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Free thoracodorsal, perforator-scapular flap based on the angular artery (TDAP-Scap-aa): Clinical experiences and description of a novel technique for single flap reconstruction of extensive oromandibular defects

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ABSTRACT

Purpose: The reconstruction of oromandibular defects can be challenging, particularly when considerable amounts of bone and soft tissues are lost. In such cases, the use of a single flap may be unsatisfactory and a concomitant free flap is needed. Here we present a chimeric, thoracodorsal perforator-scapular free flap based on the angular artery of the subscapular system (TDAP-Scap-aa) as an alternative technique for single flap reconstruction of extensive oromandibular defects.
Materials and methods: The authors studied patients who underwent reconstructions of extensive oromandibular defects with a TDAP-Scap-aa free flap. The operative technique and the clinical experiences are described. Postoperatively, surgical complications were classified with the Clavien-Dindo Classification.
Results: Five male patients (59.4 ± 8.8 years) were treated with the TDAP-Scap-aa. Average sizes for harvested hard and soft tissue components, which are both included in the flap and completely independently from each other, were 10.4 ± 1.5 cm of bone length, 2.6 ± 0.3 cm of bone height, 11.6 ± 4.8 cm of skin paddle length and 8.4 ± 1.7 cm of skin paddle width. The overall mean operation time (cut-suture) was 14.6 ± 0.9 h. The postoperative follow-up was 6 months. No complications requiring surgical treatment as well as donor site nerve damages were observed.
Conclusions: In comparison to other double free flaps, the TDAP-Scap-aa offers several advantages such as higher amounts of hard and soft tissues without prolonged operation times, and provides satisfying aesthetic outcomes and little donor site morbidity due to the preservation of muscle and nerve structures. Therefore, the TDAP-Scap-aa constitutes a clinically reliable alternative in extensive oromandibular defect reconstruction.

1. Introduction

The reconstruction of extensive composite oromandibular defects is challenging (Dolderer et al., 2010). This is especially the case if expanded anterior segmental mandibular resections include more than two-thirds of the anterior tongue and the floor of the mouth, and if extensive retromolar ororopharyngeal resections include a mandibular segment (Wei et al., 1999; Shaw et al., 2015). In such complex cases, the use of single osteocutaneous free flaps may be unsatisfactory, and a concomitant free flap is needed (Wei et al., 1999; Gabr et al., 2004). Nevertheless, a concomitant free

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flap is associated with a high degree of complexity and morbidity (Jeng et al., 2005; Posch et al., 2007; Andrades et al., 2009).

In this context, composite scapular flaps are a useful alternative for the reconstruction of segmental lower jaw resections (Brown et al., 2010). However, the principal drawback of composite scapular flaps is the postoperative shoulder morbidity caused by the sacrifice of the thoracodorsal nerve, the latissimus muscle, and the bulk of the skin paddle.

For this reason, Angrigiani et al. (1995) described the thoracodorsal artery perforator flap (TDAP), which minimizes the morbidity and enables a much thinner flap. Additionally, Shaw et al. described a chimeric flap supplied by the subscapular vessels and combined a scapular flap based on the circumflex artery with a TDAP (TDAP-Scap) (Angrigiani et al., 1995; Shaw et al., 2015). However, limitations concerning this technique include the time taken when the patient is turned intraoperatively and the relatively short pedicle (Shaw et al., 2015).

To overcome these limitations, we developed a novel single flap technique for the reconstruction of extensive oromandibular defects, which is a modification of the TDAP-Scap with a bone component supplied by the angular artery. We call this modified version of the TDAP-Scap a thoracodorsal, perforator-scapular flap based on the angular artery (TDAP-Scap-aa).

The aim of this paper is to describe the clinical experiences and the operative technique of the TDAP-Scap-aa in the reconstruction of extensive oromandibular defects.

2. Materials and methods

Before being used clinically, the TDAP-Scap-aa was tested on cadavers for training purposes with special regard to the vessel dissection of the angulary artery and the detection of the perforators through the latissimus dorsi muscle, in order to intraoperatively ensure a safe and reliable flap-harvesting procedure.

Between 2016 and 2019, a total of 125 patients were treated for head and neck carcinomas at our department in Graz, Austria. Of these, 94 required microsurgical reconstructions after tumor resection. Among the 94 patients, five were included for TDAP-Scap-aa defect reconstructions.

All included patients ($n = 5$) had large oral cavity squamous cell carcinomas (T4a-SCC) with expanded mucosal soft tissue and mandible infiltration (Table 1). In all patients, a TDAP-Scap-aa was used for the extensive oromandibular defect reconstruction after tumor resection and neck dissection and tracheotomy.

Preoperatively, all interventions were fully explained to all patients. Written informed consent and photographs were obtained. Intraoperatively, tumor resection and defect reconstruction were done in the same operation. Complications were categorized using the Clavien-Dindo Classification for surgical complications (Clavien et al., 2009). Postoperatively, all patients received adjuvant radiotherapy. In this study, all performed procedures that involved humans were conducted in accordance with the ethical standards of the National Research Committee and with the 1964 Declaration of Helsinki and its later amendments. The data gathered in this paper are presented using descriptive statistical standard methods such as means ± standard deviations (SD) unless otherwise stated.

