

Clinical Paper
Reconstructive Surgery

Prelamination of the latissimus dorsi flap for reconstruction in head and neck surgery

P. Jehn, R. Zimmerer, J. Dittmann, J. Winterboer, N.-C. Gellrich, F. Tavassol, S. Spalthoff
Department of Oral and Maxillofacial Surgery, Hannover Medical School, Hannover, Germany

P. Jehn, R. Zimmerer, J. Dittmann, J. Winterboer, N.-C. Gellrich, F. Tavassol, S. Spalthoff: Prelamination of the latissimus dorsi flap for reconstruction in head and neck surgery. Int. J. Oral Maxillofac. Surg. 2019; 48: 1163–1168. © 2019 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

Abstract. Free microsurgical tissue transfer of the latissimus dorsi flap may be indicated for the restoration of intra- and extraoral defects, especially when a large-sized skin island flap is required. In many cases, use of the latissimus dorsi flap for coverage of large-sized intraoral defects results in bulkiness due to the proportion of subcutaneous fat. Prelamination of free flaps appears to be a promising technique to overcome this flap bulkiness. This modification in flap design could improve the postoperative functional outcome, as well as reduce donor site morbidity. This article presents four novel clinical cases, in which the patients underwent prelamination of the latissimus dorsi flap with local skin grafts during oral cancer treatment in order to reduce the thickness of the free flap and allow tension-free primary closure of the donor site. These attempts successfully covered large-sized intraoral defects, achieving good functional outcomes with minimal donor site morbidity.

Key words: prelamination; latissimus dorsi flap; free flap; skin graft; cancer treatment; oral cancer; reconstruction; donor site morbidity.

Accepted for publication 13 February 2019
Available online 28 February 2019

The surgical treatment of oral cancer, involving the restoration of intra- and extraoral defects after tumour ablative surgery, is a well-established procedure in oral and maxillofacial surgery¹. Possible strategies for reconstruction range from local flaps to free microsurgical tissue transfer, depending on the site, size, and pathological nature of the disease^{2,3}. Microvascular surgery allows the transplantation of even large-sized skin island flaps to cover complex defects by performing free flap anastomosis⁴. Microsurgical

reconstruction is one of the key elements in maxillofacial surgery⁵.

Current options for the restoration of isolated soft tissue defects in head and neck surgery include free flaps from different donor sites, such as the radial forearm, lateral upper arm, rectus abdominis muscle, anterolateral thigh, and latissimus dorsi muscle, and the choice will depend on the tumour localization and size, as well as the functional and aesthetic objectives^{6,7}. Each flap offers specific advantages and disadvantages, such as adequate volume, maxi-

mum size of the cutaneous island, skin texture, versatility in design, vessel diameter, and pedicle length. On the other hand, each flap also has typical limitations and complications related to donor site morbidity, which have to be discussed before harvesting⁸. As low donor site morbidity is essential for a good postoperative outcome, this should be considered alongside the functional aspects when choosing the reconstruction technique and flap design⁹.

Among free flaps used for intra- and extraoral defect coverage, the free rectus

abdominis, anterolateral thigh, and latissimus dorsi flaps offer a large volume of soft tissue with the possibility of multiple skin islands, along with a long vascular pedicle with reliable vessels of adequate diameter^{6,7,10}. In particular, the anterolateral thigh and latissimus dorsi flaps can be harvested with large-sized skin islands, while exhibiting comparatively low donor site morbidity and only minor sequelae^{11–13}. However, the most notable disadvantage of these flaps for intraoral reconstruction is their bulkiness, which is mainly due to the subcutaneous fat layer between the harvested muscle and skin island, especially in patients who are obese^{14,15}. The latissimus dorsi flap is used mostly for extraoral defect coverage, whereas its intraoral application in head and neck reconstruction has, to date, been limited.

The aim of this study was to overcome this disadvantage of the latissimus dorsi flap by performing a technique of flap prelamination. To date, prelamination of isolated soft tissue free flaps has only been described in clinical cases involving radial forearm, antibrachial fascia, and lateral upper arm flaps, which have confirmed the method to be a suitable way to improve flap design, enhance functional aspects, and reduce donor site morbidity^{16–21}. Thus, a new surgical technique of prelaminating the latissimus dorsi flap was developed for intraoral reconstruction.

