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Clinical Paper
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Lip reconstruction using a functioning serratus anterior free flap: preliminary study

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Abstract. Reconstructive surgery to the lips requires the replacement of defective tissues with similarly functioning tissues. While non-dynamic free tissue transfers provide adequate lower lip reconstruction, improved benefits may be obtained with innervated free muscle flaps. This study reports the use of innervated serratus anterior muscle free flaps for lip reconstruction in five patients. All patients had squamous cell carcinoma of either the upper or lower lip. After resection of the tumours, the resultant defects comprised two-thirds of the lips. The innervated serratus anterior muscle free flap was transferred to the lip and an end-to-end vascular anastomosis on the facial artery was performed. The marginal mandibular branch of the facial nerve was preferred for nerve coaptation. The inner and outer surfaces of the flaps were grafted with a split-thickness skin graft. Concentric needle electromyography of the orbicularis oris and frontal muscles was performed for all patients in the preoperative, postoperative, and follow-up periods. All patients survived the surgical operation. Three patients achieved perfect oral sphincter function without drooling. Electromyography at 1 year postoperative demonstrated the successful reinnervation of the serratus anterior muscle. This study demonstrates that lip reconstruction using an innervated serratus anterior muscle free flap is a reliable method, providing a functional lower lip.

Key words: lower lip; functional reconstruction; free flap; serratus anterior muscle.

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The lips of the human face allow for essential functions like speech, feeding, oral hygiene, and the facial expression of emotions. The lower lip makes a greater functional contribution to oral competence than the upper lip[1], and is more affected by trauma or malignancies that cause lip defects[2].

The aesthetic and functional goals of lip reconstruction require the replacement of the defective tissues with similar functioning tissues. These goals can be accomplished in small or intermediate-sized lip defects with good aesthetic and functional results using local tissues. However, the restoration of large defects (i.e., defects comprising more than two-thirds of the lip) with local tissues usually results in microstomia, an unaesthetic appearance, and a negatively affected quality of life for the patient due to drooling while eating and speaking. Various microsurgical free tissue transfers, including the free radial forearm flap and anterolateral thigh flap

for lower lip reconstruction, have been described to overcome these drawbacks[3,4]. However, due to their non-contractile, adynamic features, the long-term results are usually unrewarding, and oral incompetence is very common. This problem requires the incorporation of the palmaris longus tendon or the depressor anguli oris, and the depressor labii inferioris or the masseter muscles into the radial forearm flap[5–7].

This situation has intensified the search for a functional muscle transfer. Following the first description of a functional gracilis muscle transfer to the oral sphincter in a reconstruction by Burt et al. in 2000, the process has become a popular option for the functional reconstruction of the lower lip[8]. A review of the literature demonstrated that an innervated gracilis muscle transfer remains the only option for the functional reconstruction of the lower lip[9,10].

This article presents the authors' experiences with a free and innervated serratus anterior muscle as a new option for the functional reconstruction of near-total full-thickness lip damage caused by squamous cell carcinoma[11].

Materials and methods

Five patients (three male and two female) presented with advanced lower and upper lip squamous cell carcinoma and were treated with lip reconstruction using a functional serratus anterior muscle flap following tumour resection between 2012 and 2015. Each patient's lip defect comprised more than two-thirds of the total lip area. Four of the five patients had a near-total full-thickness lower lip defect, and only one patient had an upper lip defect (Table 1). All patients were screened by magnetic resonance imaging (MRI) for neck lymphadenopathy. One patient was positive for suspected lymph node metastasis and underwent a supraomohyoid neck dissection after a positive sentinel lymph node biopsy.

Concentric needle electromyography (EMG) of the orbicularis oris and frontal muscles was performed for all patients in the preoperative and postoperative periods. Standard techniques were used for the facial nerve conduction study and needle EMG. The latency was measured from stimulus onset to the initial deflection of the compound muscle action potential (CMAP). The CMAP amplitude is measured from peak to peak[12].

Regional surgical anatomy

Details of the regional surgical anatomy (including neurovascular structures, myocutaneous, and rib myo-osseous components) have been described previously[13–15]. In this article, the significant and remarkable anatomical features of the serratus muscle free flap are emphasized. This muscle, found on the lateral parts of the thorax, is composed of 7 to 10 digitations originating from the first 10 ribs. The serratus muscle inserts on the medial border of the scapula; it stabilizes the scapula and prevents winging.

After incision and retraction of the skin and subcutaneous tissues, the serratus anterior muscle slips, with the superficially running neurovascular supply, are easily identified (Fig. 1).

The muscle has a type III vascular pattern (meaning mainly peripheral vascularity) that includes the lateral thoracic artery, which arises directly from the axillary artery to supply the upper four or five slips, and the serratus branch of the thoracodorsal artery, which arises from the subscapular branch of the axillary artery to supply the lower slips. The serratus branch of the thoracodorsal artery provides segmental branches on the posterior third of each muscle slip.

The pedicle length can be increased to 12–13 cm by choosing the lower slips of the muscle and ligating the thoracodorsal branch of the latissimus dorsi muscle for patients who have previously undergone lymph node dissection or who have suffered a radiated neck[15]. The average external diameter of the subscapular artery (4–6 mm) at the origin of the circumflex scapular artery usually matches the size of the facial artery[15]. The appropriate pedicle length is selected according to the requirements of the recipient site.

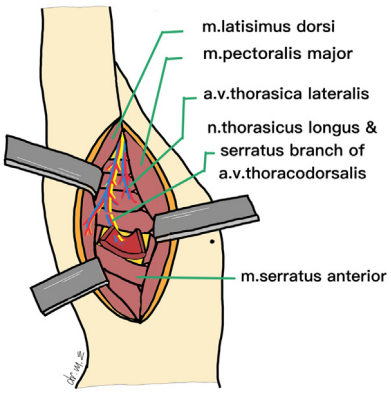

Fig. 1. Appearance of the serratus anterior muscle flap elevated from the ribs. The dissection proceeds to the subscapular artery origin with inclusion of the long thoracic nerve on the muscle fascia.

The muscle is innervated by the long thoracic nerve, which runs over the surface of the muscle and descends behind the vascular structures in the fascia, and more rigorous dissection is needed to prevent injury to the nerve.

Operative technique

Patients were operated on while in the lateral decubitus position with the arm abducted. Two surgical teams worked simultaneously. While one team resected the tumour and prepared the recipient vessels, the other team harvested the serratus muscle flap. Thus, harvest of the serratus anterior muscle is performed on the same side as the subsequent anastomosis.

All tumours of the lips were resected with a 1-cm safety margin. Before the excision of each tumour, the length of the lip to be resected was measured. During lip resection, the second team harvested the serratus anterior muscle flap using a curvilinear incision of the thorax, starting from mid-axilla and continuing to the anterior axillary fold, up to the eighth or ninth rib. After exploration and retraction of the latissimus dorsi muscle, the eighth slip of the muscle was identified and its pedicle was traced superiorly to the origin of the subscapular artery. The

Table 1. Demographic and clinical patient data.

Patient	Age (years)	Defect location	Diagnosis	Complications	Follow-up
1	55	Lower lip	SCC	–	Alive
2	79	Lower lip	SCC	Minor skin graft loss	Alive
3	69	Lower lip	SCC	–	Died of MI
4	68	Lower lip	SCC	Flap failure due to venous thrombosis	Alive
5	89	Upper lip	SCC	–	Alive

SCC, squamous cell carcinoma; MI, myocardial infarction.