2.1. Surgical technique

Preoperatively, a Doppler ultrasound located the perforator around the TDAP-Scap-aa skin paddle. Intraoperatively, flap-raising started after tumor resection and neck dissection.

Flap harvesting was performed in the lateral decubitus position with the patient's arm fixed in 90° abduction (Fig. 1). Surgical dissection commenced with the skin paddle incision at the craniodorsal edge to expose the fascia and the anterior border of the latissimus dorsi muscle and farther along this plane in a dorsoventral/cranio-caudal direction. The distal skin paddle boarder was incised after perforator identification. Only perforators >0.5 mm diameter were considered to be clinically reliable for flap perfusion and were preserved. After complete skin paddle incision, the musculocutaneous perforator dissection continued in a distal-to-proximal direction. A cleavage plane through the latissimus dorsi was created in the direction of the muscle fibers to preserve their integrity and to expose the arterial branch (descending or transverse branch) from which the perforator derived. Nerve branches were released and preserved.

The dissection of the thoracodorsal artery continued proximally to identify the angular branch. After identification of subscapular branches, the skin paddle was passed through the latissimus dorsi, and the pedicle was dissected until the subscapular vessels. The circumflex scapular branch was initially preserved, to maintain the option of including an osseous component based on the circumflex scapular artery, in case the angular branch was absent or injured. After complete exposure of the angular artery, the inferior scapular angle was grasped with a Backhaus clamp and displaced anterolaterally. The circumflex artery and vein were ligated. The serratus muscle was detached from the scapular angle and the lateral scapular border was osteotomized. We preserved a cuff of the teres major and infraspinatus muscles on the bone to avoid devascularization and to protect the vascular arcade connecting the branches between the angular and the circumflex artery (Fig. 2). The flap components were mobilized and measured for documentation (Table 2) when the pedicle dissection reached the subscapular vessels, where they were ligated and cut to complete the flap raising. Multilayer wound closure was performed at the donor site. The patient was again placed in the supine position and the flap was microvascularly anastomosed (Figs. 3 and 6). Before

Table 1
Case overview: Overview of the cases in which a TDAP-Scap-aa flap was used for extensive oromandiblar defect reconstruction.

Patient	Age (y)	Sex	Diagnosis	Tumor classification[a]				Resection status	Operation time	
				T	N	M	G		h	min
1	65	M	SCC	4	2	0	2	0	16	15
2	62	M	SCC	4	1	0	2	0	14	30
3	44	M	SCC	4	2	0	3	0	14	30
4	65	M	SCC	4	0	0	1	0	15	15
5	61	M	SCC	4	0	0	1	0	14	15
Mean ± SD	59.4 ± 8.8								14.6 ± 0.9	21 ± 8.2

M, Male; SCC, squamous cell carcinoma; SD, standard deviation; h, hours; min, minutes.
Note: The overall operation time was measured from the beginning (skin incision) to the very end of the complete surgery (wound closure). Each surgical procedure included extensive tumor resection and microvascular defect reconstruction in a single surgical procedure.
[a] pTNM.

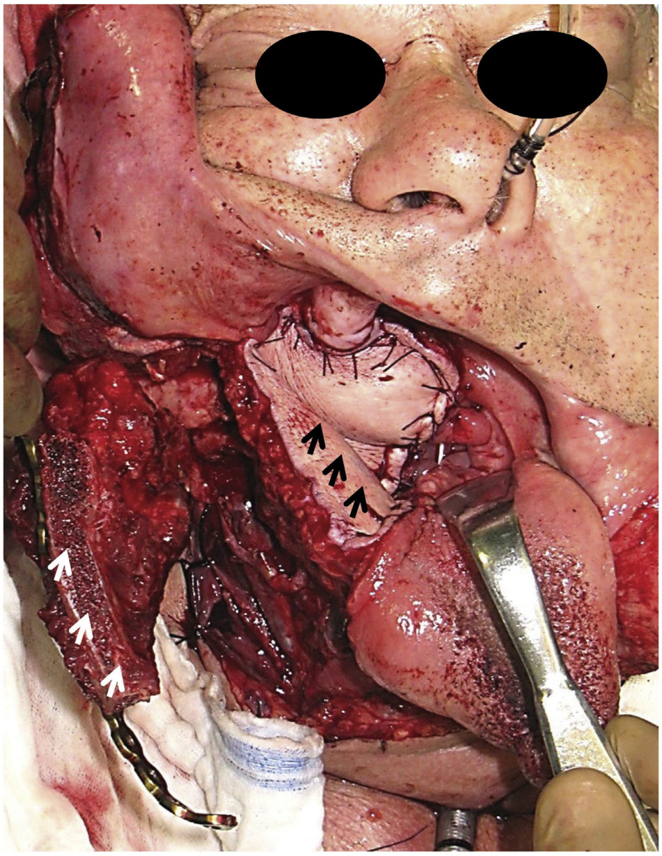

Fig. 1. Intraoperative photograph showing soft tissue reconstruction (black arrow) in the same patient shown in the figure. The 10 cm × 8 cm skin paddle has been folded to replace the cheek mucosa, soft palate, lateral pharyngeal wall, and the base of the tongue. A 9-cm-long scapular bone was fixed to the titanium plate and moved laterally (white arrow) for surgical access.

oromandibular reconstruction, the arterial flap perfusion was checked twice in two perfusion checks (directly after the microsurgical anastomosis and 30 min later) (see Fig. 4).

