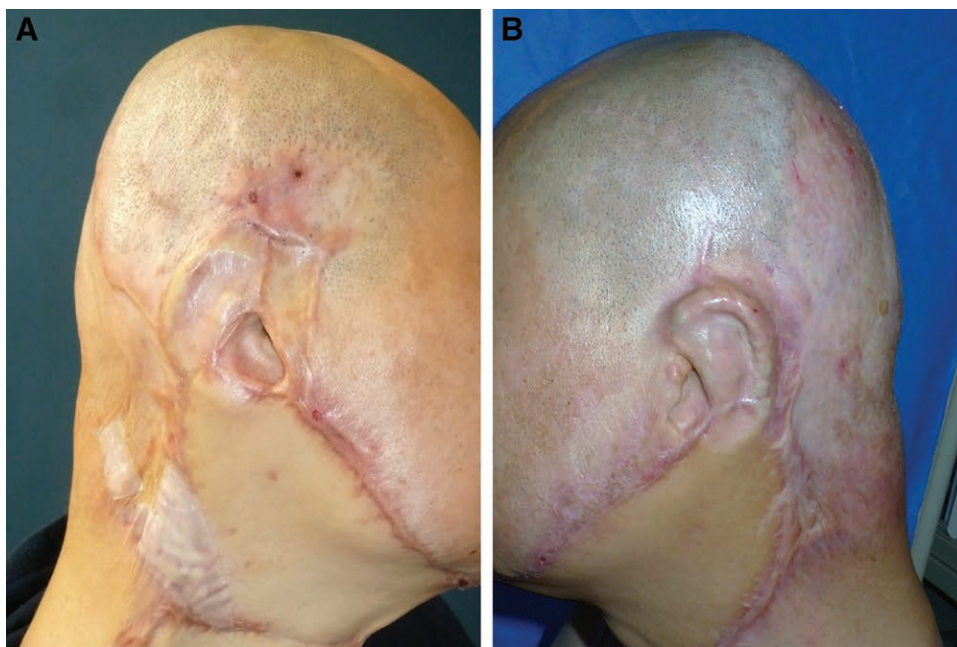


Fig. 4. After grafting on both sides. A and B, Appearance before elevation of the ears. The wounds had healed well, and there were no deformities of the ears.

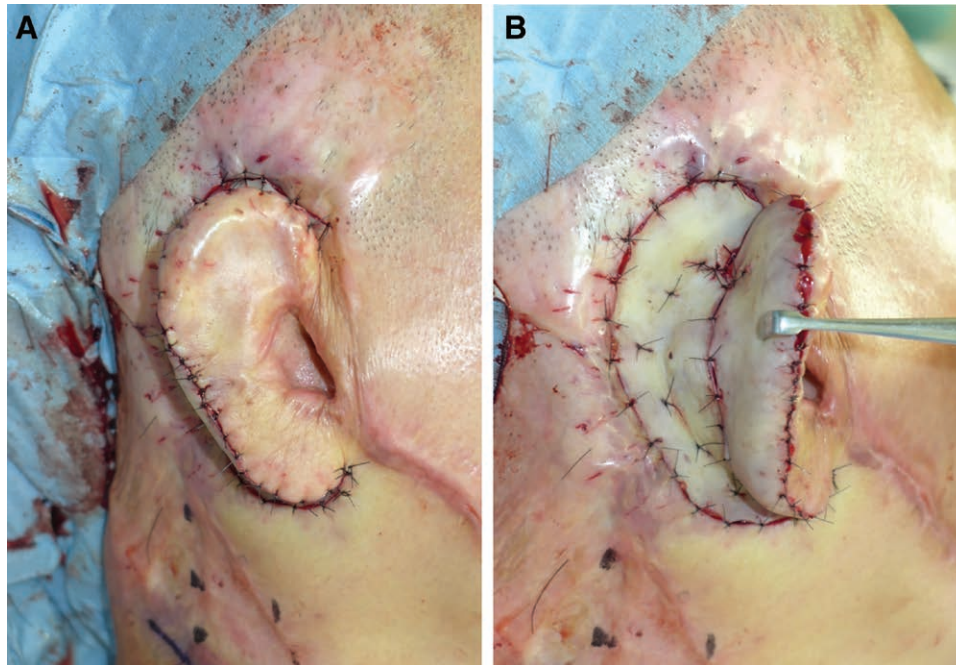


Fig. 5. Ear elevation. A and B, The right ear was elevated after an interval of >6 months. The left ear was elevated later.

injured.^{2,8} A technique in which soft tissue of the ear is debrided, embedded below the temporal skin, and then elevated later can also be useful.⁹⁻¹¹

Conversely, patients with severe extensive burns also have damage to the postauricular and temporal skin. Ears can be also saved by immediately covering the cartilage with a temporoparietal fascial flap and applying a skin graft.^{12,13} However, using this complicated technique in such patients can be time consuming.

