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IDEAS AND INNOVATIONS

Reconstructive

Defining the Dimensions of Periosteal Free Tissue Transfer Harvest Sites

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Summary: Information about the use and donor site morbidity of periosteal free flaps in head and neck reconstruction is limited. The aim of this study was to examine potential periosteal free flap donor sites with respect to their dimensions, tissue and pedicle characteristics, and predicted donor site morbidity in a cadaveric model. The following cadaveric periosteal specimens with a vascular pedicle were harvested using standard surgical approaches: skull, chest wall, sternum, scapula, iliac crest, femur, and humerus. Data relating to the periosteum size and quality, vascular pedicle, surgical factors, feasibility of use, and the potential donor-site morbidity were recorded. One female (age: 78 years, height: 152 cm) and one male (age: 65 years, height: 186 cm) cadaver were used for flap harvest. The skull, chest wall, scapula, and femur were suitable in terms of the size of the periosteum harvested. The procedure to remove the periosteum from the scalp, chest wall, and scapula had the least predicted donor-site morbidity. The pedicle length and vessel caliber from the periosteal flaps were most favorable from the skull, scapula, and iliac crest. Considering all factors, the periosteum harvested from the skull and scapula were the most promising. *(Plast Reconstr Surg Glob Open 2021;9:e3846; doi: 10.1097/GOX.0000000000003846; Published online 4 October 2021.)*

INTRODUCTION

Vascularized bone and soft tissue free flaps are widely used for complex facial reconstructions.[1–4] In contrast, periosteal free flaps are much less commonly used and little is known about their potential use and donor site morbidity. The periosteum is unique in that it contains the necessary stem cells and growth factors for osteogenesis[5] and could be applied in a variety of bespoke applications, including osteoradionecrosis,[6] medication-induced osteonecrosis of the jaw,[7] and as a vascularized carrier for bone constructs fabricated ex vivo.[5]

Periosteal flaps with vascular pedicle can be divided into three types according to their blood supply[8]: periosteum supplied (i) by the attached muscle; (ii) by the attached fascia; and (iii) directly from the vascular pedicle.[8] The aim of this study was to scope potential periosteal free flap sites in terms of their dimensions, tissue and pedicle characteristics, and predicted donor site morbidity in a cadaveric model.

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METHODS

This study involved an anatomical dissection of two adult cadavers from the University of Wollongong anatomy laboratory (New South Wales, Australia, December 2020) following human research ethics committee approval (2020/ETH02026). The licensed anatomist provided authorization in accordance with the human research ethics committee–approved body donation program (NSA70/02). Cadavers were embalmed in a formaldehyde solution (Genelyn New Form).

A standard surgical approach was used to excise the periosteum and associated surrounding tissue (pedicle, muscle, fascia) from two cadavers by two reconstructive surgeons. Standard surgical instruments and loupe magnification were used to replicate operating conditions. The vessels harvested as pedicle to the periosteal flaps were lateral skull (superficial temporal artery/vein); lateral chest

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wall (lateral thoracic artery/vein); infraspinous scapula (subscapular artery/vein); iliac crest (deep circumflex artery/vein); lateral femur (descending branch of the circumflex femoral artery/veins); lateral humerus (descending branch of the posterior circumflex humeral artery/vein).

The periosteum thickness, size, and suitability for fenestration were assessed. The pedicle was reviewed to determine its continuity viability (colored food dye injected using a Rycroft needle) and length (cm). The name, length, and diameter of the vessels were recorded after harvest. Scar length and proposed impact to activities of daily living, pain, and muscle strength were inferred. Surgical factors were recorded such as the position of the body and the chimeric options available from each flap.

Descriptive statistics were used to categorize the limitations and dimensions of vascularized periosteal donor sites.

Takeaways

Question: To scope potential periosteal free flap sites in terms of their dimensions, tissue and pedicle characteristics, and predicted donor site morbidity in a cadaveric model.

