Anatomical and Technical Aspects of Harvesting the Auricle as a Neurovascular Facial Subunit Transplant in Humans

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Background: Auricular transplants from cadaveric sources may be a viable alternative for difficult auricular reconstruction once immunologic problems are largely solved. The authors report on the neurovascular anatomy and technical details of harvesting the auricle as a single facial subunit.
Methods: Nine auricles were studied in latex-injected ($n = 5$) and fresh cadaveric heads ($n = 4$). In latex-injected heads, dissection in the neck and auricular region and microdissection within the substance of the auricle were performed under loupe magnification. The arterial network was exposed and measurements were taken, including the size, length, and diameters of vessels. The number of branches supplying the entire auricle was noted. Methylene blue dye was injected into fresh cadaveric heads through the posterior auricular ($n = 2$) or superficial temporal arteries ($n = 2$) to assess the territory supplied by each arterial system.
Results: Dye injected into the superficial temporal artery stained the upper two-thirds of the anterior and posterior auricular regions; all anterior cartilaginous eminences, except the antitragus, were homogenously stained. Dye injected into the posterior auricular artery stained the lobule, posterior auricular skin, and the depressed anterior auricular regions, including the cavum conchae, scapha, and triangular fossa. Neither the superficial temporal nor the posterior auricular arteries could adequately nourish the entire auricle as single pedicles. The auriculotemporal and great auricular nerves can be included in the transplant for sensation. The temporoparietal scalp can also be reliably included to meet reconstructive requirements.
Conclusions: The auricle can be reliably elevated as a transplant when nourished by both the superficial temporal and posterior auricular arterial systems. The external jugular vein and external carotid artery can therefore be used as the vascular pedicle for auricular transplantation. (*Plast. Reconstr. Surg.* 120: 1540, 2007.)

The auricle is a specialized and complex facial subunit that is difficult to reconstruct when severely deformed, such as by burn, trauma, or tumor ablation, or for congenital reasons. It is composed of a thin plate of yellow fibrocartilage, with characteristic eminences and depressions, which is lined with thin skin and connected to its surrounding parts and external auditory meatus by ligaments, muscles, and fibrous tissues. The most common current reconstructive alternative is the autogenous rib cartilaginous framework.[1] If the quality of skin in the periauricular area is poor, however, or if there is a shortage of autogenous cartilage because of previously failed operations, the reconstruction becomes even more difficult.[1–3] Auricular transplantation from cadaveric sources might be a valuable alternative for such patients. Recently, following the first successful composite facial/scalp[4] and auricle[5] allotransplantations in animal models, the first successful clinical case of

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human auricular allotransplantation along with the cephalocervical flap was reported by Jiang et al.[6] Successful composite tissue allotransplantation requires competent microsurgical free tissue transfer techniques, thorough knowledge of the relevant anatomy, and stringent control of immunologic allograft rejection.[7–9]

The anatomy of the auricle as related to various flap elevations has been extensively studied.[10–12] This anatomical study is the first to explore the feasibility of harvesting the auricle alone as a single neurovascular facial subunit flap.

MATERIALS AND METHODS

A total of nine auricles, five latex-injected and four fresh cadaveric, were studied. For the latex injection study, the internal carotid artery was injected with 10% buffered formalin (to induce latex coagulation), followed by pigmented latex. The heads were then kept at 4°C in refrigerators for at least 24 hours. In latex-injected heads, dissection in the neck and auricular region and microdissection within the substance of the auricle were performed under loupe magnification. The arterial network supplying the entire auricle was exposed. Measurements were taken, including the size, length, and diameters of vessels (with a Vernier caliper). The number of vascular branches was also recorded. Injection studies with methylene blue were performed in fresh cadaveric heads using either the posterior auricular artery ($n = 2$) or the superficial temporal artery ($n = 2$) to assess the vascular territory supplied by each arterial system in isolation.

