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Three-dimensional angiography of the submental artery perforator flap

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Summary *Background:* The submental flap, based on a large branch of the facial artery, is an excellent flap option which is most commonly used for head and neck reconstruction. The purpose of this report is to clarify aspects of the anatomy of the submental flap in order to improve the utility of this flap.
Methods: Ten cadavers were injected with a modified lead oxide–gelatin mixture. Four cadavers were selected for three-dimensional reconstruction using a spiral computed tomography scanner and specialised volume-rendering software. Dissection, angiography and photography of each layer were performed to outline the course of every perforator in the neck. The area of the vascular territory supplied by each source vessel was calculated. Surface areas were measured using Scion Image software.
Results: The skin and muscles on the anterior neck and mandible are nourished by several arterial perforators: facial artery, superior thyroid artery, mental artery, lingual artery and the submental artery. The diameter of the submental artery was 1.7 ± 0.4 mm at its origin from the facial artery. It sends 1.8 ± 0.6 perforators to the skin on its course towards the chin. The average size of the territory supplied was 45 ± 10.2 cm^2. Its largest perforating branch arises from behind the medial border of the anterior belly of the digastric muscle. There were multiple anastomoses between perforators from the submental artery, facial artery and sublingual artery.
Conclusions: This study clarifies the anatomy of the submental flap and provides a three-dimensional understanding to this important head and neck donor site.

The submental artery island flap is a versatile option in head and neck reconstruction, which can be used as a pedicled or free flap. The submental flap was first reported by Martin et al.[1] in 1993, and has been used as

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a myocutaneous,[2,3] osteomuscular,[4] osteomyocutaneous,[5] perforator flap,[6,7] reverse facial artery-submental artery flap[4,8] or as an adipoplatysmal flap.[9] It may be used for reconstruction of the tongue[10] and larynx,[11] repair of pharyngocutaneous fistulas,[12,13] coverage of perioral,[14] intraoral,[15–17] periorbital[18] and other head and neck defects,[15,19–22] The donor site is excellent with a well-hidden scar and often, there is an improved submental appearance after flap harvest. The flap is a reliable source of skin of excellent colour, contour and texture match for facial reconstruction. Elevation of the submental flap is relatively simple and harvest time is short.[23]

The submental artery is a well-defined and consistent branch of the facial artery. Magden et al. reported that it was present in all dissections and the anastomosis of the submental artery with the contralateral submental artery being found in 92%.[24] The arc of the pedicle allows coverage of the lower two-thirds of the face. Using a modification, the upper third of the face can be reached.[4,18] The maximum flap size reported is 18.0×8.0 cm.[22] Demir et al. showed that the maximum flap size was 13×6 cm and the minimum size was 6×3 cm (average, 10×4 cm). Direct closure of the donor site can usually be achieved in all cases.[20]

Several methods have been used to evaluate the location of the submental artery.[3,24–28] Few studies have been conducted regarding the anatomy and the distribution of the perforators of the submental artery.[6,29] In 2008, Ishihara et al. studied the submental perforator flap location and number of submental perforating vessels.[6] They described the course, location and numbers of perforators in the submental region; however, the size of the territory supplied by the perforating vessels, the relationship of the submental artery and its adjacent vessels and tissues were not documented.

To expand on the reconstructive options available, it is necessary to understand the anatomy of the human vasculature. Therefore, we developed a digitalised visible model of perforator flaps of the submental region using angiography and Materialise's Interactive Medical Image Control System (MIMICS). This technique provides morphological data, including detailed information regarding dimension, localisation and vascular territories. The advantage of this model includes its clear display of relationships of the submental artery with its adjacent vessels and tissues. The purpose of the current study is to comprehensively document the three-dimensional (3D) vascular anatomy of the submental flap.

Methods

The skin and muscles on the anterior neck and mandible are nourished by several arterial perforators: subclavian artery, the transverse superficial facial artery, superior thyroid artery, direct branches from the facial artery, lingual artery, mental artery and the submental artery. Study of the vascular anatomy of this area has been performed on 10 cadavers, which underwent whole-body carboxymethyl cellulose and lead oxide or lead oxide–gelatin injection, respectively. Bodies were obtained through the Wenzhou Medical College or Dalhousie University Donor Programme. The project was approved by the institutional Health Sciences Human Ethics. The injection technique was originally described by Rees and Taylor[30] and modified by Tang et al.[31,32] Four cadavers were selected for 3D-reconstructive modelling using spiral computed tomography (CT) scanner. 3D reconstructions of the head and neck were then performed using the MIMICS software (System ID: A13B0916F3XC, Materialise, Leuven).[32–34] Specimens were dissected in a layer-by-layer fashion to document every perforator encountered.

The lead oxide injectate is prepared as follows: 5 g of 300 Bloom pharmaceutical-grade gelatin derived from porcine skin is diluted in 100 ml of tap water and heated to 40 °C; 100 g of water-soluble red lead oxide is added. Adequate perfusion of the cadaver is indicated by the presence of the orange injectate in the sclera, fingers and toes. The average amount of lead oxide mixture injected is 26 ml kg^{-1}, depending on the degree of obesity of the cadaver.

The gelatin–lead oxide technique is the standard for visualisation of the integral topography of the blood supply of the muscle. All of the radiographic films were scanned or photographed, inverted and digitally compiled to form a montage of the regional muscles in Adobe Photoshop (Adobe Systems, Inc., San Jose, CA, USA). Each perforator was numbered and the boundaries were defined by the identification of reduced-calibre choke anastomotic vessels, which connect adjacent nutrient arterial zones. Next, the angiograms were imported into Scion Image (Scion Corporation, Frederick, MD, USA), where the area of the primary zone of individual nutrient artery was calculated.[31]

Results

Submental artery perforators

The submental artery, the major cutaneous branch of the facial artery, supplies the territory over the submandibular and submental triangles. This branch arises from the facial artery as it leaves the submandibular gland on the surface of the mylohyoid muscle. It then runs deep through or superficial to the anterior belly of the digastric muscle. It terminates close to the mandibular symphysis in the subdermal plexus and communicates with the contralateral artery, sending branches to the lower lip and the sublingual branch of the lingual artery (Figures 1 and 2).

The diameter of the submental artery was 1.7 ± 0.4 mm at the origin from the facial artery. It sends one to two (1.8 ± 0.6) perforators (diameter ≥ 0.5 mm) to the skin on its course towards the chin (Figures 1 and 2). The average size of the territory supplied by the submental artery was 45 ± 10.2 cm^2. Its largest perforating branch arises from behind the medial border of the anterior belly of the digastric muscle (Figure 1). Of particular interest is the submental artery's contribution to the vascular supply of the platysma. The platysma is a type II muscle. Its blood supply comes predominantly from the perforating branch of the facial artery and submental artery. In one of our dissections, a second cutaneous branch from the facial artery was observed. This branch passed posteriorly from