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Microvascular transplants in head and neck reconstruction: 3D evaluation of volume loss

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ABSTRACT

Background: Despite oversized latissimus dorsi free flap reconstruction in the head and neck area, esthetic and functional problems continue to exist due to the well-known occurrence of transplant shrinkage. The purpose of this study was to acquire an estimation of the volume and time of the shrinkage process.
Materials and methods: The assessment of volume loss was performed using a 3D evaluation of two postoperative CT scans. A retrospective review was conducted on all latissimus dorsi free flap reconstructions performed between 2004 and 2013. Inclusion criteria for the assessment were: resection of an oral carcinoma and microsurgical defect coverage with latissimus dorsi free flap; a first postoperative CT (CT_1) performed between 3 weeks and a maximum of 3 months after reconstruction surgery; and an additional CT scan (CT_2) performed at least one year postoperatively. The exclusion criterion was surgical intervention in the local area between the acquisition of CT_1 and CT_2. The effect of adjuvant radiation therapy was considered. Volume determination of the transplant was carried out in CT_1 and CT_2 by manual segmentation of the graft.
Results: Fifteen patients were recruited. 3D evaluation showed an average volume loss of 34.4%. In the consideration of postoperative radiotherapy the volume reduction was 39.2% in patients with radiotherapy and 31.3% in patients without radiotherapy.
Conclusion: The reconstruction flap volume required for overcorrection of the surgical defect was investigated. This study indicates that a volume loss of more than 30% could be expected one or more years after latissimus dorsi free flap reconstruction.
Clinical trial number DRKS00007534.

1. Introduction

Complete surgical resection of advanced head and neck malignancies frequently entails complex bone and soft tissue defects. Whenever there is insufficient adjacent tissue, defect coverage heavily relies on free vascularized tissue transfer (Choi et al., 2004; Shah and Gil, 2009; Hohlweg-Majert et al., 2012). A leading option for extensive facial defects has to be seen in latissimus dorsi myocutaneous flap reconstruction (Choi et al., 2004; Horn et al., 2014). During head and neck tumor reconstruction, surgeons must attempt to judge the required size of the flap to be inserted into the defect; however, due to variation between individuals, this is often rather difficult.

In addition, therapy of head and neck cancer frequently mandates the use of adjuvant irradiation; however, this use of radiotherapy can result in a loss of flexibility for connective tissues and the vascular system (Hohlweg-Majert et al., 2012). Furthermore, adjuvant radiotherapy is associated with deleterious effects on free flaps, such as fat necrosis and volume loss (Buchholz et al., 2002; Haykal et al., 2013). Sufficient shape and volume of the reconstructed tissue are important factors in obtaining satisfactory oral

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function after oral cancer therapy (Sakuraba et al., 2009; Cho et al., 2011).

The function of the reconstructed region may be further influenced by a variety of clinical factors such as postoperative radiotherapy and, in particular, the gradual reduction of the postoperative flap volume (Mucke et al., 2012; Shin et al., 2012). Most changes in reconstruction volume occur over time following head and neck reconstruction with flap surgery (Mandrekas et al., 2003; Park and Shim, 2012). The functional outcomes for speech and swallowing after partial glossectomy with free flap reconstruction were negatively influenced by postoperative radiotherapy caused by excessive shrinkage of the reconstruction tissue (Bokhari and Wang, 2007; Shin et al., 2012). This shrinkage of flap volume has led to the general recommendation to overcorrect the defect if possible (Yun et al., 2010; Cho et al., 2011).

Quantitative measurements of reconstruction volume in follow-up periods after head and neck reconstruction using a latissimus dorsi myocutaneous flap have not yet been reported. Additionally, this analysis sought to evaluate radiation effects on free flap reconstruction. These results should help in the selection of microvascular flap size and design of the flap with regards to long-term functional and esthetic considerations. This would help surgeons to determine the best possible flap volume for patients, and thereby functionality after reconstructive surgery, and would also reduce the rate of secondary procedures on irradiated flaps.

2. Materials and methods

The volume of latissimus dorsi myocutaneous free flap reconstructions after complete tumor ablation was evaluated at the University of Freiburg, in the Department of Oral and Maxillofacial Surgery and Regional Plastic Surgery, between 2004 and 2013. Ethical approval was obtained before undertaking this study. Written informed consent was obtained from all study patients.