Relevant Anatomy

The main arteries supplying the auricle are the superficial temporal artery and the posterior auricular artery, which arise from the external carotid artery. Another branch from the occipital artery provides a minor contribution to the auricular circulation.[10–13] Draining veins accompany the corresponding arteries. Sensory innervation is provided by the great auricular and lesser occipital nerves from the cervical plexus, the auriculotemporal branch of the mandibular nerve, and the auricular branch of the vagus nerve.[13]

Technique of Harvesting an Auricular Transplant

A circular incision was placed to include a 1-cm skin island surrounding the auricle. Anterosuperiorly, the dissection continued subcutaneously, immediately superficial to the galea. The parietal branch of the superficial temporal artery, the superficial temporal vein, and the auriculotemporal nerve were identified and included in the transplant. These structures were ligated cephalad unless a portion of scalp was required. Dissection then continued anteriorly in a caudal direction; the frontal, middle temporal, zygomaticoorbital, and transverse facial branches of the superficial temporal vessels were divided. Care was taken to include the neurovascular pedicle and small anterior auricular branches along the anterior portion of the auricle emanating from the superficial temporal artery and superficial temporal vein. Immediately behind the neck of the mandible, at the level of the tragus, the superficial temporal artery and superficial temporal vein penetrated deep into the substance of the parotid gland. Because the inclusion of the parotid gland may not be desirable in auricular transplantation, the branches of the superficial temporal artery and superficial temporal vein to the parotid gland and masseter muscle were divided and the gland was dissected away. Individual dissections of the superficial temporal artery and superficial temporal vein continued in different tissue planes. The superficial temporal vein united with the internal maxillary vein to drain into the posterior facial vein within the parotid gland. The posterior facial vein ran inferiorly and divided into its anterior and posterior branches between the ramus of the mandible and the sternocleidomastoid muscle. The anterior branch was ligated and the posterior branch preserved as it was joined by the posterior auricular vein to become the external jugular vein. The external jugular vein was therefore the principal draining vessel of the auricular transplant. The posterior auricular vein was dissected toward the auricle. The posterior auricular branch of the great auricular nerve was found accompanying the posterior auricular vein immediately beneath the auricular lobule. This nerve was divided and included in the transplant.

For the arterial pedicle, the superficial temporal artery was dissected toward the auricle. The internal maxillary artery, a terminal branch of the external carotid artery, was identified and divided at the level of the mandibular neck. The posterior auricular artery was identified, beneath the digastric and stylohyoid muscles and opposite the apex of the styloid process, originating from the external carotid artery and dividing into auricular and occipital branches between the auricular cartilage and the mastoid process. The occipital branch was ligated and the auricular branch included in the

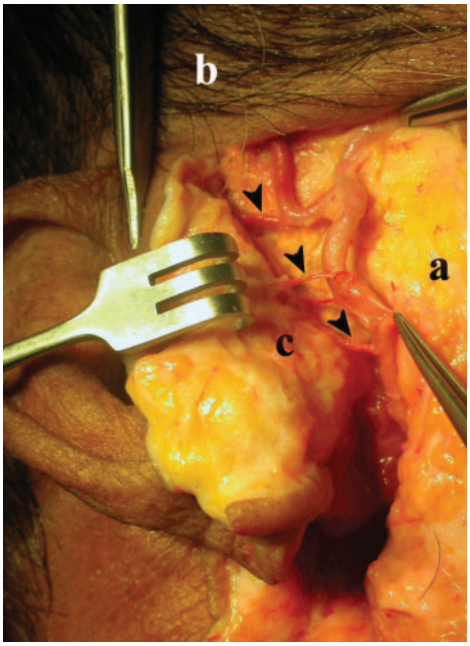

Fig. 1. The superficial temporal artery and its auricular branches (*arrowheads*). The largest branch, which crosses the helix, is uniformly located superior to the tragus (*upper arrowhead*). Note that the superficial temporal artery does not give direct branches to the lobule. *a*, Facial region; *b*, temporal region; *c*, tragal region.

