BRITISH
Journal of
Oral and
Maxillofacial
Surgery

Microvascular reconstruction and dental rehabilitation of benign severely atrophic jaws and defects of the alveolar ridge: our philosophy in 2019

Gian Battista Bottini *, Christian Brandtner, Christoph Steiner, Jörn Wittig, Felix Hartig, Corina List, Alexander Gaggl

Department of Oral and Maxillofacial Surgery, University Hospital of the Private Medical University Paracelsus, Müllner Hauptstraße 48, A-5020 Salzburg, Austria

Abstract

We deal regularly with patients who present with severe atrophy of the jaws, compromised soft tissue, or penetrating defects of the alveolar ridge that are not the result of malignant disease. For these patients we use microvascular bony flaps together with dental implants and implant-supported prostheses. The purpose of this retrospective study was to present our current management and the lessons we have learned over a 16-year period while treating 86 patients for these indications with 87 microvascular bone flaps. We used a transoral approach for the anastomosis in 60 flaps, thereby avoiding visible scars, and inserted 281 dental implants to support fixed or removable dental prostheses. Two femoral flaps developed partial necrosis, and seven implants were lost. Eighty-five of the 86 patients were satisfied with the improvement in their orofacial function and aesthetics. Poor oral hygiene, active osteomyelitis, and severe bruxism are absolute contraindications.

Introduction

We often deal with patients who present with generalised, severe atrophy of the jaw (class V–VI according to the Cawood and Howell classification),[1] and where removable tissue-borne dentures cannot offer adequate retention, stability, and support. Most of these patients have already had many augmentations and dental implants that have subsequently failed, resulting in additional defects. In these cases short implants are not indicated, either because the bone of

the maxilla is paper-thin, or because there are high risks of fracture or close proximity to the inferior alveolar nerve in the mandible.

Other patients have segmental defects of the alveolar ridge including: loss of the premaxilla; alveolar and palatal clefts with persisting oronasal fistulas in patients with cleft palate; the results of severe trauma; or iatrogenic defects after debridement for osteomyelitis or removal of large cysts. Ultimately they are all "dental amputees", affected by considerable reduction in their quality of life[2] and wishing to smile, chew, and speak with confidence.

The purpose of this retrospective study was to present our current management protocol, and describe the lessons that we have learned in treating these challenging cases over a 16-year period (Table 1).

_____

* Corresponding author.
    E-mail addresses: g.bottini@salk.at (G.B. Bottini), c.brandtner@salk.at (C. Brandtner), c.steiner@salk.at (C. Steiner), j.wittig@salk.at (J. Wittig), f.hartig@salk.at (F. Hartig), corina.list@wienkav.at (C. List), a.gaggl@salk.at (A. Gaggl).

Table 1
Checklist and decision tree for rehabilitation of "dental amputees".

1. Patients with poor oral hygiene, acute osteomyelitis, psychiatric disorders, severe bruxism, or substance abuse are excluded from treatment with implants and reconstruction
2. If there is a history of failed dental implants and augmentation, we consider a microvascular flap
3. Influence of the degree of atrophy of bone — if it is:
   * mild — we use graftless approaches
   * moderate — we use grafts
   * severe — we use flaps
4. Influence of soft tissue conditions — if they are:
   *good we use graft-less/grafts
   * poor we use flaps
5. Influence of length of localised alveolar bone defect: — if it is:
   * <3 cm we use grafts
   * >3 cm we use flaps

Fig. 1. Maxillary defect in a patient with a cleft after loss of teeth as a result of periapical and marginal periodontitis and complete resorption of a bone graft with loss of three dental implants from peri-implantitis.