Findings: Cadaveric periosteal specimens with a vascular pedicle were harvested using standard surgical approaches. The periosteum harvested from the skull and scapula were the most promising.

Meaning: Periosteum represents a resource of osteogenesis potential for use in free tissue transfer and reconstruction. This study outlines the properties of vascularized periosteal donor sites. Periosteum from the skull and scapula were more favorable due to their size and presumed limited donor site morbidity.

RESULTS

The periosteum from the skull, chest wall, sternum, scapula, iliac crest, femur, and humerus were retrieved from two cadavers. Table 1 reports the general anthropometric measures. All other data are reported in Table 2. Figures 1 and 2 are photographic examples of the periosteum of the right skull (female - in situ [Fig. 1] and alone [Fig. 2]). (**See figure 1, Supplemental Digital Content 1**, which displays periosteum from the scapula [female - in situ]. **http://links.lww.com/PRSGO/B791**.) (**See figure 2, Supplemental Digital Content 2**, which displays periosteum from the scapula [female - alone]. **http://links.lww.com/PRSGO/B792**.) (**See Video 1 [online],** which displays periosteum from the right skull [female - vascular.]) (**See Video 2 [online],** which displays the periosteum from the scapula ([female - vascular]).

The largest periosteum harvested was from the scapula (15 cm × 10 cm) and chest wall (16 cm × 12 cm). Most samples had the ability to be fenestrated and ranged in thickness from 1 mm to 7 mm.

The vascular anatomy of the periosteum from the skull, scapula, and iliac crest was clearly demonstrated by the food dye. Most periosteal samples had an artery and a vein, ranging from 2 to 7 cm in length and from 1 to 4 mm in diameter. The longest pedicle harvested was from the chest wall (6 cm) and femur (7 cm). Supine position was possible for all flaps except the scapula. The chest wall, scapula, and femur had chimeric options in contrast to the skull, humerus, sternum, and iliac crest.

Sensory loss was presumed to be the only morbidity for the skull. Obtaining periosteum from the chest wall and scapula may impact serratus anterior and teres/infraspinatus muscles respectively, leading to scapular winging and reduced shoulder function. Obtaining periosteum from the femur is likely to affect knee extension due to extensive dissection of vastus intermedius. Sternal periosteum retrieval would likely affect respiratory mechanics due to rib resection to access the internal mammary vessels. The periosteum from the iliac crest required the external oblique and internal oblique muscles to be split, which may increase the risk of abdominal wall herniation. The periosteum from the humerus requires mobilizing the radial nerve, possibly affecting wrist and finger extensions.

DISCUSSION

This study investigated periosteal free flap sites in terms of their dimensions, tissue and pedicle characteristics, and predicted donor site morbidity in a cadaveric model. The most promising periosteal flaps were from the skull and scapula (infraspinatus) due to the size harvested and the least predicted morbidity.

The periosteal flap can be harvested as a periosteal only flap or as a composite or chimeric flap. The access to the periosteum of interest is technically the same as when harvesting the overlying soft tissue as a free flap. We could secure a viable vascular supply to the periosteum by following the principle of identification of perforators and then following the associated proximal branches.

The benefits of utilizing musculoperiosteal components include those resulting from its geometric and biological attributes. Its geometric and conformational adaptability allows for a multitude of defect demands. The periosteum and muscle provide a highly vascularized surface combined with connective tissue progenitor cells.[8]

Table 1. Anthropometric Measures (cm)

	Height (Supine)	Head Circumference	Waist Circumference	Shoulder Width	Leg Length	Arm Length	Chest Circumference	Hip Circumference	Age (y)
Women	152	56.5	81	32.5	81.5	68	89	87.5	78
Men	186	60.5	95	39.9	91	85	105.5	102	65

Table 2. Periosteum Measures (Grouped Results)