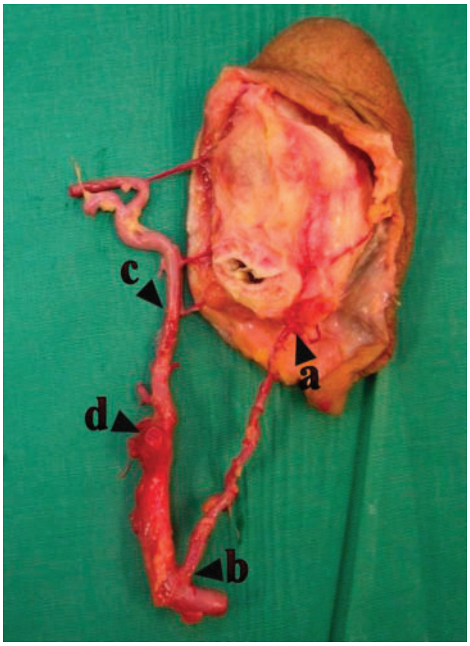

Fig. 2. The vascular pedicle of the auricular flap formed from the superficial temporal artery and the posterior auricular artery. *a* to *b*, Posterior auricular artery length; *c* to *d*, superficial temporal artery length, from the exit of the internal maxillary artery to the first auricular branch.

transplant. The auricular branch of the posterior auricular artery arose between the external auditory meatus and the auriculocephalic sulcus, giving off several branches to the lobule and posterior auricle. Attention was paid to protect these branches, and the cartilaginous base of the auditory meatus was divided. The auricle was then separated from its surrounding soft tissues, but its two pedicles, the superficial temporal and posterior auricular vessels, were not yet divided. Dissection of the external carotid artery and external jugular vein were continued until the required length of pedicle was harvested.

RESULTS

Latex Injection Studies

Superficial Temporal Artery

The superficial temporal artery provided a mean of three (range, two to four) branches to the auricle along its anterior margin; the largest was uniformly located superior to the tragus (Fig. 1) and crossed the ascending helix to join the network in the triangular fossa and scapha. The blood supply to the triangular fossa and scapha was therefore mainly from the superficial temporal artery network. The first anterior auricular branch of the superficial temporal artery arose immediately below the level of the tragus (Fig. 1). At this point, the artery became superficial as it exited from the substance of the parotid gland. The superficial temporal artery did not provide direct branches to the auricular lobule (Fig. 1). A lower branch supplying the lobule could not be identified in any of the specimens (Fig. 1).

The mean length of the superficial temporal artery, from its first auricular branch to the exit point of the internal maxillary artery, was 3.0 cm (range, 2.5 to 3.5 cm) (Fig. 2), and its mean external diameter was 3.25 mm (range, 3.0 to 4.0 mm). The external carotid artery, from the exit point of the internal maxillary artery to the carotid bifurcation, was 5.75 cm long (range, 5.0 to 6.0 cm), and its mean diameter was 6.0 mm (range, 5.0 to 6.0 mm).

Posterior Auricular Artery

The auricular branch of the posterior auricular artery ascended behind the ear in the auriculocephalic sulcus and gave off two to three sizable branches to the lower, middle, and upper posterior auricle (Fig. 3). The auricular lobule was predominantly supplied by a network of branches from the posterior auricular artery (Fig. 3). Some branches curved around the cartilaginous margin, whereas others perforated it to supply the anterior

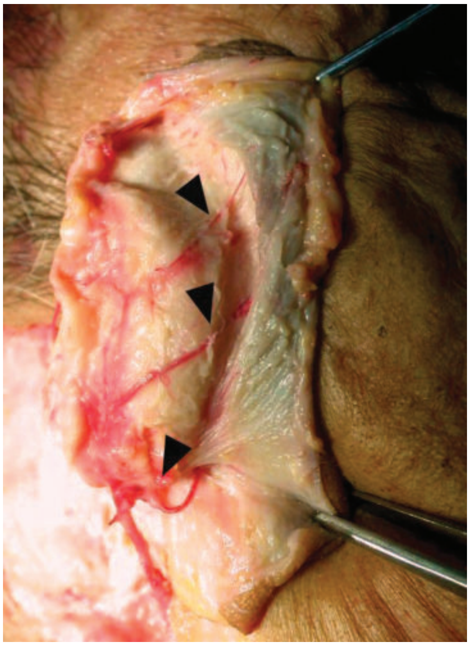

Fig. 3. The posterior auricular artery and its branches to the lower, middle, and upper posterior auricle (*arrowheads*). Note that the lobule of the auricle is predominantly supplied by a network formed by branches from the posterior auricular artery.

surface of the auricle. The cymba, cavum conchae, scapha, and helix were supplied by branches from the posterior auricular artery. It formed anastomoses with the parietal and anterior auricular branches of the superficial temporal artery. The mean length of the posterior auricular artery, from its first branch supplying the inferior pole of the auricle to its exit from the external carotid artery, was 3.5 cm (range, 2.5 to 4.5 cm), and its mean external diameter was 2.25 mm (range, 2.0 to 3.0 mm) (Fig. 2).

