Creating a re-expanded prefabricated island flap constructed with an anastomosed vascular pedicle for burned ear reconstruction: a case report

Yang Chen[1#], Wanfu Zhang[1#], Fei Han[1], Xiaolong Hu[1], Lin Tong[1], Yunwei Wang[1], Shaohui Li[1], Peng Cao[2], Liwei Dong[3], Hao Guan[1]

[1]Department of Burn and Cutaneous Surgery, Xijing Hospital of Air Force Medical University, Xi'an, China; [2]Department of Burns and Plastic Surgery, General Hospital of Ningxia Medical University, Yinchuan, China; [3]Department of Plastic Surgery, Xijing Hospital of Air Force Medical University, Xi'an, China

Contributions: (I) Conception and design: H Guan, L Dong; (II) Administrative support: H Guan; (III) Provision of study materials or patients: W Zhang, F Han, X Hu; (IV) Collection and assembly of data: Y Chen, Y Wang, S Li; (V) Data analysis and interpretation: Y Chen, L Tong, P Cao; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Hao Guan. Department of Burn and Cutaneous Surgery, Xijing Hospital, Air Force Medical University, 127 Changle Western Road, Xi'an 710032, China. Email: guanhao@hotmail.com; Liwei Dong. Department of Plastic Surgery, Xijing Hospital, Air Force Medical University, 17 Changle Western Road, Xi'an 710032, China. Email: drliweidong@163.com.

Background: The combined use of various flap techniques has rapidly improved the reconstruction quality of auricle defects that are complicated by a scarcity of periauricular skin after severe burns. Nevertheless, there is still no preferable method when the optimal alternative skin to cover the auricular framework is unavailable and the periauricular vascular network is devastated.

Case Description: Copious scars were observed in the periauricular region, neck, forearm, and supraclavicular region of a 19-year-old man. He had been burned by high-voltage electricity and exhibited a right auricular defect. We innovatively created a prefabricated expanded island flap constructed with an anastomosed vascular pedicle buried in the anterior thoracic chest, followed by flap transfer, tissue re-expansion, and sculpted autologous costal cartilage implantation. The remnant ear was successfully reconstructed in a three-stage surgical procedure.

Conclusions: All the flaps survived well without any complications. The reconstructed right ear had a natural shape and a clear structure without apparent displacement and deformation during follow-up. The patient was satisfied with the final appearance, and his neck mobility markedly improved. Advantages and disadvantages were discussed. This procedure explored a novel solution to construct an auricular framework covering for patients who do not have high-quality donor skin and lack anastomotic vessels in the recipient area.

Keywords: Auricular defect; burned ear reconstruction; case report; flap prefabrication; re-expansion

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Introduction

Compared to microtia reconstruction, reconstruction of auricular defects after a burn injury is more arduous and complex. A lack of periauricular skin and destruction of the vascular network around the burned ears are the main issues that need to be solved. After years of constant exploration, satisfactory burned ear reconstruction has been achieved by the combination of tissue expansion and

Figure 1 Preoperative photograph of the partial defect of the right ear. This image is published with the patient's consent.

distal composite framework prelamination followed by flap transfer to the defect location. The supraclavicular skin, neck skin, and medial forearm skin are the best alternative areas for the auricular framework prelamination for this process (1-3). When none of the above regions are available, using another area of hairless skin color matched to the periauricular area to cover the auricular framework may be possible, however, reports on this option are rare. One of the hidden challenges is how to solve the problem of excessive skin thickness. Here, we describe an innovative reconstructive solution for a remnant ear caused by an electrical burn. By combining expanded island flap prefabrication, microsurgical transfer, flap re-expansion, and autologous costal cartilage implantation, we successfully obtained a "new" ear with matching thickness to the periauricular skin that was similar in color and had a preferable ear definition. We present the following case in accordance with the CARE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1427/rc).

Case presentation

All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

A 19-year-old man who had been burned by high-voltage electricity and had undergone multiple surgical reconstructions of wounds covering his body in the Department of Burn and Cutaneous Surgery of Xijing Hospital expressed a strong desire to repair the partial defect of his right ear without any artificial material (*Figure 1*). He had not been able to raise his head to a normal amplitude for over one year because of a massive scar contracture of the neck. The upper one-half of the auricle was still intact, but available periauricular skin was insufficient. Extensive scarring was also visible on the forearm and supraclavicular region. Therefore, previous successful cases of framework prelamination in the above areas could not be emulated (1-3). We also immediately disregarded the modified Brent-Nagata's methods combined with skin grafting because a previous surgical exploration had found that the superficial temporal artery had been destroyed, making it difficult for the temporoparietal fascial flap to survive. After preoperative analysis and in-depth communication with the patient, flap transplantation, tissue expansion, and autologous costochondral graft reconstruction were chosen.

