Laryngoscope Investigative Otolaryngology

The Surgical Anatomy of Soft Tissue Layers in the Mastoid Region

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Background: An understanding of the soft tissue layers in the mastoid region has become important for otologic reconstructive surgery. The objective of this study was to clarify the surgical anatomy of the soft tissue layers in the mastoid region and reveal its clinical significance.

Methods: Cadaveric study.

Results: Our dissections showed the soft tissue layers consisting of skin, subcutaneous layer, superficial and deep mastoid fasciae, and periosteum. The superficial mastoid fascia was continuous with the temporoparietal fascia cranially and the superficial cervical fascia caudally. The deep mastoid fascia could be clearly separated from the superficial mastoid fascia and has continuity to the loose alveolar layer in the temporoparietal region. However, it caudally fused with the fascia and ligament of the sternocleidomastoid.

Conclusions: A comprehensive understanding of soft tissue layers would improve otologic reconstructive surgery.

Key Words: Temporal bone surgery, surgical anatomy, otology, cadaveric study, fascia.

Level of Evidence: NA

INTRODUCTION

The fascial layers of the postauricular lesion (mastoid region) have been studied extensively.[1–8] Otorhinolaryngologists often use the postauricular soft tissue for temporal bone surgery, the most popular method being the palva flap, a musculoperiosteal flap based on the concha of the auricle.[9–11] This technique is frequently used for otological surgery. Development of surgical skills and the understanding of soft tissue layers has provided a variety of local soft tissue flaps to promote wound healing and reduce surgical defects. However, the soft tissue layers in the mastoid region and its continuity to the adjacent area remain unclear. A comprehensive understanding of this region is required to improve otologic reconstructive surgery.

In this study, we carried out a detailed investigation of the anatomical structure of the soft tissue layers in the mastoid region. We then described a case illustrative of the effectiveness of the mastoid fascia for otologic surgery, which demonstrates that flaps of the mastoid fasciae can be used to promote epithelialization after canal wall down mastoidectomy.

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Editor's Note: This Manuscript was accepted for publication 19 April, 2019.

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Funding: Part of this work was supported by the University of Florida Foundation and JSPS KAKENHI, Grant number JP 18K16895.

Conflict of Interest: The authors report no personal financial support for this article and no conflicts of interest related to any of the materials or devices described in this article.

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DOI: 10.1002/lio2.271

METHODS

In this study, all cadaveric dissections were performed by first author in the late Dr. Albert L. Rhoton Jr.'s laboratory at the University of Florida. Use of these pictures was permitted by The Rhoton Collection. This study was approved by Kyushu University Institutional Review Board for Clinical Research (#28-346).

Three adult cadaveric heads were used to examine the soft tissue layers in the mastoid region. The arteries and veins were perfused with red- or blue-colored silicone rubber, Thinner 200, and RTV catalyst (all Dow Corning, Midland, Michigan), and dissected under ×3 to ×40 magnification. Bone dissection was performed using a Midas Rex drill (Medtronic, Fort Worth, Texas). The dissections were performed in a step-wise manner from the lateral direction.

In an illustrative case, we performed canal wall down mastoidectomy using a free fascial graft on the right side and double pedicled fascial flaps on the left side of the same patient. The period required for the completion of epithelialization was compared between sides to evaluate the effectiveness of our procedure. We defined complete epithelialization as the point at which the mastoid cavity had completely dried up.

RESULTS

Figure 1 illustrates the anatomy in the mastoid region. Vascular supply in the mastoid region is derived from the occipital, postauricular, and superficial temporal arteries, which arise from the external carotid artery. The main trunks of these three arteries in the mastoid region course between the superficial and deep mastoid fasciae.