Moreover, the most important problem is that the ear cartilage does not have sufficient intensity for maintaining the shape of the ear against the contracture forces that consequently occur, and deformities can also easily occur despite using the above-mentioned techniques to save the ear.¹⁻³ Most patients with a deformity or loss of an ear due to a burn wish to undergo early reconstruction of the ear because most patients also have facial injuries and want to hide ugly facial scars by wearing a mask or glasses.

There are several techniques for reconstructing an ear that has been contracted, deformed, or lost. Techniques using various local skin flaps and chondrocutaneous flaps have been reported for partial defects and deformities.^{6,7,14,15} For larger defects, a costal cartilage graft is mainly used, and the cartilage is generally covered with a temporoparietal fascial flap and skin grafting.^{16,17} However, the use of costal cartilage has a serious problem because most burn patients are adults, in whom the costal cartilage is hard and fragile, making it difficult to fabricate the elaborate shape of an ear. Further, infection can shortly occur in burn patients. Grafted costal cartilage can be easily absorbed and destroyed if it is infected. Although a technique using Medpor has recently been reported, it will also become exposed and will have to be removed if infection occurs.¹⁸

In our case, because the skin surrounding the ear was also injured, local skin flaps or one of the above-mentioned techniques could not be used. Almost all skin in the ear had deep or deep burns or deep dermal burns, except for the concha, and it was predicted that other areas would get worse over time. Thus, we predicted that exposure and loss of the ear cartilage would inevitably occur. The technique of covering with a temporoparietal fascia could also not be used because the patient had severe extensive burns, and operations to save the patient had to be performed first.

Our technique is based on the concept of salvaging and using as much ear cartilage as possible. The procedure of amputating the ear and banking the ear cartilage in the early period can prevent the progress of necrosis and infection. This procedure can be performed by one surgeon in an area away from the patient, whereas other surgeons can perform debridement for other body parts simultaneously. The skin around the ear can heal soon, and care for the ear is unnecessary. Reconstruction of the ear can be performed after the scar around the ear has matured, other body areas have healed, and the patient's general condition has improved. The main advantage of our technique is that the frame that is fabricated by combining the ear and costal cartilage has both sufficient intensity in the costal cartilage and a smooth curved surface together with elasticity in the ear cartilage. Costal cartilage can be harvested minimally and does not have to be fabricated to a complicated shape because the main shape of the frame can be created by the ear cartilage. Therefore, this technique can be used for adults in whom the costal cartilage is too hard and fragile to be fabricated delicately.

Concerning the use of banked ear cartilage, techniques in which all soft tissues of the ear are denuded or