Flap design

Preoperatively, the vascular condition of the face and neck was assessed by color Doppler ultrasound (CDUS). After drawing and tracing a line from the anterior superior iliac spine to the lateral border of the patella, the following parameters of the descending branch of the lateral femoral circumflex artery (db-LFCA) in the bilateral thighs were also detected by CDUS: location, distribution, diameter, quality, and perforators. A free anterolateral thigh perforator (ALTP) flap in the right thigh was outlined and designed for repairing the neck scar (*Figure 2A*). The descending branch of the lateral femoral circumflex vascular bundle in the left thigh was designed to be an autologous vascular graft and served as a vascular carrier in prefabricating an island flap at the anterior thoracic region (*Figure 2B*). The island flap was created to be the auricular framework covering.

We divided the whole surgical procedure into three stages. The detailed technical methods are described in the following section.

Stage one

First, a 12×14 cm neck scar was stripped and excised above the superficial cervical fascia. Appropriate lysis of the residual scar contractures at the neck improved the patient's neck mobility. After adequate hemostasis was achieved, we microscopically explored the facial arteriovenous stump in the lower jaw, where 1 artery and 1 vein were identified, isolated, and temporarily clamped. Then, adequate

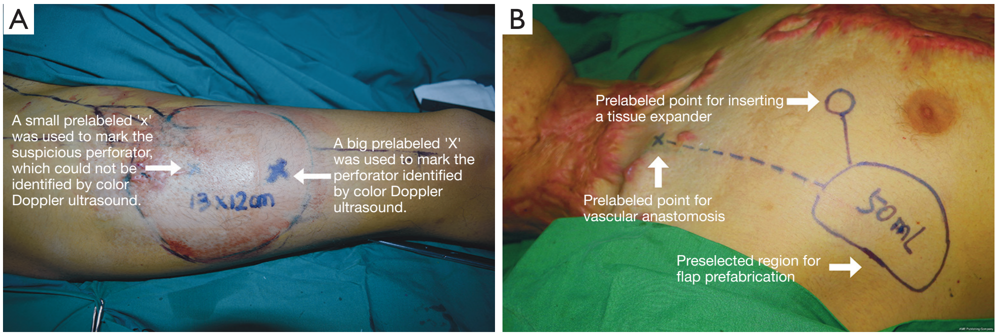

Figure 2 Flap design. (A) The preoperative anatomical markings are made on the right thigh to design a free ALTP flap. One perforator was identified by CDUS and marked with a big "X"; another suspicious perforator was marked with a small "x". (B) The preoperative anatomical markings were made at the anterior thoracic region to design a prefabricated expanded island flap and for vascular anastomosis. ALTP, anterolateral thigh perforator; CDUS, color Doppler ultrasound.

hemostasis was re-established. The exposed wound at the neck was covered with normal saline gauze and prepared for flap transplantation.

The ALTP flap was harvested using the classic surgical technique previously described (4). The dimensions of the ALTP flap depend on the actual size of the neck defect after scar excision, so the dissection was initiated 1 cm away from the pre-designed boundary of the flap in the right thigh. At the lateral border of the flap, the skin, subcutaneous tissues, and fascia were incised, followed by a subfascial dissection until the musculocutaneous or septocutaneous perforators were visible. After elevating the flap appropriately, two perforators were identified and dissected in a retrograde fashion. One of the perforators, which did not originate from the db-LFCA, was cut and ligated. Another perforator was tracked to the main trunk of the db-LFCA, which was dissected meticulously through the muscles until the required vascular pedicle length was obtained (*Figure 3A*). The ALTP flap was harvested with part of the db-LFCA as the pedicle and grafted to the neck wound (*Figure 3B*). The proximal portion of the db-LFCA pedicle was microscopically anastomosed to the facial vessels, and the distal portion was temporarily clamped. The flap was observed to be well-perfused after the restoration of blood supply. After complete hemostasis and sufficient drainage were achieved, the wound at the donor site was covered by epidermal sheets.

Subsequently, on the surface of the left thigh, a lateral thigh incision was made upon the intermuscular septum between the rectus femoris muscle and the vastus lateralis muscle and deepened to the septum. The dissection was continued by separating the longitudinal fibers of the rectus femoris and the oblique fibers of the vastus lateralis until the db-LFCA was identified. A 10 cm long portion of the db-LFCA vascular bundle, consisting of 1 artery with 2 associated veins, was harvested to serve as the vascular graft (*Figure 3C*). Heparinized saline was infused into the vascular graft to remove blood clots.