Materials and methods

In this study, prelamination of the latissimus dorsi flap with free defatted full thickness skin grafts was performed in four patients with oral squamous cell carcinoma who were treated surgically in the Department of Oral and Maxillofacial Surgery, Hannover Medical School. Soft tissue restoration with a free soft tissue flap was planned in every case because of the expected defect size. The usual soft tissue flaps used in the department for similar defects (such as the radial forearm flap, lateral upper arm flap, or anterolateral thigh flap) could not be used in three of the four patients due to significantly compromised vascularization of the upper and lower extremities. The fourth patient had a tumour relapse, and radial forearm and lateral upper arm free flaps from the left side had been applied previously. This patient wished to avoid further risk to the other upper extremity and explicitly declined the raising of a flap from the lower extremities. Therefore, the possibility of defect coverage with a prelaminated free latissimus dorsi flap was proposed and accepted by the patients.

Flap prelamination was performed on the left side of the back in two patients and on the right side in two patients. The surgical treatment was performed in a two-step procedure, with tumour staging and flap prelamination in the first phase and tumour resection, flap raising, and defect coverage in the second. All tumours were classified based on the Union for International Cancer Control (UICC) tumour–node–metastasis (TNM) classification (T, primary tumour size; N, regional lymph nodes; M, distant metastasis) and were either located in the maxillary and palatal region (upper jaw) or in the floor of the mouth. Patient characteristics are shown in Table 1.

Phase 1: Tumour staging and flap prelamination

Prior to the intended tumour resection, all patients underwent a stationary staging procedure, including pan-endoscopic exploration under general anaesthesia. During the same intervention, prelamination of the latissimus dorsi flap was performed while the patient was lying in a dorsal straight position. A skin incision of approximately 20 cm was made at the anterior border of the latissimus dorsi muscle (Fig. 1A). A spindle-shaped full thickness skin graft approximately 3 cm wide was harvested directly alongside the incision, by making a parallel incision posterior to the first cut (Fig. 1B). The subcutaneous fat layer was removed from the skin graft (Fig. 1C), and the defatted graft was divided centrally across into two cutaneous grafts of the same size (Fig. 1D). Next, the latissimus dorsi muscle was identified and raised to the depth of the lateral thoracic wall and the serratus anterior muscle, as well as to the surface level from the subcutaneous tissue, without affecting the vascular pedicle (Fig. 1E). Subsequently, the two skin grafts were placed side by side on the outer surface of the latissimus muscle and stabilized using absorbable sutures (Fig. 1F). Primary wound closure was then performed at the lateral back site. The minimum post-operative healing period was 14 days.

Table 1. Patient characteristics.

Patient number	Sex	Age (years)	Localization	TNM ^a	Prelamination side
1	Female	74	Upper jaw	rpT2pN0cM0	Right
2	Female	67	Mouth floor	pT2pN0cM0	Right
3	Female	79	Upper jaw	pT4apN0cM0	Left
4	Female	70	Upper jaw	pT3pN0cM0	Left

^a TNM, tumour–node–metastasis classification; p, pathological finding; c, clinical finding; r, relapse.

Phase 2: Tumour resection, flap raising, and defect coverage

In all cases, tumour resection with concomitant bilateral neck dissection and restoration of the intraoral defect were performed simultaneously as a second procedure after tumour staging and prelamination of the latissimus dorsi flap. The surgery was always performed using a two-team approach by harvesting the flap with the patient lying in a dorsal straight position. Harvesting did not require changing the patient's position, as the incision was made along the course of the existing scar at the lateral back site where prelamination was done (Fig. 2A). After re-entry, the latissimus dorsi muscle was dissected again carefully from the lateral thoracic wall and serratus anterior muscle, as well as from the subcutaneous fat layer, with respect to the healed skin grafts on the outer surface (Fig. 2B). Next, the latissimus dorsi flap was raised as a free flap, along with the newly formed skin island and the supplying thoracodorsal vascular pedicle as a thin musculocutaneous transplant without the surrounding fat layer (Fig. 2C). The microsurgical anastomosis was performed in the usual manner, allowing sufficient blood perfusion for the transplant (Fig. 2D). After completion of the tumour resection, a section was immediately prepared and examined by the pathology department (Fig. 2E). After determining tumour-free margins in all cases, the reconstruction procedure was performed by contouring the vascularized transplant and placing it in the defect site; good visible signs of recapillarization were observed (Fig. 2F). Subsequently, intra- and extraoral wound closure was done with absorbable sutures and clipping. Since there was no appreciable loss of skin at the lateral back site, easy closure of the donor site was noted without any wound tension.