Postoperatively, routine intensive care treatment included vital parameter monitoring, regular clinical flap controls, and medical administration of antibiotics, analgesics and donor site wound controls.

After discharge, all patients were followed-up in a 14-days period until their sixth postoperative month and further within our ongoing oncologic follow-up program in 3-month periods until their fifth tumor-free year.

3. Results

A total of 5 patients (59.4 ± 8.8 years of age) underwent TDAP-Scap-aa reconstructions (Table 1). The overall operation time including tumor resection and reconstruction (cut-suture) was 14.6 ± 0.9 h, 21 ± 8.2 min (Table 1). Average sizes for the harvested hard and soft tissues were 10.4 ± 1.5 cm of bone length, 2.6 ± 0.3 cm of bone height, 11.6 ± 4.8 cm of skin paddle length and 8.4 ± 1.7 cm of skin paddle width (Table 2). Table 3 gives a detailed overview about these flap characteristics, and also the side, the primary tumor site and the defect extension (Fig. 6). In all cases, adequate arterial perfusion of the flap components was observed in both perfusion checks.

Postoperatively, two patients developed a seroma at the donor site. Another developed a local donor site infection, which delayed the wound healing process and further resulted in an associated lung infection due to postoperative immobility. Two patients required blood transfusions on the second postoperative day due to the expanded resection and wound area. However, all complications were solved conservatively without sequelae by daily wound managements and the administration of intravenous antibiotics (penicillin) for 8 days. No injuries to nerves with consequent paresthesia were observed. According to the Clavien-Dindo Classification (Clavien et al., 2009), we registered two grade I and three grade II complications (Table 4).

In all cases, the latissimus dorsi muscle and the thoracodorsal nerve could be preserved. The range of motion (ROM) of the donor site arm prior to operation was clinically equal when compared 12 weeks postoperatively in patients 1 and 2, while patients 3 and 4 reached full preoperative ROM 14 weeks after the operation. Patient 5 had a prolonged limited lateral arm movement postoperatively due to the delayed wound healing of the donor site skin, but achieved full preoperative ROM 18 weeks after surgery.

3.1. Patients

Patients 1 and 2 presented with extensive SCCs of the tonsils involving the mandible, soft palate, base of the tongue and cheek mucosa. Ipsilateral modified supraomohyoid neck dissection was performed before tumor resection.

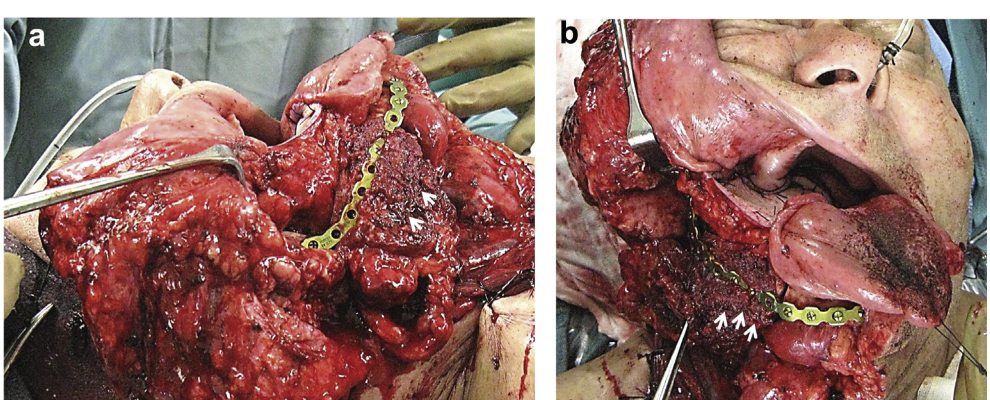

Fig. 2. (a and b) Intraoperative photograph of the same patient shown in Fig. 1. After soft tissue reconstruction and microvascular anastomosis, a titanium plate was fixed to the symphysis, and the bony component of the flap (white arrows) was placed in the appropriate position for lower jaw reconstruction. The bone component of the flap is partly covered by muscular soft tissue for sufficient blood supply (white arrows). (a) View from the right side. (b) View from the front.

Table 2
Extension of resection: Overview about the surgical defect extension due to extensive oromandibular tumor resection and flap components for all cases.

Extension of resection and flap sizes							
Case no.	Side and primary site of tumor	Extension of defect	Side of flap harvest (left/right)	Size of bone component[a]		Size of skin component[b]	
				Height (cm)	Length (cm)	Length (cm)	Width (cm)
1	Right tonsil	Tonsil, mandible, soft palate, base of tongue	right	2.9	10	10	8
2	Left tonsil	Tonsil, mandible, soft palate, base of tongue	left	2.8	9	10	10
3	Right floor of mouth midline crossing	Mandible, two-thirds of anterior tongue	right	2.5	12	10	8
4	Left floor of mouth midline crossing	Mandible, two-thirds of anterior tongue, skin of the chin	left	2.3	12	20	10
5	Right floor of mouth midline crossing	Mandible, floor of mouth	right	2.6	9	8	6
Mean (±SD)				2.6 ± 0.3	10.4 ± 1.5	11.6 ± 4.8	8.4 ± 1.7

[a] Lateral border of the scapular bone (measurement beginning from the scapular tip).
[b] Size of skin paddle.