At the same time as acquiring the vascular graft, a subcutaneous pocket was created by careful dissection in the superficial layer of the deep fascia at the anterior thoracic region. A 50 mL expander was placed into the subcutaneous pocket. Then, blunt dissection of subcutaneous tissue between the subcutaneous pocket and the neck wound was performed to create a subcutaneous tunnel. The proximal end of the vascular graft was microscopically anastomosed to the distal end of the db-LFCA pedicle of the ALTP flap to form the anastomosed vascular pedicle. The distal end of the vascular graft was ligated and pulled into the subcutaneous pocket through the subcutaneous tunnel and finally placed between the subcutaneous tissue and the expander to prefabricate an island flap. A drainage tube with negative pressure was placed under the expander (*Figure 3D*). All incisions were closed with interrupted sutures. The static expansion was retained for 1 month after the available area was obtained.

Stage two

Seven months later, the path, anastomotic patency, and normal blood flow of the anastomosed vascular pedicle were confirmed by CDUS. The facial scar was excised using the same technique described in stage one. First, the dissection was carried out until a sufficient length of the

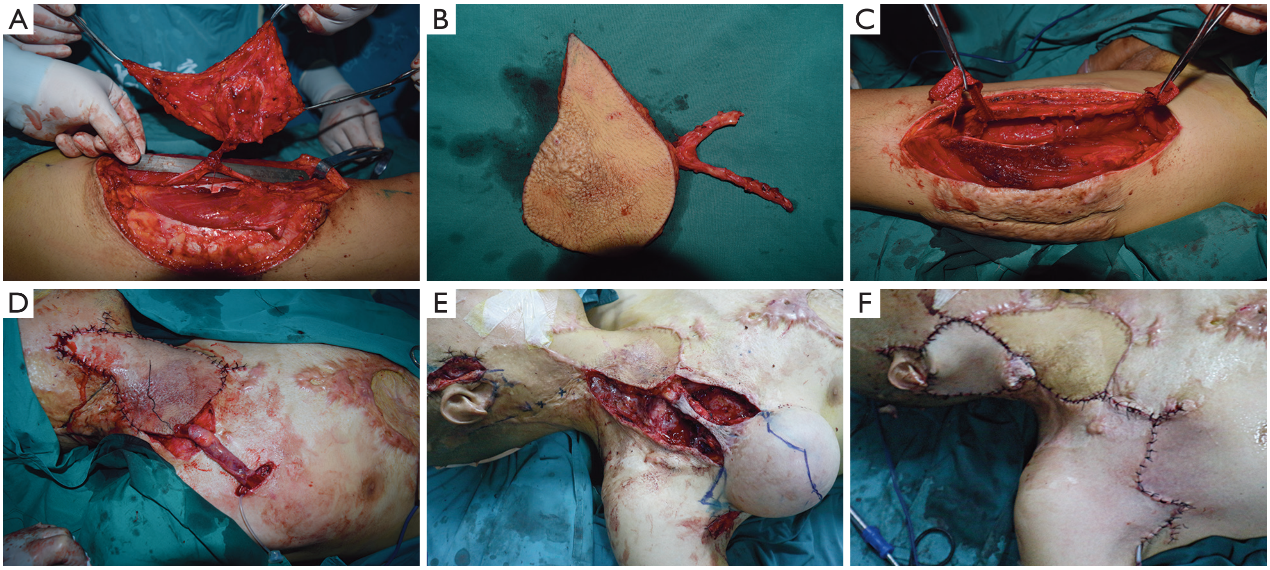

Figure 3 Flap transplantation and prefabrication. (A) After adequate intramuscular dissection, the ALTP flap was raised very carefully from below upwards to fully expose the only perforator, which originated from the db-LFCA. (B) A photograph showing the free ALTP flap acquired from the right thigh. (C) A 10 cm descending branch of the lateral circumflex femoral vascular bundle was measured in the left thigh. (D) The vascular graft was anastomosed proximally to the pedicle of the ALTP flap and distally buried between the subcutaneous tissue and the expander. This picture was captured before the vascular anastomosis to facilitate the observation of the subcutaneous path of the vascular graft. (E) The vascular pedicle of the island flap was prudentially dissected to a sufficient length, which enhanced the operability of flap transposition. The stump of the superficial temporal vein was meticulously explored and well prepared for vein anastomosis. (F) Flap transposition was completed, and all the incisions were directly sutured. ALTP, anterolateral thigh perforator; db-LFCA, descending branch of the lateral femoral circumflex artery.