Results

After the prelamination procedure using the free defatted full thickness skin grafts directly from the target donor site, all harvested latissimus dorsi flaps showed

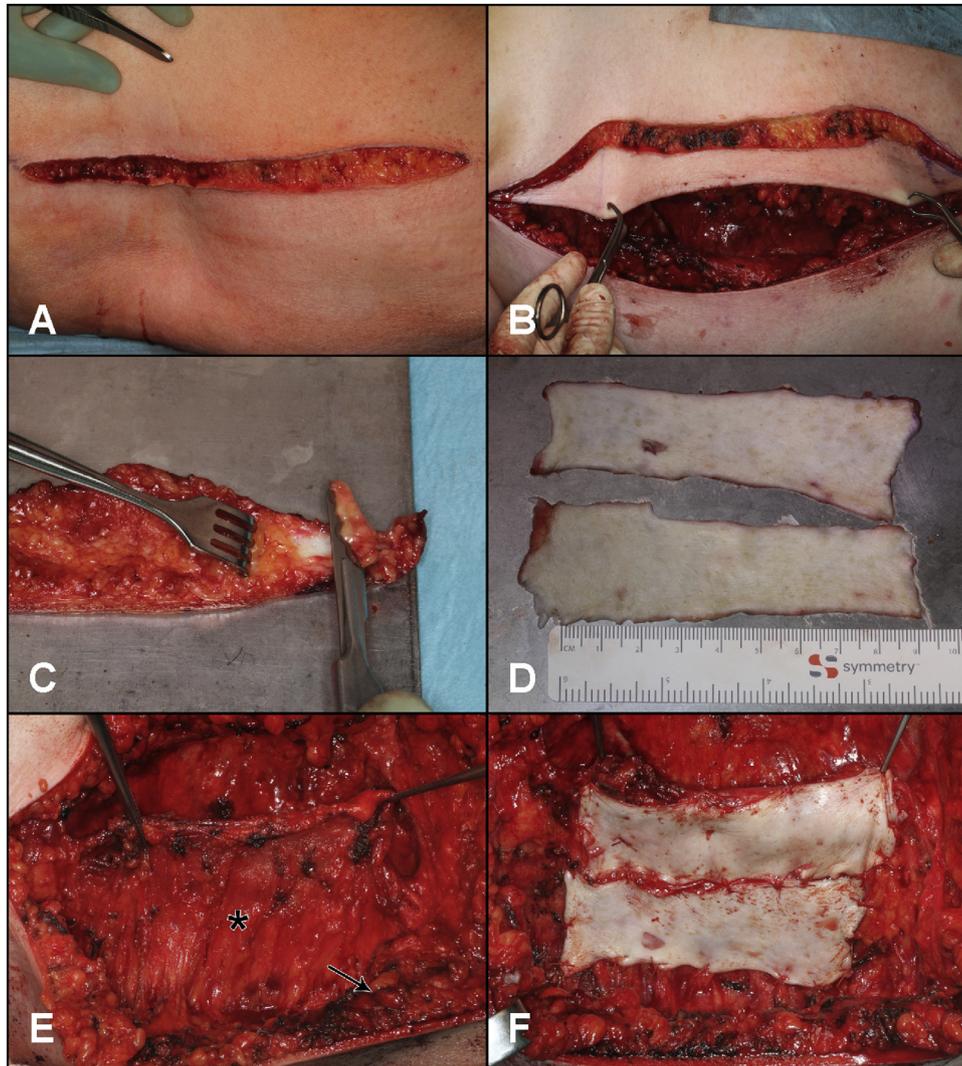


Fig. 1. Intraoperative images of latissimus dorsi flap prelamination on the right side. (A) Skin incision at the anterior border of the latissimus dorsi muscle. (B) Harvest of a spindle-shaped full thickness skin graft directly alongside the incision. (C) Removal of subcutaneous fat from the full thickness skin graft. (D) Defatted full thickness skin graft divided centrally across into two grafts of the same size. (E) Dissection of the latissimus dorsi muscle from the subcutaneous tissue; the asterisk (*) indicates the latissimus dorsi muscle and the arrow indicates the subcutaneous fat layer. (F) Fixation of the two same-sized skin grafts side by side on the outer surface of the latissimus dorsi muscle.