Patients 3, 4 and 5 presented with large T4a SCCs of the anterior floor of the mouth expanding over the midline (Table 1). Bilateral, supraomohyoid neck dissection was performed after extended mandibular resection between the lower left and right molar region, included two-thirds of the anterior tongue and the floor of the mouth. In patient 4, the skin of the chin area was removed because of tumor infiltration.

Skin paddles were used for intraoral soft tissue restoration (Fig. 1), the lateral scapular border for mandible reconstruction (Fig. 2, Table 2). The harvested bone was osteotomized in segments for a natural shape (Table 2) and fixed bicortically with a 2.5-mm reconstruction plate (Modus 2.5 Locking Reconstruction Plates; Medartis AG, Basel, Switzerland) to the mandible.

Microsurgical anastomoses were performed ipsilaterally in patients 1 and 2 and on the right recipient vessels in patients 3, 4 and 5 using a standard surgical microscope (Carl Zeiss Meditec AG;

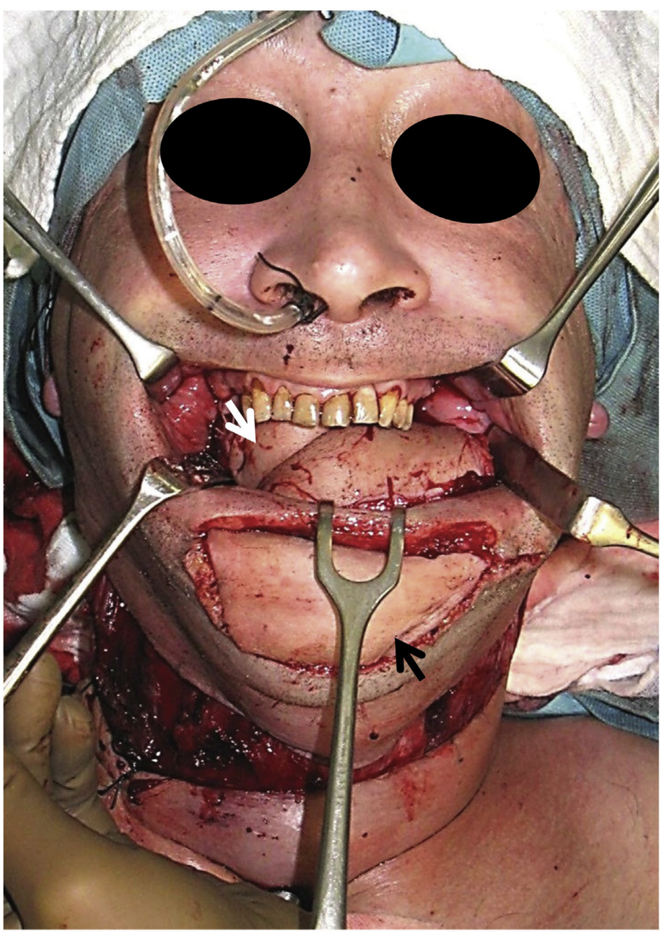

Fig. 3. Intraoperative photograph showing soft tissue reconstruction (white arrows) after resection of a large T4 squamous cell carcinoma of the anterior floor of the mouth. The soft tissue component of the flap covers both the intraoral and extraoral part of the defect (white arrow). The proximal part of the 20 × 10 cm skin paddle has enorally been folded to impart bulk to the new tongue and to replace the entire floor of the mouth. The distal part of the flap reconstructs the resected skin extraorally. The intraoral (white arrow) and extraoral (black arrow) parts of the soft tissue component are indicated.

Fig. 4. Intraoperative photograph showing soft tissue reconstruction in the same patient shown in Fig. 3. The distal third of the skin paddle of the flap was positioned extraorally, in order to replace the skin in the chin area.

Table 3
TDAP-Scap-aa characteristics: Detailed characteristics of the TDAP-Scap-aa used for extensive oromandibular defect reconstruction due to oncologic surgery.

TDAP-Scap-aa characteristics					
Case no.	Flap entity		Donor site (left/right)	Anastomosis (artery)	Preservation of nerve[a] (yes/no)
	Hard tissue	Soft tissue			
1	X	X	right	Facial artery	Yes
2	X	X	left	Superior thyroid artery	Yes
3	X	X	right	Lingual artery	Yes
4	X	X	right	External carotid artery	Yes
5	X	X	left	Superior thyroid artery	Yes

TDAP-Scap-aa: chimeric, thoracodorsal, perforator-scapular flap based on the angular artery.
[a] Thoraco-dorsal nerve; anastomosis: exoral; hard tissue: scapular bone; soft tissue: skin.

Table 4
Postoperative complications after tumor resection and reconstruction with a TDAP-SCAP-aa classified using the standardized Clavien-Dindo Classification (Clavien et al., 2009).

Postoperative complications	
Case no.	Grade[a]
1	I
2	I
3	II
4	II
5	II

TDAP-Scap-aa: chimeric, thoracodorsal, perforator-scapular flap based on the angular artery.
Note: All complications that occurred after the surgical procedure were solved with conservative treatments.
[a] Clavien-Dindo Classification for complications (Grade I–VII).