Dye Injection Studies

Neither the superficial temporal artery nor the posterior auricular artery alone provided homogenous dye staining to the entire auricle (Fig. 4). Injection into the posterior auricular artery stained the posterior auricular skin and anterior auricular depressions, including the cavum conchae, scapha, and triangular fossa (Fig. 4, *left* and *center*); approximately 8 × 5 cm of the adjacent temporal scalp was also stained. Injection of this artery failed to stain the tragus (Fig. 4, *left* and *center*).

Injection of the superficial temporal artery stained the upper two-thirds of the posterior and anterior auricle (Fig. 4, *center* and *right*), including all the anterior cartilaginous eminences except the antitragus. The temporoparietal scalp region was also stained. The cavum conchae and the lobule were not stained following superficial temporal artery dye injection (Fig. 4, *center* and *right*).

DISCUSSION

Facial subunits, which include the auricles, forehead, eyelids, nose, cheek, upper and lower

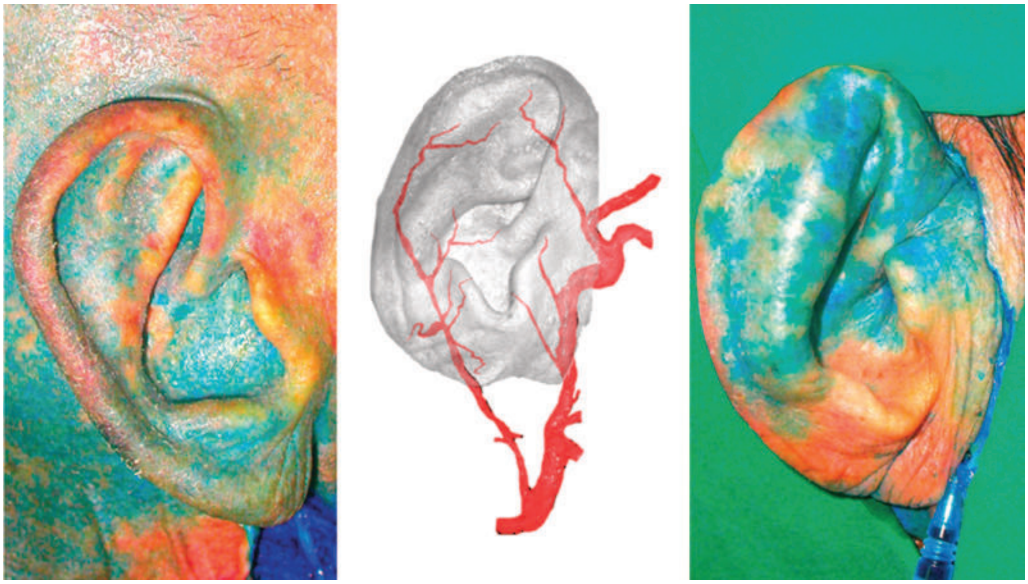

Fig. 4. Staining pattern of the auricle following methylene blue dye injection. (*Left*) Staining after injection into the posterior auricular artery. (*Center*) Schematic drawing of branches arising from the superficial temporal artery and the posterior auricular artery that cause characteristic staining patterns. (*Right*) Staining after injection into the superficial temporal artery.

lips, chin, submentum, and neck, define adjacent topographic areas with characteristic skin qualities, outlines, and shapes.[14,15] The subunit approach to facial reconstruction is a useful principle to follow for concealing scars, maintaining skin qualities, and restoring morphologic and landmark symmetry.[15] Although microvascular surgery allows the replacement of large defects, the reconstruction of facial units that have specialized functions and three-dimensional configurations, composed of support, lining, and cover, remains a great challenge.