During the study period, 15 patients were recruited who fitted the following inclusion criteria: resection of an oral carcinoma and microsurgical defect coverage with latissimus dorsi myocutaneous free flap; a first postoperative computed tomography scan (CT_1) performed between 3 weeks and a maximum of 3 months after reconstruction surgery; and an additional CT scan (CT_2) performed after at least one year post-reconstruction. The exclusion criterion was surgical intervention in the local area between the acquisition of CT_1 and CT_2.

Recorded parameters included: age, sex, pathohistological stage of cancer, marking of the tumor resection margin and adjuvant radiation therapy between CT_1 and CT_2, and duration between CT_1 and CT_2. CT scans were performed routinely during the clinical trial for surveillance to detect metastasis and recurrence of cancer. No additional CT scans were performed for this study.

Dataset CT_1 and CT_2 were imported and registered in the planning system iPlan (iPlan 3.0.3 BrainLab, Feldkirchen, Germany) for each patient, using a bone fusion registration based on mutual information in the region of the primary tumor. Two experienced clinicians were identified to contour the free flap graft. The reconstruction volume of the latissimus dorsi myocutaneous free flap was then outlined manually using the brushing tool included in the software. Contouring was carried out by outlining the architectural distortion relating to the surgical excision visible on each CT slice (Fig. 1). Where surgical marking of the resection margin at the outer edges of the free flap reconstruction using titanium ligature clips had been used, contouring was carried out by outlining the outer part of titanium clips on each CT slice and the volume was determined (Fig. 2). Delineation of reconstruction volume was performed with a fixed window level (0 Hounsfield units) and width (500 HU) by two experienced observers. The same clinicians checked the volume three times for each patient and the median value was set as the reconstruction volume.

Descriptive statistics for quantitative variables are given as the mean value. For statistical analysis, the Wilcoxon matched-pairs signed-ranks test and *t*-test, two-sample *t*-test with equal variances and a quantile–quantile plot were performed. The data were analyzed with the Statistical Package for the Social Sciences (SPSS for Windows 21. Chicago, IL, USA).

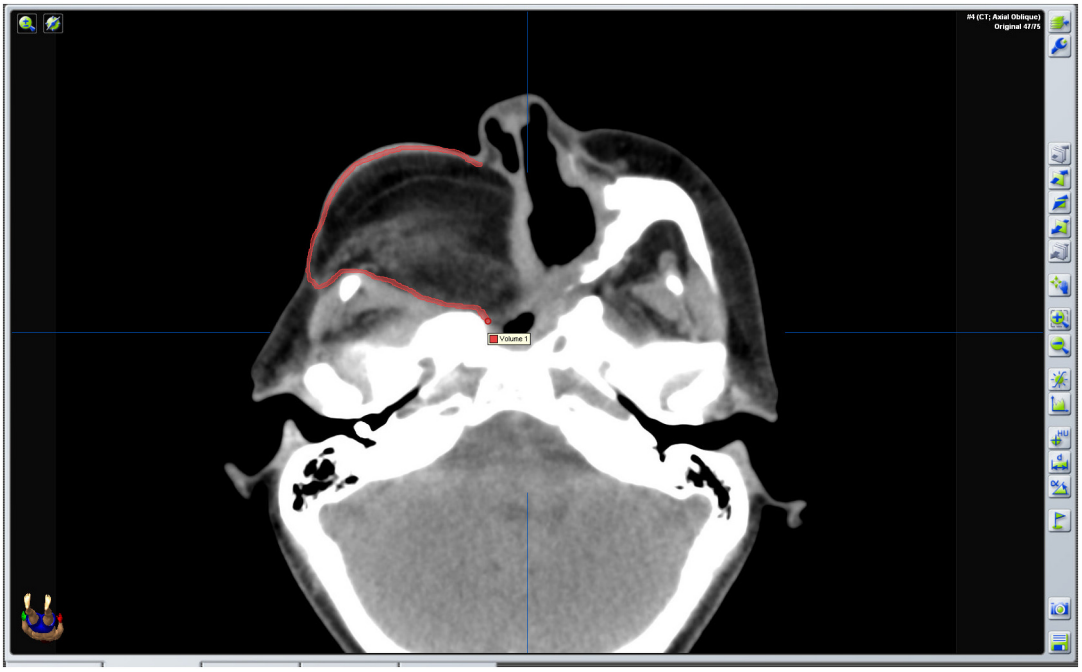

Fig. 1. Contouring of the latissimus dorsi myocutaneous free flap was carried out by outlining the architectural distortion relating to the surgical excision visible on each CT slice. Delineation was performed using the iPlan planning system.