Oberkochen, Germany) and microsurgical sutures (sizes 9-0 and 10-0).

4. Discussion

The principal objectives in oromandibular reconstructions are the maintenance of the oral competence, the bite force (facilitating mastication) and satisfactory aesthetics (Cordeiro and Hidalgo, 1995; Futran and Mendez, 2006).

In extensive oromandibular defect reconstruction, these goals are usually achieved by using multiple or double free flaps (Bianchi et al., 2010a, 2010b). In anterior mandibular defect reconstruction, a bone-containing free flap is mandatory. Otherwise, the lack of support for the suprahyoid musculature, the inferior lip and the lateral segments of the mandible trigger oral incompetence, the Andy-Gump deformity, glossoptosis and/or airway obstruction (Cordeiro et al., 1999). If the defect additionally includes the tongue or involves the floor of the mouth, the use of an osteocutaneous flap with a skin paddle alone may limit the functional tongue mobility, which compromises speech and swallowing (Bianchi et al., 2003; Andrades et al., 2009). In such cases, a second free flap may be harvested to reconstruct the form and function of the residual structures (Wei et al., 1999a; Futran and Mendez, 2006; Posch et al., 2007; Andrades et al., 2009). Specifically, when lateral mandibular defects involve bone structures and large amounts of oropharyngeal soft tissues, a combination of a bone-containing free flap and a second soft tissue flap may be needed. In such extended oral defects, a double free flap is strongly indicated to reduce the functional impairment leading to scar retractions and further to a limited tongue mobility and oropharyngeal function (Wei et al., 1999b).

Over the past decades, the reconstruction of such extended defects has been managed using multiple or double free flaps. The survival rates of these flaps range from 93% to 100% and are similar to single free flaps (Futran and Mendez, 2006). Nevertheless, some concerns remain.

First, double free flaps are associated with high morbidity and mortality. The rates of early and late complications are also high, ranging from 30% to 50% (Gabr et al., 2004; Jeng et al., 2005; Futran and Mendez, 2006; Posch et al., 2007; Andrades et al., 2009), which reflects the complexity of double free flap reconstruction techniques and the resulting high patient vulnerability associated with poor general and nutritional conditions (Yazar et al., 2005). The second issue is the selection of the right recipient vessels. In contrast to non-operated necks where two sets of vessels can be found generally easily for a double free flap connection, it may be necessary in previously operated and irradiated necks to expose vessels on the contralateral side (Cordeiro et al., 1999; Bianchi et al., 2010a, 2010b), or to consider the possibility of an additional free flap in the case of flap failure, severe complications or second primary cancer (Bianchi et al., 2010b). The third disadvantage of multiple free flaps is the long operation time, which is exhausting for the patient, although this can probably be reduced if several surgical teams work efficiently together.

These issues have encouraged the search for alternatives to double free flaps in the past decades.

According to some authors, the principal objectives in oromandibular reconstructions (Cordeiro and Hidalgo, 1995) can also be achieved by exploiting the versatility of chimeric flaps from the thoracodorsal system (Wei et al., 1999b; Dolderer et al., 2010; L'Heureux-Lebeau et al., 2013; Shaw et al., 2015).

However, the main drawback related to the majority of such composite flaps from the thoracodorsal system is the use of a musculocutaneous latissimus dorsi flap as a skin paddle (Shaw et al., 2015). Particularly relevant is the bulkiness of the soft tissues and the donor site morbidity caused by the scarification of the muscle and thoracodorsal nerve.

To overcome these problems, Agrigiani et al. developed the thoracodorsal artery perforator flap (TDAP) in the early 1990s (Angrigiani et al., 1995; Cordeiro and Hidalgo, 1995). Although this flap has been principally used for breast reconstructions, the TDAP is also ideal in head and neck reconstructions for the following reasons: 1) two surgical teams can work simultaneously; 2) the skin paddle can cover large areas of skin or mucosa; 3) the suprafascial thickness can be decreased to obtain a very thin and uniform paddle that is comparable to that of a forearm flap; 4) the hairless nature of the skin paddle allows it to be used for intraoral reconstruction; 5) the length of the pedicle (15 cm on average) and the size of the vessels permit microvascular anastomoses; 6) if the perforator is damaged, the skin paddle can be repositioned during the operation and another perforator can be found, or the flap can be converted into a latissimus dorsi flap; 7) there is minimal donor site morbidity (muscle strength, range of shoulder motion) due to the preservation of the latissimus dorsi motor nerve; 8) the donor site can be self-closed, which leaves behind only a hidden axillary