well-vascularized healing of the transplanted skin. No limitations in terms of skin size or shape were observed. Following a healing period of minimum 14 days, the flaps were harvested using a standard procedure, and all transplants could be obtained as thin musculocutaneous free flaps without any subcutaneous fat layer and with an adequately sized skin island, suitable for coverage of the relevant defect. Furthermore, wound closure at the lateral back site was easily possible without any signs of skin tension.

Postoperatively, no flap failure was observed. Good blood perfusion of the transplants was confirmed by visible recapillarization. Additionally, there were no signs of postoperative complications in

wound healing, such as infection, haematoma, or wound dehiscence, either for the prelamination or the restoration procedure. Regarding the postoperative outcomes among the patients who completed clinical follow-up, there was no substantial compromise in speech, mastication, or swallowing function, which was attributed to the thin free flap design (Fig. 3A, B). Regarding the donor site, no remarkable signs of functional impairment such as pain, nerve damage, or restricted mobility were noted (Fig. 3C).

Discussion

In this study, prelaminated free musculocutaneous latissimus dorsi flaps, accom-

plished using autologous skin grafts directly from the donor site, were used successfully to achieve good functional restorations of intraoral defects after tumour ablation.

There has recently been increased interest in the role of the free radial forearm flap in intraoral soft tissue reconstruction among some research groups. Lauer et al. performed prelamination of free radial forearm flaps with tissue-engineered mucosa grafts for coverage of intraoral defects after tumour ablation in five patients¹⁶. With the intentions of improving tissue quality at the recipient site and decreasing donor site morbidity, they reported successful healing after transplantation in most of their cases, with good

