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Microvascular reconstruction of the tongue using a free anterolateral thigh flap: Three-dimensional evaluation of volume loss after radiotherapy

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ABSTRACT

The goal of tongue microvascular reconstruction is to maximise oral function with less morbidity while preserving speech and swallowing. This kind of reconstruction often requires a bigger flap volume than is actually needed to repair the defect. This is because every reconstructive flap is subject to a shrinking process due to oedema reduction and differences among individual tissue healing processes. Moreover, patients with advanced cancers often need adjuvant radiation therapy, which can result in further flap volume loss. For these reasons, we designed this study to assess the three-dimensional flap volume loss after tongue reconstruction using an anterolateral thigh flap (ALTF). Our aim was to analyse the effects of radiotherapy on flap volume loss. The volume of ALTF was evaluated using the following protocol: an initial (T_1) post operative magnetic resonance imaging (MRI) scan was acquired between 3 and 8 weeks after the reconstructive procedure; a second (T_2) MRI scan was obtained 6 months later; and a third (T_3) MRI scan was performed 1 year after the end of treatment. Three-dimensional flap contouring was carried out, with outlining of the graft margin and comparison of its tissue density with that of the surrounding structures. Flap volume was calculated using dedicated software. In total, 20 patients who satisfied the inclusion criteria were enrolled. Adjuvant radiation therapy was administered in 11 of the 20 patients. In the patients treated with postoperative radiotherapy, the mean flap volume loss was 16.5 cm^3. The patients who were not irradiated postoperatively showed a mean flap volume loss of 6.9 cm^3; this difference was statistically significant ($p = 0.041$). Our study indicated that 12 months after the end of treatment, patients reconstructed with an anterolateral thigh free flap had an average volume loss of 44.2% if treated with radiotherapy, whereas an average flap shrinkage of 19.8% occurred in patients who did not undergo postoperative radiotherapy. For these reasons, we recommend over-correction by a factor of 1.4 in radiotherapy-treated patients, while a correction factor of 1.2 should be sufficient in patients not undergoing adjuvant radiotherapy.

1. Introduction

The most common sites of primary oral squamous cell carcinomas (OSCCs) are the tongue and the floor of the mouth (Woolgar et al., 1999). Although surgery remains the main procedure for oral cavity cancer treatment, radiotherapy is often indicated as adjuvant treatment for locally advanced tumours.

Approximately 40% of all OSCC patients referred for treatment require resection of the tongue to varying degrees (Brown, 1999). Immediate reconstruction should be performed after complete excision of the tumour (Lam and Samman, 2013).

Quality-of-life (QoL) studies have shown that speech and swallowing are the most important factors for patients undergoing tongue surgery (Tarsitano et al., 2012, 2013). The severity of the functional impairment is influenced not only by the site of the tumour but also by the extent of the surgical resection.

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Reconstruction of the tongue is necessary when oral cavity obliteration, palatal contact, and mobility are impaired to the extent that normal swallowing and speech will be affected adversely (Neligan et al., 2003). The aim of reconstruction is to maximise oral functions with less morbidity, preserving speech and swallowing and reducing donor site morbidity (Kimata et al., 2003). Some years ago, the anterolateral thigh flap (ALTF) was introduced as an ideal flap for oral soft tissue reconstruction (Kimata et al., 2003).

Tongue reconstruction often requires a bigger flap volume than is actually needed to repair the defect. This is because every reconstructive flap undergoes a shrinking process due to oedema reduction and interindividual differences in the healing process. Moreover, patients with advanced head and neck cancers often need adjuvant irradiation therapy, which can result in further flap volume loss in addition to other negative effects of radiotherapy on the surrounding tissues, such as loss of elasticity and flexibility of soft tissues (Choi et al., 2004; Hohlweg-Majert et al., 2012; Mucke et al., 2012). Also, functional outcomes of swallowing and speaking are negatively influenced by postoperative radiotherapy, because of excessive flap shrinkage (Haykal et al., 2013). These findings regarding shrinkage have resulted in a general consensus that the defect should be overcorrected (Yun et al., 2010; Cho et al., 2011).

The shape and bulk of the reconstructed tongue are closely correlated with postoperative swallowing capacity (Kimata et al., 2003). These oral functions are better in patients with a protuberant or semi-protuberant reconstructed tongue than in those with a flat or depressed tongue. On the basis of these findings, the use of broad and thick flaps is usually preferred. In clinical practice, however, it is extremely difficult to control the subsequent volume reduction and sagging of the flap, in particular when postoperative radiotherapy is performed. Quantitative measurements of ALTF volume loss in tongue reconstruction have not been reported before.