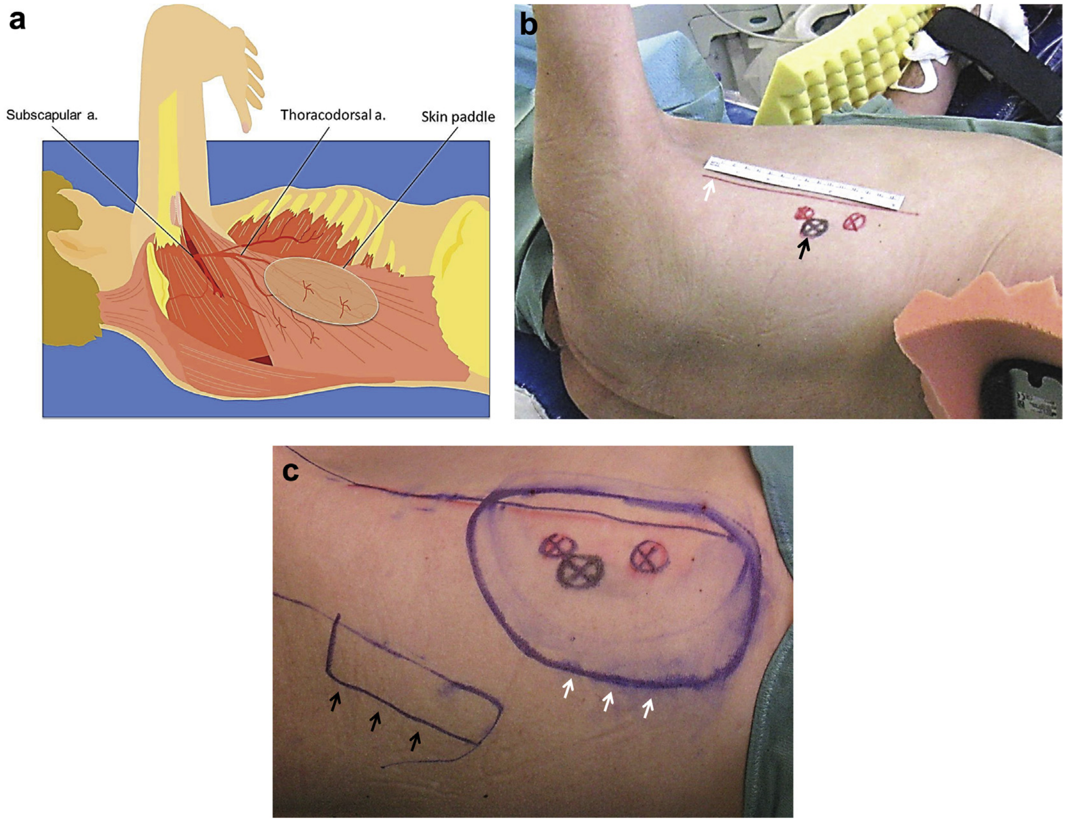

Fig. 5. (a–c) Representation of the position of the patient and the anatomy during flap harvesting. The flap is raised after tumor ablation and neck dissection, with the patient in the lateral decubitus position and the arm fixed in 90° of abduction. Doppler ultrasound was performed the day before operation to precisely locate the perforator around the skin paddle. (a) Schematic view. Note: a. = artery. (b) Intraoperative overview showing the incision line (white arrow) and the Doppler sound verified perforators (black arrow). (c) Detailed view showing the skin paddle design (white arrow) and the localization of the scapular bone (black arrow).

scar; and 9) the possibility that all free composite flaps of the axillary region can be linked together to a thoracodorsal artery perforator flap paddle (Bacha et al., 2012).

Later, in 2015 Shaw et al. described a chimeric flap from the subscapular vessels when combining a scapular flap based on the circumflex scapular artery with a TDAP flap, termed the TDAP-Scap (Shaw et al., 2015). Accordingly, the chimeric TDAP-Scap afforded abundant volume, design flexibility, large vessels and minimal donor site morbidity (Wei et al., 1999a), which render the TDAP-Scap an excellent alternative to double free flaps for oro-mandibular defect reconstruction.

Nevertheless, this method shows two main limitations: first, the relatively short pedicle associated with the use of the circumflex scapular vessels, and second, the time taken to turn the patient, which is associated with a prolonged operating time (Shaw et al., 2015).

Fig. 6. Intraoperative photograph of the same patient shown in Figs. 1 and 3. The flap has been raised and the pedicle dissected to the subscapular artery and vein. The white arrow indicates the localization of the main perforators in the soft tissue component that were verified using Doppler ultrasound prior to dissection. View from the right side.

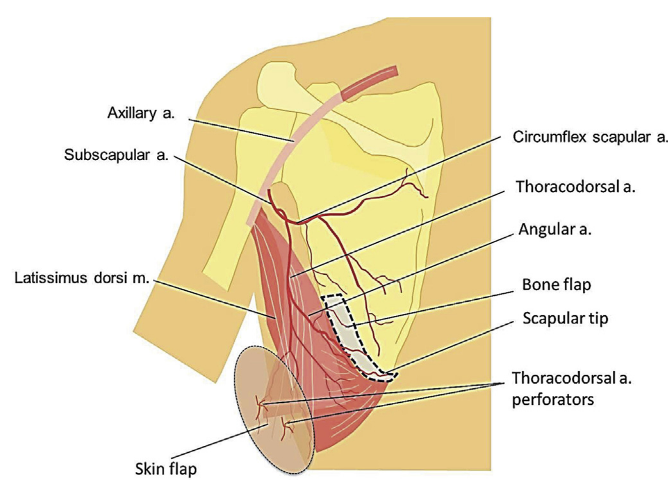

Fig. 7. Schematic representation of the anatomy and components of the chimeric, thoracodorsal artery perforator-scapular free flap based on the angular artery (TDAP-Scap-aa). Note: a. = artery.