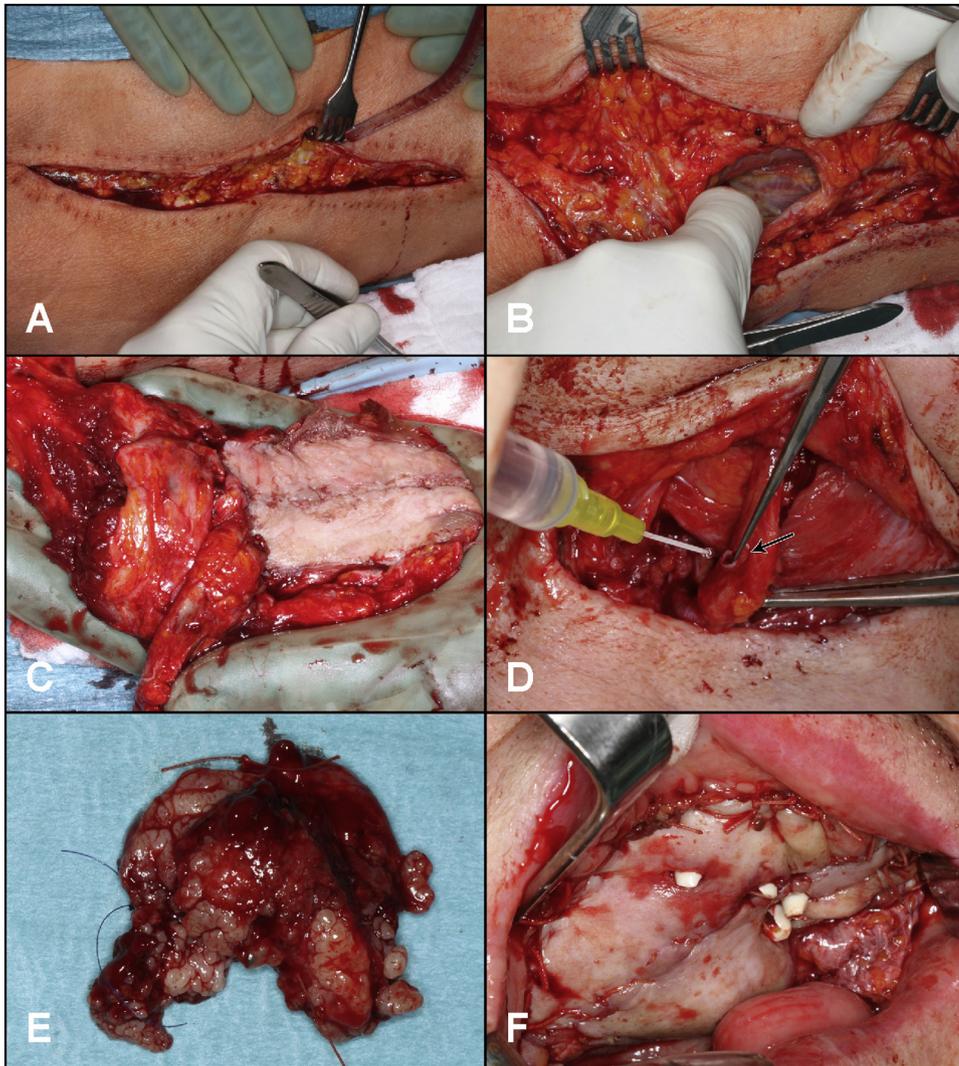


Fig. 2. Intraoperative images showing the raising of a prelaminated latissimus dorsi flap on the right side. (A) Re-entry incision along the pre-existing scar. (B) Dissection of the latissimus dorsi muscle with respect to the skin grafts. (C) Harvest of the prelaminated latissimus dorsi flap. (D) Microsurgical anastomosis showing sufficient blood perfusion; the arrow indicates visible venous return. (E) Resected tumour. (F) Defect coverage with the prelaminated latissimus dorsi flap.

functional outcomes in mouth opening and speech. For soft tissue defects of the floor of the mouth, Chiarini et al. described their experience in prelaminating fascio-mucosal free flaps at the antibrachial fascia with mucosal grafts from the cheek in 10 cases. All flaps healed uneventfully, showing a significant increase in mucosal graft surface²⁰. However, the size of the epithelial island necessary for adequate mucosal grafts that can be generated during this prelamination procedure is limited. A similar study was performed by Millesi et al., who reconstructed the floor of the mouth in 10 patients by prelaminating a fascial radial forearm flap with buccal mucosa grafts¹⁸. With this technique, thin, pliable, and resistant fascio-mucosal flaps with a surface area of up to $7 \times 4 \text{ cm}^2$ could be generated, preserving the skin and subcu-

taneous tissue at the donor site and enabling primary wound closure and a reduction of local morbidity. Poeschl et al., in a retrospective comparative analysis of 32 free radial forearm flaps, observed that prelaminated fascio-mucosal flaps had a higher shrinkage rate than non-prelaminated flaps¹⁹. Therefore, the number of secondary operations to improve functionality was higher following prelamination, whereas donor site morbidity was lower. In a retrospective study of 17 patients who underwent intraoral defect coverage with a prelaminated radial forearm fascio-mucosal flap, Kim et al. reported favourable outcomes and minimal donor site morbidity¹⁷. However, the authors stated that the effect of postoperative radiation therapy on the mucosa following surgical reconstruction with a

prelaminated flap is still unknown. Krimmel et al. described a case of a cleft palate closure using prelamination of the lateral upper arm flap, another common soft tissue flap for intraoral restoration of moderately sized defects²¹. Prelamination was done with the oral mucosa to avoid the disadvantages of the lateral upper arm flap, in particular the transfer of keratinized and hair-bearing skin to the oral cavity. After palate reconstruction with the free mucosal prelaminated upper arm flap, healing was uneventful. After 6 weeks, the flap could not be distinguished from the surrounding tissue.