Patients and methods

Series 1: 2003–2010

Between 2003 and 2010 the senior author treated 40 patients at another unit. In this group, 14 patients had been edentulous for some time, and 10 of them had generalised, severe, atrophy of the jaw. Other conditions included post-traumatic defects (n = 16), cleft palate (n = 5), and debridement for osteomyelitis (n = 5). Eleven of the maxillary defects communicated with the nasal cavity or the maxillary sinus. Thirty-five of the 40 patients had already had 1–6 previous failed attempts at reconstruction and dental rehabilitation in the form of implants, osteodistraction, free non-vascularised autografts, and xenografts (Fig. 1). Most of these patients presented with extensive scarring and atrophic soft tissues. The first intervention in all cases was reconstruction of the alveolar ridge with microvascular free flaps (medial femoral condyle (MFC) (n = 18), deep circumflex iliac artery (DCIA) (n = 12), and fibular free flaps (FFF) (n = 10), for a total of 21 reconstructions of the mandible and 19 of the maxilla). Of those cases (27/40) had intraoral anastomoses (Fig. 2).[3,4]

Fig. 2. Position and exposure of the recipient's vessels for intraoral anastomosis (facial artery and vein).

A total of 136 dental implants were inserted in those flaps (3.4 implants/flap) 4–6 months after microvascular surgery, loading taking place 4–6 months after implantation. Six vestibuloplasties were done later to improve the condition of the peri-implant soft tissues.

Series 2: 2011–2018

Building on the experience of the first series, we have since treated 46 patients with similar diagnoses. We retrospectively analysed their records for diagnosis, treatment, complications, and outcomes.

We have excluded all tumour-related reconstructions (immediate reconstructions after resections of head and neck tumours and delayed reconstructions for osteoradionecrosis, non-union, or medication-related osteonecrosis of the jaws). We also excluded two non-compliant patients: one with extremely poor oral hygiene and the other with severe parafunctional habits and bruxism who later developed a psychiatric disorder.

There were 20 men and 26 women, with a mean (range) age of 45 (15–79) years.

Eight patients had generalised severe atrophy as a result of longstanding edentulism, one had oligodontia, and one had pycnodysostosis. Three had localised segmental defects of the alveolar ridge as a result of edentulism, and they all had a history of failed dental implants and augmentations. Six further patients had post-traumatic defects, and the others had cleft palate (n = 16), segmental defects after debridement for osteomyelitis (n = 8), and removal of a large cyst (n = 3).

For reconstruction of these 46 patients we used MFC flaps (n = 39), FFF (n = 5), scapular flaps (n = 2), and one DCIA flap (one patient had two flaps). We reconstructed the maxilla in 35 cases (Fig. 3) and the mandible in 12. As well as raising an MFC flap, we also harvested non-vascularised bone grafts from the anterior iliac crest (n = 9) to improve the contours of the reconstructed segment (onlay grafts), for filling the gaps between the MFC and native bone, or using it as a graft to lift the sinus floor. We covered the onlay grafts with the vascularised periosteum of the MFC flap.
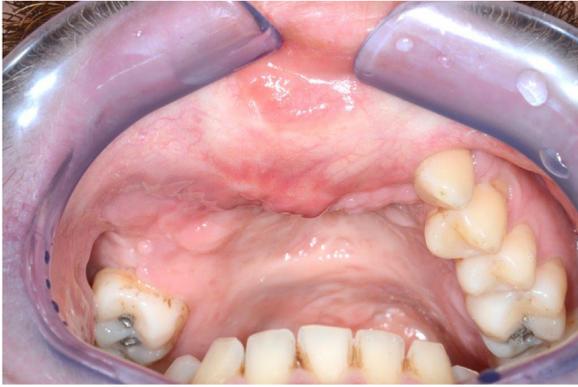
Fig. 3. Maxilla after reconstruction of the alveolar ridge with a medial femoral condylar flap.

Fig. 4. Outcome after implant-borne fixed dental prostheses.