The posterior auricular artery is given off above the digastric muscle. It ascends under the parotid gland and passes around the mastoid process along the styloid process giving off its branches. It mainly supplies blood to the lobule of the parotid gland, the posterior surface of the auricle, and the postauricular skin. The occipital artery is given off near the

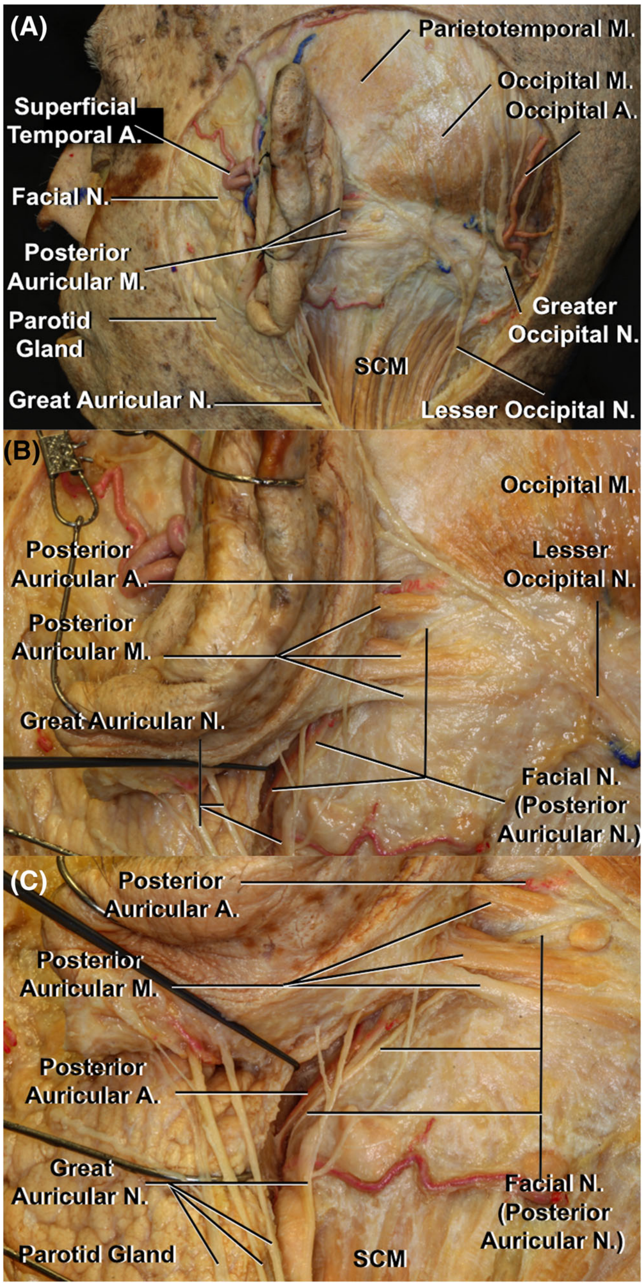

Fig. 1. Gross anatomy of the mastoid region. (A) View after the removal of the dermis and subcutaneous tissue around the auricle. (B) Enlarged view of the mastoid region of (A). (C) The course of the posterior auricular artery in the mastoid region. A. = artery; M. = muscle; N. = nerve; SCM = sternocleidomastoid.

lower margin of the posterior belly of the digastric. It courses posteriorly and ends in the posterior part of the scalp. Its auricular branch supplies the medial surface of the concha and frequently gives off a branch, which enters the skull through the mastoid foramen and supplies the dura mater, diploe, and mastoid cells; this latter branch sometimes arises from the main trunk of the occipital artery. The superficial temporal artery begins in the parotid gland behind the mandibles and crosses over the posterior root of the zygomatic process of the temporal bone. It is divided into the anterior frontal and posterior parietal branches above the zygomatic process. The parietal branch curves upward and backward on the side of the head, lying superficial to the superficial layer of the deep temporal fascia. Its auricular branch anastomoses with the posterior auricular and occipital arteries.