Apart from these previous studies, it appears that no other clinical study involving the prelamination of free flaps for intraoral reconstruction has been published. In particular, the prelamination

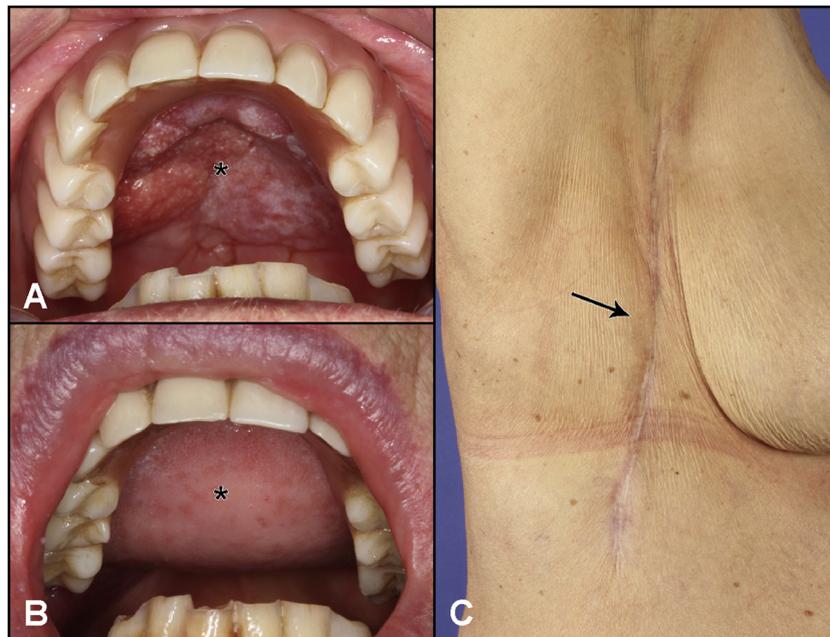


Fig. 3. Clinical images of a 74-year-old woman treated with a prelaminated latissimus dorsi flap. (A) Initial intraoral clinical view of a squamous cell carcinoma in the upper jaw; the asterisk (*) indicates the squamous cell carcinoma. (B) 1-year follow-up view after defect restoration with a free prelaminated latissimus dorsi flap; the asterisk (*) indicates the prelaminated latissimus dorsi flap. (C) 1-year follow-up view of the right donor side; the arrow indicates the pale visible scar.

of a musculocutaneous free flap, such as the latissimus dorsi flap, has not yet been described for clinical application in humans. In a small animal study with rabbits, Ahn et al. examined the fabrication of a myomucosal flap using tissue-engineered bioartificial mucosa created with oral keratinocytes cultured on an amniotic membrane²². The high survival rate of the keratinocytes after 2 weeks based on macroscopic and microscopic examinations demonstrated successful fabrication of a prelaminated myomucosal latissimus dorsi flap in rabbits. In another study with rabbits, Adams et al. constructed a myoadipose flap in the latissimus dorsi region as a new composite flap for reconstructive surgery²³. They concluded that transfer of a reliable myoadipose flap is possible due to the survival of viable fat in the experimental flaps. Although the results of both prelaminating and prefabricating the latissimus dorsi flap were promising, no clinical application of these methods has occurred to date. There have been no efforts to overcome the disadvantages of this flap in intraoral reconstruction with respect to its bulky structure, which often leads to functional impairment.

Wolff et al. described intraoral defect coverage with isolated muscle flaps from different donor sites (vastus lateralis, pectoralis major, internal oblique, and temporalis muscle) in a combined

experimental and clinical study assessing flap epithelialization, shrinkage, and functional outcomes²⁴. Although sufficient and thin coverage of the defects was achieved in most cases, the authors stated that isolated muscle flaps undergo considerable atrophy with distinct cicatricial transformation leading to a reduction of flexibility and constriction of the surrounding tissues. Therefore, the application of isolated muscle flaps was not recommended for mobile areas of the oral cavity. The use of various isolated muscle flaps has been described in clinical applications^{25,26}. As these muscle flaps have no attached skin island, secondary granulation is required. In this context, different animal studies have shown that after surface granulation, the epithelialization process starts after approximately 2 weeks. After around 8 weeks, the surface is covered by hyperkeratinized epithelium and the granulated tissue has transformed to fibrotic tissue^{24,27}. Thus, isolated muscle flap application could be an alternative to musculocutaneous flaps in select cases; however, functional issues caused by the flap shrinkage and the long-term epithelialization process must be taken into account, especially when postoperative irradiation is necessary or functional aspects have to be considered.