vascular pedicle of the island flap was achieved to facilitate flap transposition. The stump of the superficial temporal vein was also dissected to an adequate length in preparation for vein anastomosis (*Figure 3E*). Based on the shape of the facial wound, an expanded prefabricated island flap (8×10 cm) was harvested at the anterior thoracic region after removing the 600 mL expander and its capsule. Survival and patency of the island flap were confirmed immediately by bleeding at the edge. One special note that we made was not to separate the flap paddle from its pedicle. Then, the island flap with its vascular pedicle was rotated up to the facial wound. The stump of the superficial temporal vein was not anastomosed with the superficial vein of the expanded flap because the island flap established its own blood circulation and was observed to be well perfused. The island flap was interruptedly sutured below the remnant auricle (*Figure 3F*) and was subsequently re-expanded. A negative suction tube was also left in place. The donor area was directly closed with interrupted sutures.

Stage three

At 18 months after the prefabricated flap transfer, the re-expanded flap had survived well; it reached the expected area and had a similarly well-matched thickness and texture to the periauricular skin (*Figure 4A*). The contralateral eighth costal cartilage was carved into a two-layer framework with the guidance of a 2-dimensional (2D) template (5). The superior layer of the new framework was sculpted to create the helix, scapha, and antihelix, and the inferior layer was fixed underneath to create a suitable ear projection (*Figure 4B*).

Along the superior border of the re-expanded flap, an incision was made to remove the expander, followed by necessary debulking of the flap. The costochondral framework was attached to the remnant auricular cartilage with 5-0 proline sutures (*Figure 4C*). The inferior layer was fixed to the mastoid region to prevent the framework from shifting. Incisions were interruptedly sutured. Negative pressure drainage was placed around the framework to

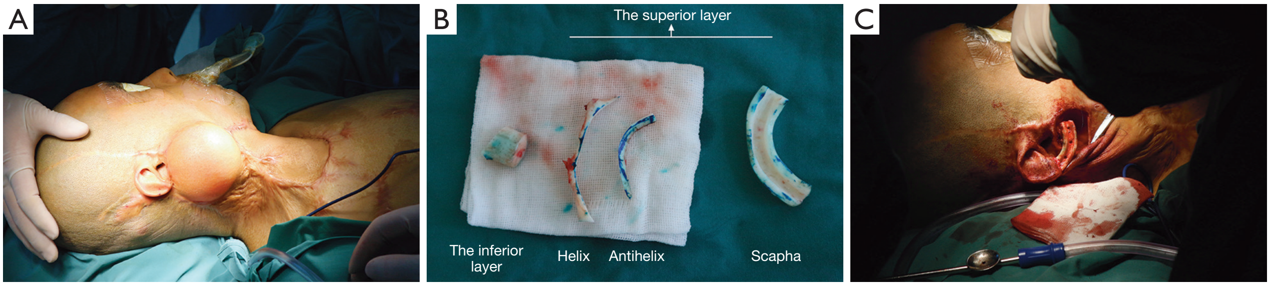

Figure 4 Auricular framework reconstruction. (A) Eighteen months after the implantation of the retroauricular expander. Adequate flap area was achieved by re-expansion. The color and texture met the requirements of the auricular framework covering. (B) The complete structure of the sculpted autologous costal cartilage framework. (C) The costochondral framework was attached to the remnant auricular cartilage with 5-0 proline sutures.

Figure 5 A photograph of the right ear one year after auricle defect reconstruction. This image is published with the patient's consent.

facilitate auricular shaping and was removed 6 days later.

The whole procedure lasted 2 years and 8 months. The 1 year follow-up after the procedure showed that all transferred flaps survived well, without any complications. Observation and evaluation showed that the reconstructed ear had a natural shape and a clear structure without apparent displacement and deformation (*Figure 5*). Marked improvement of neck mobility was achieved. The patient was satisfied with the final result. The donor site scars were acceptable.

Discussion

Just like the modified Brent-Nagata's methods, conventional methods for auricular framework prelamination are dependent on either sufficient normal periauricular skin or a sound periauricular vascular network (6-9). Unlike microtia patients, most burned ear patients have extensive burns to their whole body, leading to a scarcity of alternative skin and scar deformities in multiple areas. Any implanted auricular framework is not likely to resist continued scar contracture, and normal ear morphology is difficult to maintain (10,11). Moreover, irreversible damage to the periauricular vascular network makes it difficult for any flap to survive. For our patient, the most urgent tasks were to reduce the scar area to recover the mechanical properties of normal skin around the ear and recover the epidermal blood supply to create a good periauricular condition for the prefabricated flap transfer.