Three main nerves are present in the mastoid region: the great auricular and the lesser and greater occipital nerves. The great auricular nerve originates from the cervical plexus at the levels of C2 and C3, supplying sensation to the skin overlying the lower aspect of the pinna and angle of the mandible. The lesser occipital nerve provides sensation to the occipital scalp. It arises from the lateral branch of the dorsal ramus of the C2 and/or C3 spinal nerves and courses along the posterior border of the sternocleidomastoid muscle. It perforates the deep cervical fascia and continues upward along the side of the head behind the auricle, innervating the skin of the mastoid region and communicating with the great auricular nerve, the greater occipital nerve, and the posterior auricular branch of the facial nerve. The greater occipital nerve arises from the medial branch of the dorsal ramus of the C2 spinal nerve and innervates the posterior region of the scalp.

The muscular structure related to the mastoid fascia is the posterior auricular muscle. It usually contains two or three fascicles and is supported by the posterior auricular ligament. These arise from the mastoid periosteum and are attached to the eminence of the cymbal concha and the ponticulus, passing through the deep and superficial mastoid fasciae.

To reveal the soft tissue layers in the mastoid region, we first performed a C-shape incision behind the auricle from the postauricular region to the upper neck. The incision was carried through the skin and into the subcutaneous tissue (Fig. 2A). Caudally, the subcutaneous tissue of the mastoid region is continuous with the superficial cervical fascia, below which the great auricular nerve is located. The superficial layer of the deep cervical fascia—covering the sternocleidomastoid—is extremely thin and was very difficult to elevate as a distinct layer in our dissection (Fig. 2B, 2C).

After the subcutaneous layer was elevated together with the superficial cervical fascia of the neck, we found the fibrous fascial layer of mastoid region spreading. The cranial continuation of this fascial layer is the temporoparietal fascia, which represents the superficial mastoid fascia and covers or includes the posterior auricular muscle. This layer is firmly attached to the superior nuchal line, and a part of it blends into the superficial cervical fascia.

Further beneath the superficial mastoid fascia is an areolar fascial layer termed the deep mastoid fascia. This layer continues toward the cranial in a loose areolar layer, which sometimes is referred to as the innominate fascia and the subgaleal fascia in the temporoparietal region. It separates the temporoparietal fascia from the superficial layer of the deep temporal fascia, which directly covers the temporal muscle. The deep mastoid fascia is attached to the periosteum of the superior nuchal line. The loose areolar layer in the temporoparietal region caudally unites the deep mastoid fascia (Fig. 2D). The deep mastoid fascia blends into the fascia and ligament of the sternocleidomastoid muscle anterior to the attachment of the posterior auricular muscle to the periosteum. Due to the attachment of this muscle, the deep mastoid fascia attaches to the superior nuchal line without continuity to any cervical layers inferiorly.