In the present clinical study, prelamination of the latissimus dorsi flap appeared to be an easy and feasible procedure for the

restoration of oral defects within the framework of cancer treatment. Prelamination was successful in overcoming the limitations of latissimus dorsi free flap application, generating a suitable transplant with limited shortcoming in skin island design and low donor site morbidity. This technique reduced the disadvantages associated with bulky structures, which lead to functional problems in speech, mastication, and swallowing, as well as related complications at the donor site due to potential wound tension. As only a small number of patients were included in this study, further investigations involving a large patient cohort are needed to validate the results.

Nevertheless, successful debulking of the latissimus dorsi flap was achieved through the use of the skin prelamination technique, and the results of this study indicate the possibility of applying this flap for intraoral use, even in obese patients. This study clearly demonstrates that the increased application of this method in clinical practice could decrease functional limitations in reconstructive surgery and broaden the spectrum of specific applications for certain free flaps. Furthermore, the latissimus dorsi flap could be a reliable alternative for patients in whom the harvesting of other free flaps is not possible. Further studies on prelamination for flap improvement should be undertaken and encouraged.

Funding

No specific funding was obtained for this work.

Competing interests

The authors have no conflict of interest to declare. All authors have reviewed the manuscript and agreed to the submission.

Ethical approval

Ethical approval was obtained from the Ethics Committee of Hannover Medical School (Hannover, Germany).

Patient consent

Written consent was obtained from the patients to perform the surgical treatments and to publish the clinical data and photographs.

Acknowledgements. We would like to thank Editage (www.editage.com) for English language editing.