Periosteum	Periosteum Thickness (Mean, mm)	Periosteum Size (Mean, Length × Width, cm)	Scar Length (Mean, cm)	ADL Deficit*	Pain#	Impact on Muscle Strength* (Yes/No)	Vascularized (Yes/No)	Diameter of Pedicle (Range, mm)	Length of Pedicle (Range, cm)
Skull	1.7	11.5 × 10.2	24 long; 15 each end	Sensory loss	None	No	Yes	Arteries = 2 Veins = 1.5–2.5	2–4
Chest wall	2.5	14 × 12	28	Mild	Mild	Yes (serratus anterior)	Possible	Arteries = 2 Veins = 2	4–6
Sternum	3	14 × 2.5	25 long; 6 each end	Major	Major	Yes (intercostal)	NA	Artery = 3 Vein = 3	5
Scapula	1.2	13.7 × 9.3	21	Mild	Mild	Yes (infraspinatus)	Yes	Arteries = 2–4 Veins = 2–4	3–5.5
Iliac crest	4.3	7.7 × 5.3	25	Mild	Moderate	Yes (external and internal oblique)	Yes	Arteries = 2–3 Veins = 1–4	2–5
Femur	4	18 × 4.4	38	Major	Mild	Yes (patella tendon, vastus intermedius)	Yes	Arteries = 2–3 Veins = 2.5	6–7
Humerus	3	8.5 × 2.5	20.5	Mild	Mild	Possible (brachioradialis)	Unable	Unable	4

* Predicted.
ADL, activities of daily living; NA, not applicable.

The applications for the use of free tissue transfer with such a combination might include the reconstruction of both soft tissue and skeletal defects.[9] Additionally, periosteum has been used to generate customized bone constructs with the potential to reconstruct segmental mandibular defects using the in vivo bioreactor concept.[10–12]

There are some limitations to this study. It was not possible to raise periosteal only flaps due to the nature of embalmed tissue. For this reason, we harvested some myofascial components with the periosteal flap to assess the previously stated parameters. Use of fresh cadavers may reveal different periosteal samples, and donor-site morbidity was based on assumptions. Although we only had composite flaps, we successfully demonstrated the flow of dye from the pedicle to the peripheral periosteal extent.