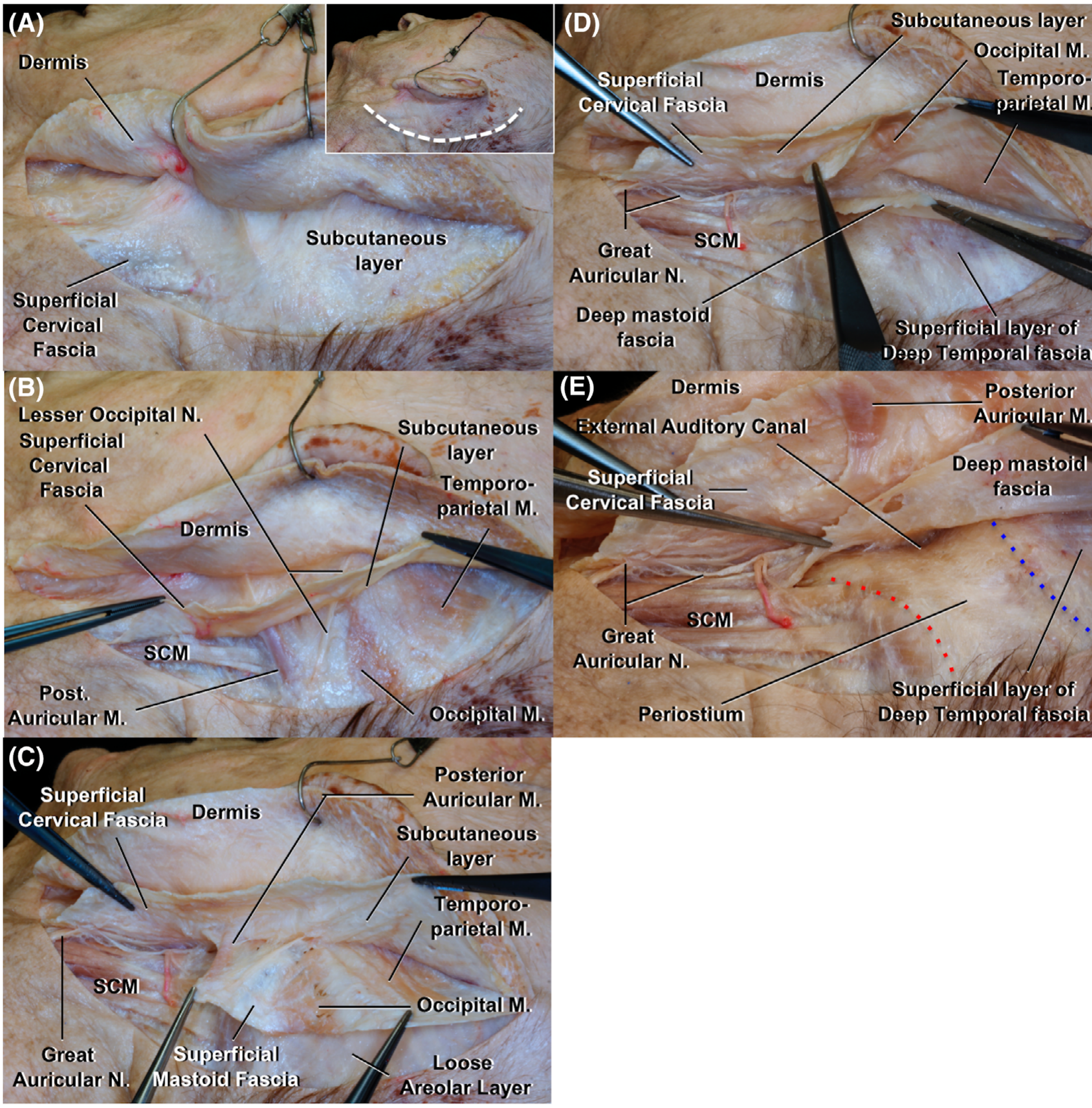

Fig. 2. The cadaveric dissection shows each soft tissue layer in the mastoid region. (A) View after elevation of the dermis. (B) View after elevation of the subcutaneous tissue. (C) The elevated superficial mastoid fascia is continuous with the superficial cervical fascia in the portion anterior to the attachment of the posterior auricular muscle to the periosteum. (D) The elevated deep mastoid fascia is continuous with the fascia and ligament of the sternocleidomastoid. (E) The elevation of the deep mastoid fascia exposes the periosteum of the mastoid region between the temporal line (blue dotted line) and superior nuchal line (red dotted line). M. = muscle; N. = nerve; SCM = sternocleidomastoid.

There are five isolated fascial layers on the upper portion of the postauricular surface, between the dermis and the temporal bone. These are the subcutaneous, superficial temporal fascia, loose areolar tissue, superficial layer of deep temporal fascia, and pericranium. In contrast, there were four distinctive fascial layers on the caudal portion to the superior temporal line: the subcutaneous, superficial mastoid fascia, deep mastoid fascia, and periosteum (Fig. 2). In our dissection, there was no variation in the fascial layers among the three cadaveric heads (ie, six sides).

ILLUSTRATIVE CASE

A 71-year-old female underwent canal wall down mastoidectomy for the bilateral treatment of cholesteatoma, consisting of sequential surgeries. On the right side, she underwent conventional surgery using a free fascial graft to cover the exposed mastoid bone. Fascial grafts were harvested from the loose areolar layer and superficial layer of the deep temporal fascia. On the left side, double pedicled fascial flaps were used to promote epithelialization of the mastoid cavity (Fig. 3).