In our opinion, the first issue can be addressed by harvesting the lateral border of the scapula based on the angular artery (Kärcher, 1991; Coleman and Sultan, 1991). The angular branch of the thoraco-dorsal artery is consistently between 2.5 and 8 cm in length (Coeugniet et al., 2007) and ensures a sufficiently supplied and reliable bone segment that can be harvested up to 20 cm in length from either the medial or the lateral scapula (Seneviratne et al., 1999). In this context, the anatomy of angular branch-based free scapular flaps was already highlighted in the literature (Kärcher, 1991; Coleman and Sultan, 1991; Choi et al., 2015). These highlights were reported to be excellent advantages (pedicle length, nature of bone quality, donor site morbidity) in complex oromandibular and midfacial reconstructions (Seneviratne et al., 1999).

As it was described by Choi et al. (2015), we also harvested the lateral border of the scapular bone based on the angular branch, but additionally we combined this flap with an independent perforator-based soft tissue skin paddle, accordingly to the perforator flap technique described by Angrigiani et al. (1995). We termed this free flap a "chimeric, thoracodorsal perforator-scapular flap based on the angular artery" ("TDAP-Scap-aa") (Fig. 7).

An important concern about chimeric osteocutaneous free flaps from the subscapular system including the TDAP-Scap-aa is the time taken to intraoperatively turn the patient for the flap-raising procedure (Fig. 5), which may lead to a prolonged operation time (Wei et al., 1999a). However, as mentioned before, optimization of the operation time is also one of the main issues in double free flap harvesting.

In order to address this limitation, Wei et al. (1999b) developed an efficient work flow concerning the simultaneous work of multiple surgical teams (Wei et al., 1999b; Wallace et al., 2014). Using this work flow in multiple free flap harvesting, average