The objective of this study was to assess the three-dimensional flap volume loss after tongue reconstruction using ALTF. In particular, we aim to analyse the effects of radiotherapy on flap volume loss. Consequently, these results will be useful as a guide for surgeons when reconstructing a tongue, allowing for the correct amount of overcorrection using the ALTF. Moreover, this could enable surgeons to calculate the correct flap volume, determine the best reconstruction method for the patient, and ensure better long-term functional recovery and a reduced rate of secondary irradiated flap procedures.

2. Materials and methods

This retrospective study included 20 patients with a histological diagnosis of primary tongue squamous cell carcinoma seen at the Maxillofacial Surgery Unit of the University of Bologna between 2009 and 2014. Institutional Review Board approval was not required. During the study period, all patients who met the following inclusion criterion were recruited: undergoing primary tongue microvascular reconstruction using ALTF after a partial or subtotal glossectomy. In all cases ALTF was harvested as fasciocutaneous flap in order to obtain good pliability, according to Wei technique (Wei et al., 2002). When fasciocutaneous flap was planned, the incision was carried through the deep fascia. The flap was mobilized laterally until the major perforators to the skin were identified. The remaining skin incisions were then completed, and subfascial dissection was continued toward the intermuscular septum between the rectus femoris and the vastus lateralis muscles. The rectus femoris muscle was then medially displaced to allow exploration of the intermuscular space, exposing either the septocutaneous perforators or the beginning of the myocutaneous perforators. The pedicle was dissected in a retrograde fashion either to the descending branch for the septocutaneous flaps or through the vastus lateralis muscle in patients with myocutaneous perforators.

The volume of ALTF was evaluated using the following protocol: an initial (T_1) postoperative magnetic resonance imaging (MRI) scan was acquired between 3 and 8 weeks after the reconstructive procedure; a second (T_2) MRI scan was obtained 6 months later; and a third (T_3) MRI scan was performed 1 year after the end of the treatment. Patients with surgical intervention in the local area between the T_1 and T_3 assessments were excluded, as were patients who did not complete this evaluation.

Tumour excision was performed through a trans-mandibular approach or by using the pull-through technique. The extension of the resection was in all cases a hemiglossectomy or a subtotal glossectomy. With respect to the surgical procedure, a hemiglossectomy was defined as resection of at least 50% of the mobile tongue; a subtotal glossectomy was defined as a resection of between 50 and 75% of the tongue. No bone resection was performed.

Adjuvant radiotherapy was required in 11 of the 20 patients according to the National Comprehensive Cancer Network guidelines.

The patients were divided into two groups: patients having postoperative radiotherapy (Group A) and patients treated with surgery alone (Group B). For each patient, data sets T1, T2, and T3 were imported into the Advanced Open Source picture archiving and communication system (PACS) workstation Digital Imaging and Communications in Medicine (DICOM) reading software OsiriX (ver. 7.0.2.; http://www.osirix-viewer.com/) to identify the flap contours and calculate the flap volume using the dedicated software tool. Contouring was carried out manually, by the same surgeons (AT, SB), with outlining of the flap margin and comparison of its tissue density with that of the surrounding structures (Figs. 1 and 2). The volume was measured separately on two occasions and the mean was set as the flap volume.

2.1. Statistical analysis

Descriptive statistics for quantitative variables are given as means. Fischer's exact test was used to determine the influence of radiotherapy (group A vs. B) on flap volume shrinkage. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using SPSS for Windows software (ver. 13.0; SPSS Inc., Chicago, IL, USA).

3. Results

Twenty patients who met the inclusion criteria were enrolled. There were 12 men and 8 women with a mean age of 63 years (range: 28–83 years). All patients have OSCCs. TN stage and defect sizes are listed in Table 1.

Adjuvant radiation therapy was administered between the T_1 and T_2 assessments in 11 of the 20 patients (Table 1). Intensity-modulated radiation therapy (IMRT) was performed in all cases, with a mean dose of 62 Gy (range: 60–63 Gy). The remaining 9 patients did not receive adjuvant radiotherapy.

The mean flap volume in all patients at T_1 was 35.43 cm^3 (range: 30.5–39.5 cm^3). The overall mean flap volume at the second measurement (T_2) was 25.08 cm^3 (range: 19.3–30.9 cm^3). The overall mean flap volume at the T_3 measurement was 23.15 cm^3 (range: 18.3–28.9 cm^3). A mean flap volume loss of 34.7% was demonstrated between the T_1 and T_3 measurements (Table 2).

For group A, the mean flap volume at T_1 was 37.35 cm^3. The flap volume at the T_3 measurement was 20.85 cm^3 (Table 2).