First, the superficial mastoid fascial flap was raised, leaving behind the deep mastoid fascia. This fascial flap had a pedicle inferiorly and included the posterior auricular artery. The deep mastoid fascial flap was then raised with the pedicle superiorly, leaving the periosteal layer. These two fasciae were used to cover the exposed mastoid bone (Fig. 3). A small part of the bone in the mastoid cavity at the lateral side remained exposed and was covered by the periosteum of the mastoid. The mastoid cavity was packed with strip gauze and this packing was replaced

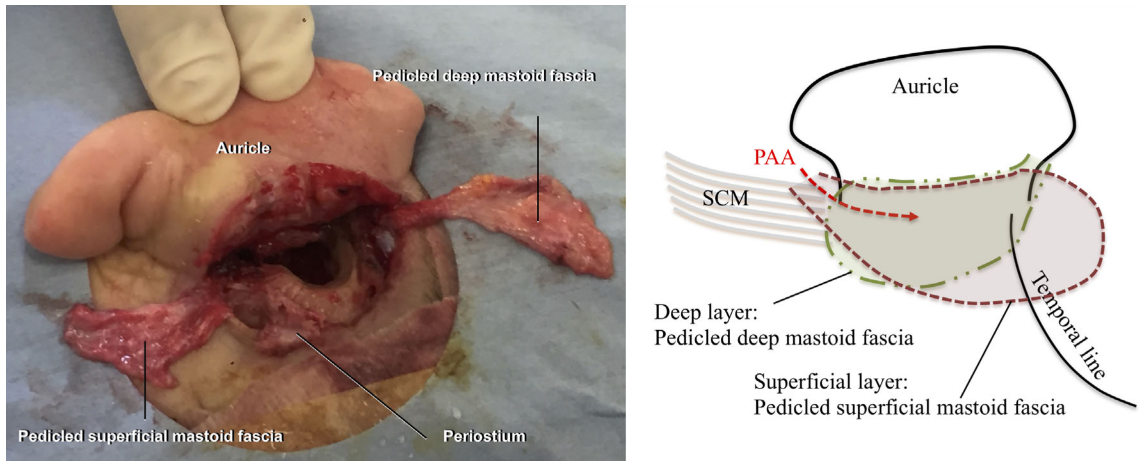

Fig. 3. The double pedicled flaps, arising from the mastoid fasciae, were used for otologic reconstructive surgery after canal wall down mastoidectomy. PAA = posterior auricular artery; SCM = sternocleidomastoid muscle.