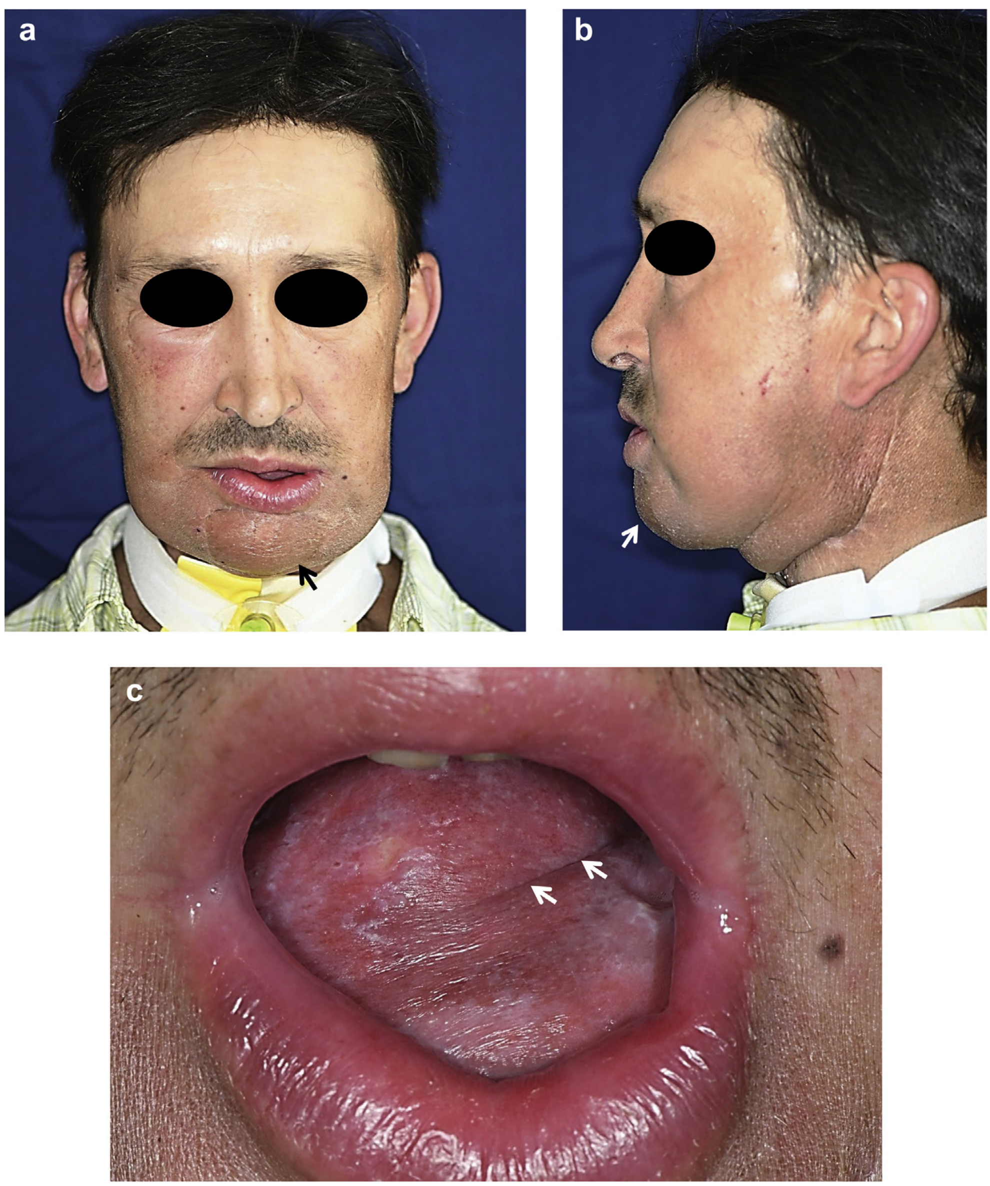

Fig. 8. (a–c) View of the patient shown in Fig. 3 and after 1 month after adjuvant radiation therapy when wound healing was finished. (a) View from the front. The black arrow indicates the distal part of the skin paddle that replaces the skin in the chin area. (b) View from the left side. The arrow indicates the skin paddle of the flap (c) Intraoral view. The proximal part of the skin paddle was used to cover the entire floor of the mouth and has been folded (white arrow) to a new tongue. Note: A tracheostoma protects against aspiration because of swallowing impairments due to radiation therapy and surgical sequelae.

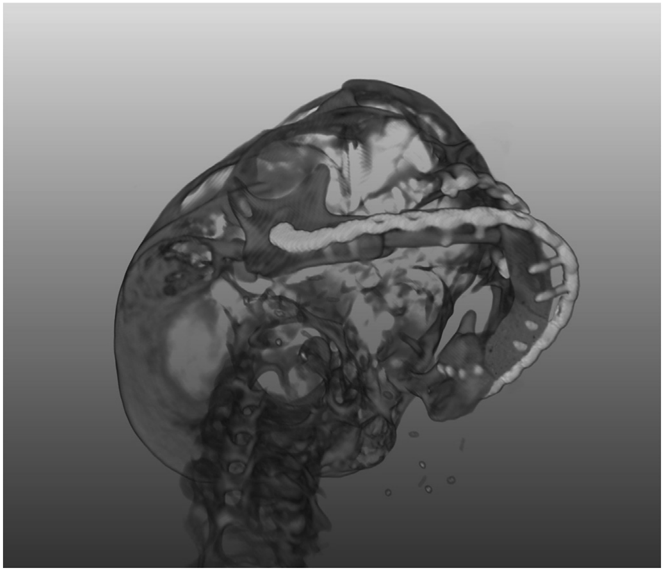

Fig. 9. Postoperative radiological result after extensive tumor resection and oromandibular reconstruction with a TDAP-Scap-aa at the time when wound healing was finished. A three-dimensional computed tomographic image reconstruction was performed for a better radiological assessment. To achieve an adequate mandibular shape, the scapular bone was osteotomized in three segments and fixed bicortically with a conventional 2.5-mm reconstruction plate to the mandible. View from below, showing the mandible and all three bone segments of the flap. The contour of the scapular approximates that of the mandible on the left and the right sides.

operative times are described to be about 14 h 25 min (Wei et al., 1999b).

In our clinical experience, the average operation time for raising a TDAP-Scap-aa is similar to the operation times reported for double free flaps (Wei et al., 1999b). Nevertheless, the harvesting of a TDAP-Scap-aa does in fact take longer in comparison to other osteocutaneous single flaps that can be raised in the supine position when using a two-team approach. This prolonged operation time due to the patient-turning procedure can be a disadvantage of the TDAP-Scap-aa when compared to other single osteocutaneous flaps. However, the operation time needed for the TDAP-Scap-aa does not limit this flap-raising technique in comparison to other double free flap methods.

Using the TDAP-Scap-aa technique, we could further observe high amounts of reliable bone components that can be harvested from the lateral scapular bone when the angular branch of the thoracodorsal vessels is used as a blood supply. These amounts of harvested bone were higher than those already described in previous works that investigated free angular branch-based scapular flaps (Dolderer et al., 2010; Choi et al., 2015; Tracy et al., 2019) (Table 2).

5. Conclusion

In our clinical experience, the TDAP-Scap-aa provides several advantages for extensive oromandibular defect reconstruction. The TDAP-Scap-aa does the following: 1) it offers large amounts of soft and hard tissues such as pliable skin and nature bone; 2) it provides two components that are completely independent from each other; 3) it has only one donor site; 4) it provides highly flexible soft tissues that can cover large three-dimensional intraoral and/or extraoral defects (Figs. 1 and 3); 5) it provides a thickness and volume reduced skin paddle for intraoral lining (Figs. 3 and 8); 6) it provides a skin and bone component based on the same pedicle, which avoids a second anastomosis (Fig. 6); 7) it reduces the overall morbidity in comparison to a musculocutaneous latissimus dorsi flap or to a double free flap; 8) it provides a very long pedicle that allows a microvascular anastomosis over a long distance (Fig. 6) and even to the contralateral side; 9) it provides a donor site that can be self-closed and that leaves behind only a hidden axillary scar; and 10) it does not cause prolonged operation times compared to double/multiple free flaps. Moreover, the TDAP-Scap-aa showed satisfying aesthetic results, both clinically and radiologically (Figs. 8 and 9).

Author contributions

Conceived and designed this work: MP, JW. Performed the operation: MP, JW, MF. Analyzed the data: MP, JW, JCD. Contributed reagents/materials/analysis tools: MP, JW, MF, MS, JE, JCD, RW, NJ, WZ. Wrote the paper: MP, JW.

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Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2019.07.021.

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