References

- Omura K. Current status of oral cancer treatment strategies: surgical treatments for oral squamous cell carcinoma. *Int J Clin Oncol* 2014;**19**:423–30.
- Vorrasi JS, Kolokythas A. Controversies in traditional oral and maxillofacial reconstruction. *Oral Maxillofac Surg North Am* 2017;**29**:401–13.
- Namin AW, Varvares MA. Functional outcomes of sensate versus insensate free flap reconstruction in oral and oropharyngeal reconstruction: a systematic review. *Head Neck* 2016;**38**:1717–21.
- Jeong WS, Oh TS. Oral and oropharyngeal reconstruction with a free flap. *Arch Craniofac Surg* 2016;**17**:45–50.
- Kansy K, Mueller AA, Mücke T, Kopp JB, Koersgen F, Wolff KD, Zeilhofer HF, Hölzle F, Pradel W, Schneider M, Kolk A, Smeets R, Acero J, Hoffmann J, DÖSAK collaborative group for microsurgical reconstruction. Microsurgical reconstruction of the head and neck - current concepts of maxillofacial surgery in Europe. *J Craniomaxillofac Surg* 2014;**42**:1610–3.
- Brown JS, Magennis P, Rogers SN, Cawood JI, Howell R, Vaughan ED. Trends in head and neck microvascular reconstructive surgery in Liverpool (1992-2001). *Br J Oral Maxillofac Surg* 2006;**44**:364–70.
- Yadav SK, Shrestha S. Microvascular free flaps in oral and maxillofacial reconstruction following cancer ablation. *J Nepal Health Res Counc* 2017;**15**:88–95.
- Pipkorn P, Rosenquist K, Zenga J. Functional considerations in oral cavity reconstruction. *Curr Opin Otolaryngol Head Neck Surg* 2018;**26**:326–33.
- Frederick JW, Sweeny L, Carroll WR, Peters GE, Rosenthal EI. Outcomes in head and neck reconstruction by surgical site and donor site. *Laryngoscope* 2013;**123**:1612–7.
- Low TH, Lindsay A, Clark J, Chai F, Lewis R. Reconstruction of maxillary defect with musculo-adipose rectus free flap. *Microsurgery* 2017;**37**:137–41.
- Li BH, Jung HJ, Choi SW, Kim SM, Kim MJ, Lee JH. Latissimus dorsi (LD) free flap and reconstruction plate used for extensive maxillo-mandibular reconstruction after tumour ablation. *J Craniomaxillofac Surg* 2012;**40**:293–300.
- Lee KT, Mun GH. A systematic review of functional donor-site morbidity after latissimus dorsi muscle transfer. *Plast Reconstr Surg* 2014;**134**:303–14.
- Girod A, Boissonnet H, Jouffroy T, Rodriguez J. Latissimus dorsi free flap reconstruction of anterior skull base defects. *J Craniomaxillofac Surg* 2012;**40**:177–9.
- Horn D, Jonas R, Engel M, Freier K, Hoffmann J, Freudlsperger C. A comparison of free anterolateral thigh and latissimus dorsi flaps in soft tissue reconstruction of extensive defects in the head and neck region. *J Craniomaxillofac Surg* 2014;**42**:1551–6.
- Aladami MT, Han B, Li C, Helal H, Gao Z, Li L. Factors to consider when deciding on the type of free-flap reconstruction of head and neck soft tissue defects. *ORL J Otorhinolaryngol Relat Spec* 2017;**79**:230–8.
- Lauer G, Schimming R, Gellrich NC, Schmelzeisen R. Prelaminating the fascial radial forearm flap by using tissue-engineered mucosa: improvement of donor and recipient sites. *Plast Reconstr Surg* 2001;**108**:1564–72.
- Kim GG, Halvorson EC, Hang AX, Pederson WC, De Santis G, Hackman TG. Prelamination of radial forearm free flap with buccal mucosa. *Otolaryngol Head Neck Surg* 2013;**148**:341–3.
- Millesi W, Rath T, Millesi-Schobel G, Glaser C. Reconstruction of the floor of the mouth with a fascial radial forearm flap, prelaminated with autologous mucosa. *Int J Oral Maxillofac Surg* 1998;**27**:106–10.
- Poeschl PW, Kermer C, Wagner A, Klug C, Ziya-Ghazvini F, Poeschl E. The radial free forearm flap—prelaminated versus non-prelaminated: a comparison of two methods. *Int J Oral Maxillofac Surg* 2003;**32**:159–66.
- Chiarini L, De Santis G, Bedogni A, Nocini PF. Lining the mouth floor with prelaminated fascio-mucosal free flaps: clinical experience. *Microsurgery* 2002;**22**:177–86.
- Krimmel M, Hoffmann J, Reinert S. Cleft palate fistula closure with a mucosal prelaminate lateral upper arm flap. *Plast Reconstr Surg* 2005;**116**:1870–2.
- Ahn KM, Lee JH, Hwang SJ, Choung PH, Kim MJ, Park HJ, Park JK, Jahng J, Yang EK. Fabrication of myomucosal flap using tissue-engineered bioartificial mucosa constructed with oral keratinocytes cultured on amniotic membrane. *Artif Organs* 2006;**30**:411–23.
- Adams WP, Griffin JR, Friedman RM, Rohrich RJ, Robinson JB. The myoadipose flap: a new composite. *Plast Reconstr Surg* 1998;**102**:735–40.
- Wolff KD, Dienemann D, Hoffmeister B. Intraoral defect coverage with muscle flaps. *J Oral Maxillofac Surg* 1995;**53**:680–5.
- Tavassol F, Rücker M, Barth EL, Kokemüller H, Bormann KH, von See C, Gellrich NC. Serratus anterior free flap in oral reconstruction. *J Oral Maxillofac Surg* 2009;**67**:2577–82.
- Abubaker AO, Abouzgia MB. The temporalis muscle flap in reconstruction of intraoral defects: an appraisal of the technique. *J Oral Maxillofac Surg* 1997;**55**:1423–30.
- Elshal EE, Inokuchi T, Sekine J, Sano K. Experimental study of epithelialization of the muscle-only flap in the oral cavity. *J Oral Maxillofac Surg* 1997;**55**:1423–30.

Address:
 Philipp Jehn
 Department of Oral and Maxillofacial
 Surgery
 Hannover Medical School
 Carl-Neuberg-Str. 1
 30625 Hannover
 Germany
 Tel.: +49 (0)511 532 4877;
 Fax: +49 (0)511 532 4740
 E-mail: Jehn.Philipp@mh-hannover.de