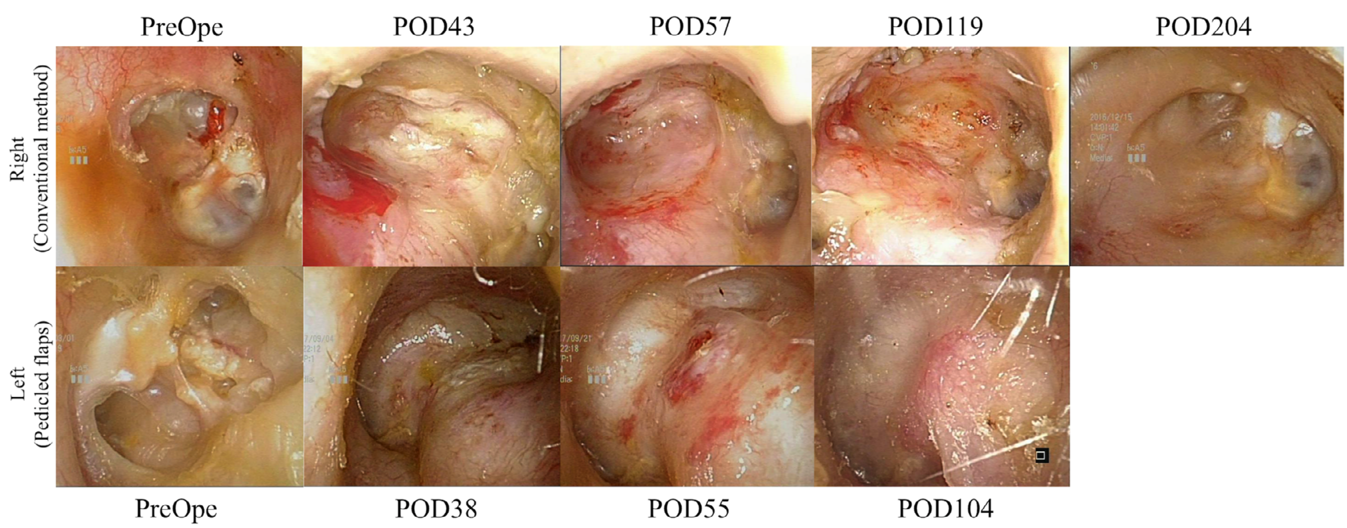

Fig. 4. Comparison of the postoperative course of two different procedures of otologic reconstructive surgery after canal wall down mastoidectomy on the same patients.

every 2–4 weeks postoperatively. When the mastoid cavity has completely dried up, the packing was removed from the ear.

After 4 months, it was found that the mastoid cavity on the right side was completely epithelialized. In contrast, the cavity on the left side spent only about 1 month to almost finish to be epithelialized without the necrosis of the fascial layer; no cavity problem was found here 14 months after surgery on the left side (Fig. 4).

DISCUSSION

The anatomy of the mastoid-postauricular region is complex. Although several studies have investigated the soft tissue layers of the mastoid region, the surgical anatomy remains unclear. As most previous studies were based on a few cadaveric dissections or surgeon experience, it is understandable that the findings and descriptions of the layers in these studies were inconsistent.[1–8] A comprehensive understanding of soft tissue layers would improve the otologic reconstructive surgery. Furthermore, the cooperation of neurosurgeons, head and neck surgeons, and plastic surgeons has become common practice on lateral skull base surgery in recent times, and therefore, a shared understanding of the mastoid fascial layers as well as fascial layers of the temporoparietal region can help to facilitate a multilateral exchange of experience and expertise.

The anatomy of the temporoparietal region has been studied in detail. Davidge et al reviewed the literature and proposed a standardized nomenclature for the anatomic structures of the temporoparietal region.[12] Several previous studies have reported a detailed anatomical description of the soft tissue layers in the mastoid region.[1,3,5–8] Although the superficial and deep mastoid fasciae were described in these studies, the continuity to the cervical portion has remained unclear. Considering the present findings and those previously reported, the layers in the mastoid region can be separated into five layers from superficial to deep: 1) skin; 2) subcutaneous; 3) superficial mastoid fascia (the same plane as the temporoparietal layer); 4) deep mastoid fascia (the same as the perifascial areolar tissue or loose areolar layer); and 5) periosteum. The superficial mastoid fascia exhibits continuity both cranially and caudally. In contrast, the deep mastoid fascia exhibits wide continuity cranially, and caudally blends into the fascia and ligament of the sternocleidomastoid or ends at the attachment site of the posterior auricular muscle to the periosteum. The number of cadaveric heads in our study was limited. Therefore, further study is warranted to assess the variation between these fascial layers.

In the otologic region, the vein,[13] perichondrium,[14] cartilage,[15] temporalis fascia, and perifascial areolar fascia[16,17] have been used for grafting in myringoplasty. Heermann was the first to report the use of the temporalis fascia for this purpose.[18] Currently, the autologous temporalis fascia is the most commonly used region for graft because of its convenient location.