The face is an integral part of an individual's identity and psychological outlook. Regarding the effects of facial disfigurement on individuals, MacGregor remarked that an "*unsightly scar* or *conspicuous defect* may be as severe a social and economic handicap as complete physical incapacity."[16] The effects of facial disfigurement should not be underestimated.

The ability to reconstruct facial subunits with specialized form and function from cadaveric sources could revolutionize the field of reconstructive surgery. This option presents an immense availability of neurovascular composite tissue blocks that could closely match the features, such as dimensions, texture, hairiness, and thickness, of any given facial defect. A near-normal facial appearance could be achieved in a single stage, with subsequent reestablishment of motor and/or sensory functions. Importantly, donor-site morbidity would be nonexistent. The requirement for nonspecific, toxic, lifelong immunosuppression to maintain a non–life-saving allotransplant, however, remains a major concern, and debates regarding the clinical application of such allotransplants continue. Only if adequate immunosuppression or donor-specific immunotolerance can be achieved with more acceptable risk profiles can composite tissue allotransplantations, such as that of the auricular subunit as described in this article, become a widespread clinical practice. In addition to the immunologic concerns, the technical aspects of a transplant should always be elucidated before clinical attempts. In this study, we explored the feasibility of elevating the auricle as a neurovascular facial subunit transplant (Fig. 5) and established the technical details.

The arterial anatomy of the auricle has previously been studied as related to various flap harvests from different parts of the auricle. It was believed that the anterior auricular surface was supplied by the superficial temporal artery and the posterior surface by the posterior auricular artery.[10] This study found that the superficial temporal artery provides a greater contribution to the anterior and posterior aspects of the upper two-thirds of the auricle and that the posterior auricular artery provides a greater contribution to the posterior skin and lower third of the auricle. We also noted an absence of blood supply from the superficial temporal artery to the auricular lobule, which contradicts the findings of earlier studies.[10,13] Likewise, Pinar et al. recently showed that a lower superficial temporal artery branch to the lobule was absent in 10 of 15 specimens.[12]

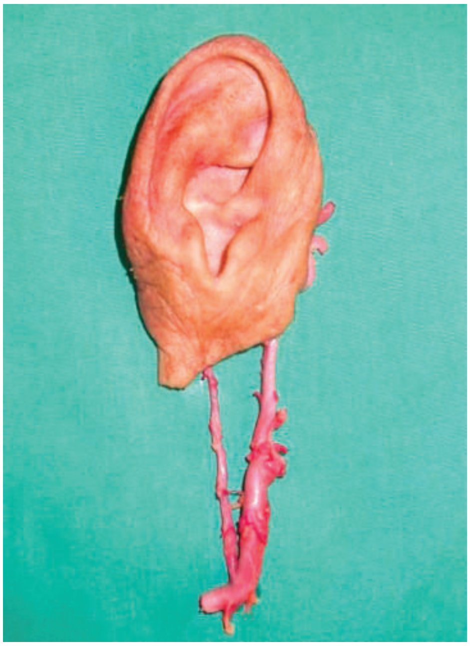

Fig. 5. Anterior view of the auricular flap based on the posterior auricular artery and superficial temporal artery.

Because anastomoses exist between the two arterial systems, the auricle could potentially be well vascularized by one arterial system if the other was ligated intraoperatively.[17,18] If the entire auricle is to be harvested as a flap, however, these interconnections are divided or damaged, necessitating the inclusion of both arteries to provide a reliable circulation. Our dye injection studies revealed that neither the superficial temporal artery nor the posterior auricular artery alone was adequate to homogenously stain the entire auricle, making inclusion of the external carotid artery necessary.

CONCLUSIONS

The allotransplantation of facial subunits at the present time appears only applicable to those patients who are already on potent immunosuppression for other reasons, such as to maintain a previous vital organ allotransplant. These procedures represent a new frontier in reconstructive surgery that could become a clinically widespread practice if safe transplantation tolerance strategies or less toxic immunosuppressants are developed.

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DISCLOSURE

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this article.

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