For many years, the ALTP flap has been the preferred choice for neck and head defect reconstruction (12). The ALTP flap has numerous merits, including thin and large pliable skin, long and big pedicle vessels for easily bridging a vascular defect in burn wounds, and the lowest donor site morbidity (13). Even though it is safer to harvest an ALTP flap based on multiple perforators, in our case, the ALTP flap was harvested based on a single perforator because only one perforator was identified, and it did not exceed the upper limit of the available flap area as previously reported (14,15). However, according to our experience, an ALTP flap based on a single perforator has its own advantages of increased operability, ease of contouring, and increased pedicle reach. A meticulous dissection of the perforator through muscle should be implemented to avoid local vascular complications, such as vasospasm or blockage of blood flow. Immediate flap grating after excision could help to maintain flap viability.

Due to the anatomical variations, most of the intramuscular dissection of the musculocutaneous perforator may inevitably cause injury to the vastus lateralis muscle in various degrees (16), as observed in our case. The perforators were more likely to be affected by strong compression from the obvious muscle cuff preserved around the perforator (17). Fortunately, the ALTP flap in our case presented with good blood supplies and without complications from vascular insufficiency. In the postoperative clinical observation, the patient never mentioned any discomfort in his lower limbs. The potential risks of injury to the perforator further urged us to improve the suprafascial dissection technique as early as possible.

The descending branch of the lateral femoral circumflex vascular bundle is considered an ideal vascular carrier for flap prefabrication. Most microsurgeons are acquainted with its anatomy with respect to the ALTP flap and the vastus lateralis muscle. The variations of pedicle and perforators should not pose much of an issue with harvesting the vascular graft if an adequate diagnosis is made via CDUS. The following benefits also make the descending branch of the lateral femoral circumflex vessels the best vascular carrier for our flap prefabrication (18): (I) appropriate diameter and length are conducive to the vascular anastomosis and flap rotation; (II) retaining sufficient perivascular fascia helps revascularization between the vascular graft and the prefabricated flap; (III) there is a greater flap survival area; and (IV) there is low morbidity of the donor site.

A study showed that the re-expansion technique had been widely used in patients without enough normal tissue for coverage of the defects in recent years. It has been shown to be safe and reliable as long as the dermis of the skin is sufficiently thick (19). Therefore, static expansion was retained for about 1 month to assist in repairing the dermis and resisting contracture after our expander at the anterior thoracic region reached the ideal volume. Although providing large dimensions and good elasticity (20), the skin in the anterior thoracic region is less than perfect in texture and thickness compared with skin in the periauricular region. We re-expanded the transferred prefabricated island flap, successfully obtaining a similar thickness and color, which were considered more important in our case. Our experience showed that removing the fibrous capsule around the expander made the re-expanded skin floppy and elastic. Our follow-up showed that there was no significant scar hyperplasia on the re-expanded flap. In our case, flap prefabrication and tissue expansion were performed concurrently to shorten the total procedure time, thin the flap, and enrich the blood supply. However, too short a time interval between filling each expander is not recommended due to the possibility of vascular collapse and compression, which may hinder flap revascularization.

Elaborate framework fabrication was another important foundation for successful burned ear reconstruction. The advantages of autologous costal cartilage were self-evident. It could be harvested minimally from the patient. In our case, the main shape and the axial position of the ear framework could be created by the remnant ear cartilage. The "stack-up" technique provided an exquisite multiple-layer framework, allowing for relatively clear projection of the ear and the concha depth (5). Meanwhile, adequate re-expanded flap coverage allowed the anterior and posterior appearance to be established simultaneously, which helped achieve the uniformity of color and texture of the anterior and posterior parts of the reconstructed ear.

Imperfect thickness and slight hyperpigmentation of the re-expanded flap were regrettable due to insufficient expansion time. Although no occurrence or worsening of the specific signs of flap venous congestion was observed in our case, we still recommend accurate diagnosis and adequate dissection of blood vessels in the recipient area, and gentle manipulation when transferring any vascular pedicles or grafts. The disadvantages of our method also include wound pain related to the lengthy reconstruction time, an increased scar area due to multiple flap transfers, and a lack of intraoperative nerve preservation. However, these shortcomings leave us room for improvement.

Concerning the diversity of the area and depth of burn damage, there is no perfect solution for every patient. However, the combination of flap re-expansion, flap prefabrication, and microsurgical techniques may help us to salvage an otherwise dire situation, and to engender a new gold standard of flap construction. This starting point opens up the avenue to reconstruct the small organs on the body surface using the distal complete framework prefabrication in the future.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-1427/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1427/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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