In 1997, Parmekar et al reported that a vascularized axial pattern temporoparietal fascia flap is a useful technique for mastoid obliteration when using the canal wall down technique.[19] Similarly, Ramsey et al reported that an inferiorly pedicled, postauricular periosteal-pericranial flap was effective in providing a dry and complication-free mastoid cavity after mastoid cavity obliteration in canal wall down tympanomastoidectomy.[20] Lee et al presented a technique that used an inferiorly based, postauricular, pedicled flap of the deep temporalis fascia and mastoid periosteum for postauricular canal wall down mastoidectomy and tympanoplasty.[21] Large areas of nonviable free fascia or tissue placed in direct contact may result in necrosis. Covering the bone surface with the pedicled and vascularized fascia flap can facilitate the re-epithelization process and assist drying-out of the cavity. Parmekar et al mentioned that a dry mastoid cavity can be completed as early as 3–6 months after canal wall down procedures.[19]

Follow-up 14 months after surgery showed that our independent two-flap technique, applied to canal wall down tympanomastoidectomy for the treatment of cholesteatoma, provided a dry, low-maintenance mastoid cavity. The period until the complete epithelialization of the cavity after surgery was drastically shortened using this technique compared with that observed using the conventional method without a pedicled fascial flap. This technique can thus be a reliable and effective option, providing a dry and complication-free mastoid cavity. Although we have here reported a case treated with this technique, the number of currently available cases is limited. Therefore, further studies are required to determine the reliability and effectiveness of this technique.

A major advantage of our two-flap technique is the absence of a necessity for extension of the skin incision upward beyond the temporal line. The commonly used skin incision for tympanoplasty is sufficiently large to harvest the two flaps, which almost fully cover the bone surface of the mastoid cavity. In cases in which the two flaps are not sufficiently large to cover the bone surface, the periosteum can also be used. An inferiorly pedicled, axial pattern superficial mastoid fascia is supplied by the posterior auricular artery. Superiorly pedicled, deep mastoid fascia is not axial pattern flap. However, the advantages of the latter are the following: 1) this fascia is readily revascularized (abundance of tiny vascular networks)[22,23]; 2) it can be extended upward beyond the superior temporal line without damage to the superficial temporal fascia of the temporal muscle, because it is continuous with the areolar layer of the temporoparietal region; and 3) it is a flexible and stretchable tissue, thus easily adjustable depending on the area of the bony exposure.[22,24,25] Alternatively, one can harvest the inferiorly pedicled, deep mastoid fascia and superiorly pedicled, superficial mastoid fascia supplied by the auricular branch of the superficial temporal artery. The deep mastoid fascia cannot be extended inferiorly because it blends into the fascia of the sternocleidomastoid, as shown by our dissections. Both fasciae can be extended upward if the additional skin incision is made upward.

The areolar layer consists of connective tissues, which include collagen elastic tissue and reticular fibers. Furthermore, it contains a rich vascular plexus. Carstens et al reported the properties of the loose areolar tissue in the cranial region, which include elastic strength, vascularity, minimal donor site morbidity, and multiple potential pedicles.[26] The loose areolar layer is able to survive on an area with scarce circulation while providing new blood supply to the defect.[22,24] Another advantage of this layer is that it is a flexible tissue. It thus constitutes an appropriate option for the coverage of the surface of exposed bone in the mastoid cavity. In the present case, the pedicled deep mastoid fascia was not actually richly supplied with blood after its elevation; however, no necrosis of this fascia was detected postoperatively, and it promoted adequate and rapid epithelialization. The advantages of the pedicled areolar flap are that keeping the pedicle promotes revascularization, and that it can be firmly attached in place to cover bony surfaces.

CONCLUSION

We investigated the five soft tissue layers in the mastoid region and the continuity of the mastoid fascia caudally and cranially. Each soft tissue layer exhibits distinct characteristics. A comprehensive understanding of the soft tissue layers would improve otologic reconstructive surgery.

Acknowledgements

The authors would like to express their gratitude to the late Prof. Albert L. Rhoton, Jr., University of Florida, for giving us the opportunity to study the surgical anatomy of the mastoid fascia.

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