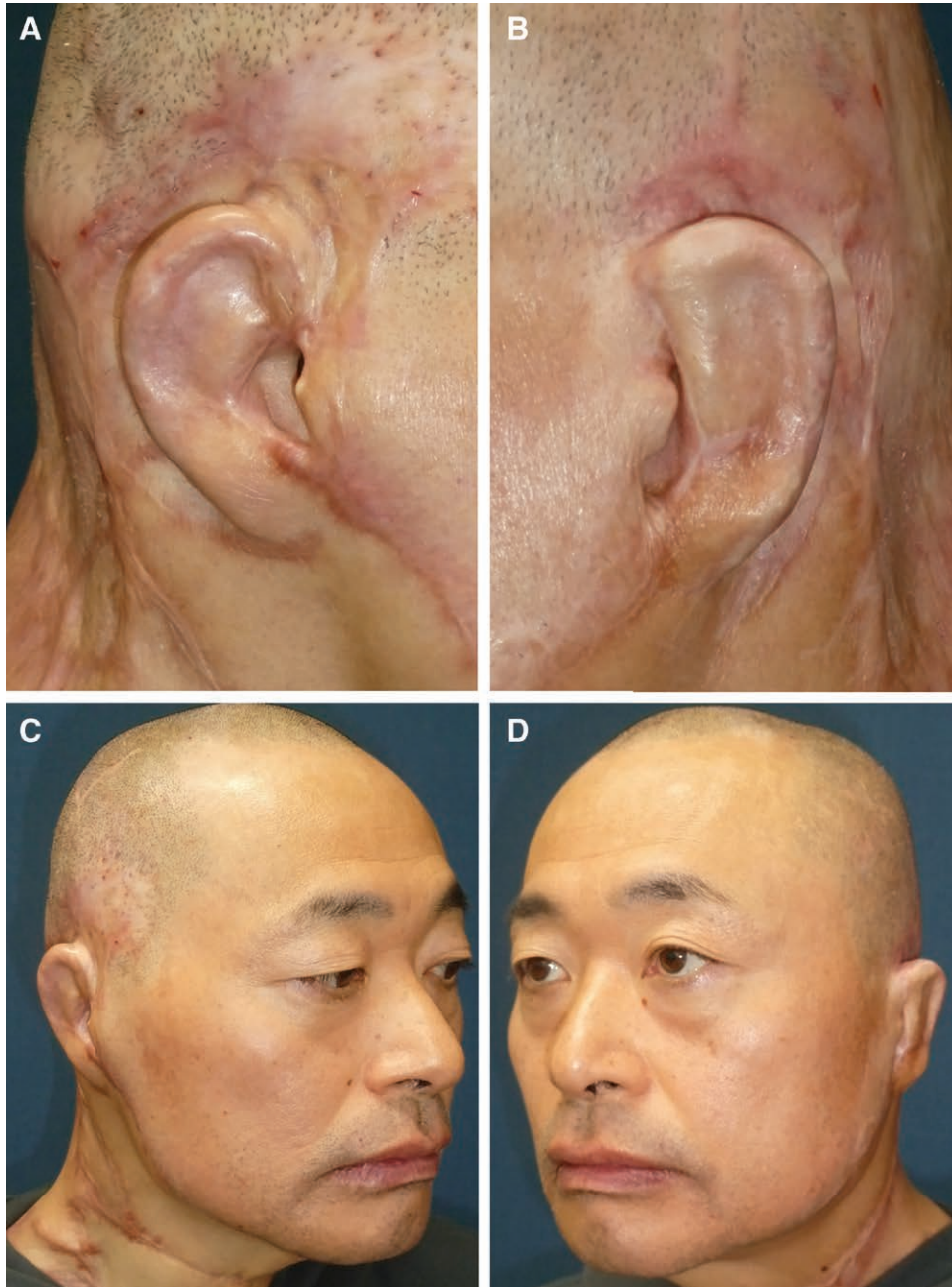


Fig. 6. Postoperative appearance. A and B, Appearance 2 years after ear elevation. The reconstructed ears maintained a good and natural shape. C and D, Visible impression of the patient was greatly improved.

the skin is de-epithelized have been reported for cases of traumatic amputation of the ear.^{9,11,19,20} Banked ear cartilage can be easily absorbed or can easily contract during banking or after regrafting.²¹ However, in our case, the banked cartilage had maintained the original shape with little absorption or deformity at the 2-year follow-up.

The postauricular area, anterior chest, abdomen, or subclavicular area can be considered as sites of a subcutaneous pocket to bank the cartilage. We selected the anterior chest in our case because the costal cartilage can be harvested simultaneously during skin incision from the same wound during the second operation, without leading

to a different scar. However, the fat layer of the anterior chest was too thin to prevent the pressure and to maintain the shape of the banked cartilage. Thus, the banked area should be an area with a thick fat layer, such as the abdomen. Moreover, in our case, the ear cartilage had some absorption when the banked cartilage was removed and banked again; therefore, each cartilage should be banked in another area when both ears have been injured.

CONCLUSIONS

We have developed a new technique for the treatment of a deep burn in the whole ear. In this novel technique, the

ear is amputated, the soft tissues are denuded, and then the cartilage is banked in a subcutaneous pocket in the trunk. The cartilage is later regrafted in combination with costal cartilage. This technique can be used for cases in which treatment for another large area of the body surface should be prioritized to save the patient's life. The main advantage of our technique is that the frame fabricated by the combination of ear cartilage and costal cartilage has both sufficient intensity in costal cartilage and a smooth curved surface together with elasticity in the ear cartilage.

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PATIENT CONSENT

The patient provided written consent for the use of his image.

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