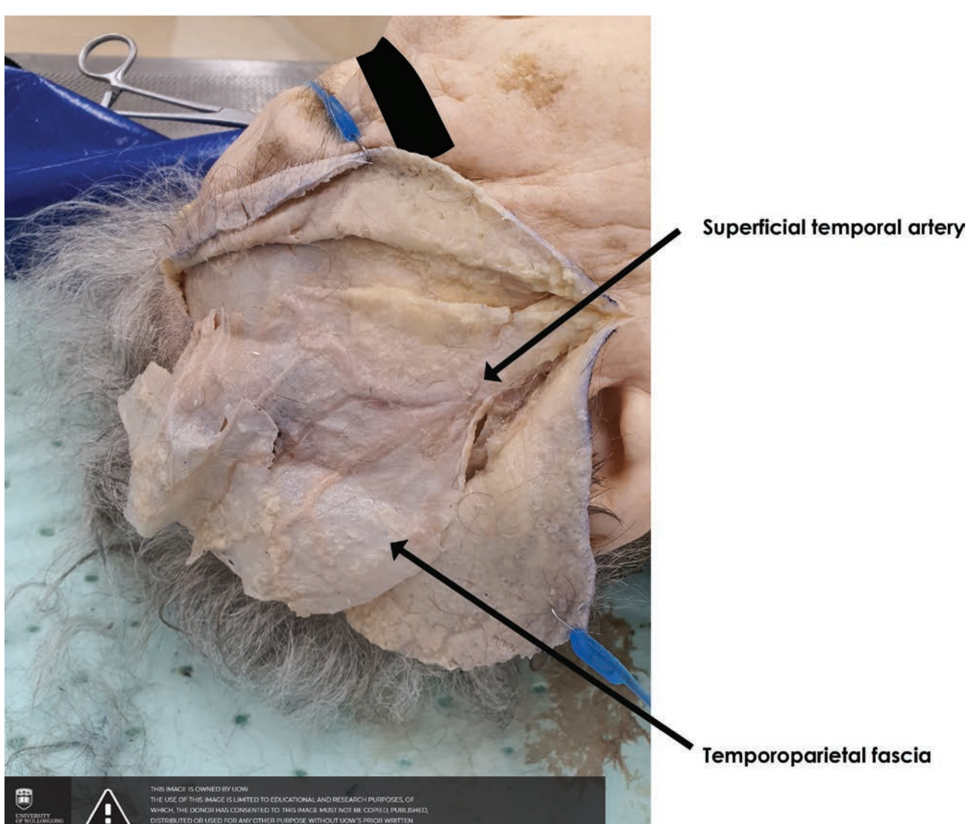

Fig. 1. Periosteum right skull (female)—in situ.

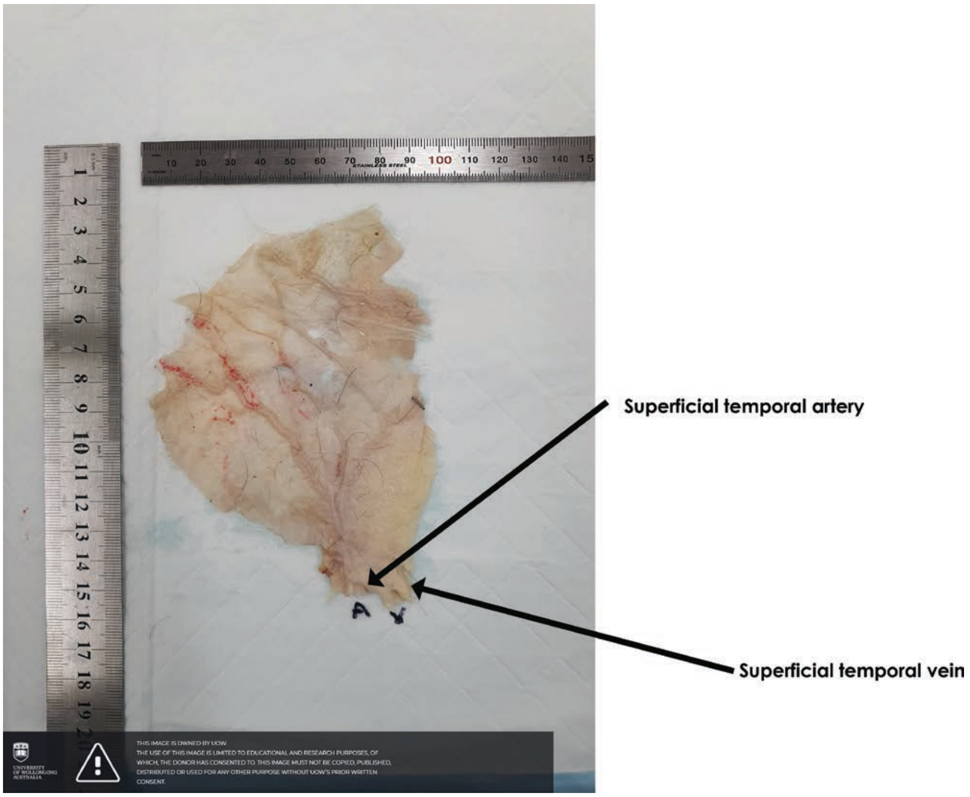

Fig. 2. Periosteum right skull (female)—alone.

CONCLUSIONS

Periosteum represents a resource of osteogenesis potential for use in free tissue transfer and reconstruction. This study outlines the properties of vascularized periosteal donor sites. Periosteum from the skull and scapula were more favorable due to their size and presumed limited donor site morbidity.

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