Surgical techniques for raising the FFF, scapular, and DCIA flaps have been described extensively elsewhere.[5–7] For the MFC flap, we refer to the descriptions by Gaggl et al,[8] Brandtner et al,[9] and Wong et al.[10] We never used a tourniquet. We were able to anastomose the vessels by a transoral approach in 33 of the 47 flaps. In the remaining 14 flaps, we used an extraoral approach consisting of a 3 cm long submandibular incision within a skin crease.

The mean (range) duration of hospital stay was 13 (6–31) days.

Four months after flap surgery with FF, DCIA, and scapular flaps, and six months after MFC flaps, we defined in 3-dimensions the ideal number and positions of the implants according to the principle of backward planning (Planmeca ProMax® 3D Max, software Planmeca Romexis®).

We used surgical guides to locate the ideal position for the implants at operation. For particularly complex cases we used surgical navigation templates (Implant 3D® software, Med 3D, positioning device X1med 3D, Schick Dental).[11] We inserted a total of 145 dental implants (Straumann), roughly three implants in each flap (range 1–6), all submerged.

We loaded the implants four months after insertion in FF, DCIA, and scapular flaps, and six months after MFC flaps, because of the softer consistency of the bone in this flap. We favour implant-supported removable overdentures in cases of total edentulism, and fixed dental prostheses for localised defects.

Results

Series 1: 2003–2010

In the first series, all transplants healed. Three patients reported hypoaesthesia of the lateral thigh after harvest of the DCIA flap, and one revision of a scar at the donor site was necessary after harvest of a FFF. Three implants out of 136 (2%) did not osseointegrate. Functional and aesthetic results were satisfactory in all cases (Fig. 4).

Series 2: 2011–2017

Two of the MFC flaps in this group partially necrosed and required debridement, but we could still insert implants in the flaps after they had healed. We lost 4/145 implants (3%).

In one patient with DCIA flaps, we had to remove two implants (out of three) because of recurrent osteomyelitis of the transplant. The infection spread from the recipient site to the flap and proved refractory to medical treatment despite several courses of targeted antibiotics intravenously. The same patient developed a haematoma of the abdominal wall and later a hernia despite the use of a mesh to prevent herniation. After removal of two implants and debridement, this patient is currently free from infection. The third implant has partially integrated but cannot support a dental prosthesis. We are not planning to insert any more implants given the high risk of recurrence of osteomyelitis in this case.

We had one case of sensitivity and motor deficit of the lower extremity (complex regional pain syndrome) after harvest of an MFC flap that resolved in six months with physiotherapy.

Forty-five of the 46 were satisfied with their improvements in orofacial function and aesthetics.

Discussion

Different options are available for reconstructing and rehabilitating patients with advanced atrophy of the jaw: graft-less (short and tilted implants, zygomatic implants, and osteodistraction), bone grafts, and free flaps.

Graft-less

Using short or tilted implants is the simplest and most cost-effective solution and can be done safely under local anaesthesia with minimal trauma and a short recovery time. It is more straightforward and has fewer complications than augmenting and inserting standard implants.[12,13] However, short and tilted implants cannot be used when the alveolar ridge is missing entirely, when the basal bone is paper-thin

(maxilla), or when they would cause a mandibular fracture (residual mandible height less than 6 mm) or injury to the neurovascular bundle.

Zygomatic implants require considerable skill and general anaesthesia. They are associated with severe immediate complications (such as perforation of the orbit or the brain), or delayed complications such as recurrent sinusitis and infections even years after placement.[14,15] Their failure rate is high (11%)[15] and their removal can be challenging, so we do not use them.

Osteodistraction can augment the alveolar ridge, either by splitting the bone or using distractors.[16,17] However, this technique has limitations: osteodistraction in three directions is not possible and the basal bone has to be high enough with sufficient vascularisation and regenerative potential for it to be successful. Distractors are technique-sensitive and can require regular long-term follow-up and good compliance from the patient. Given these difficulties we have abandoned them, despite achieving good outcomes.

Bone grafts

Autografts have osteoconductive, osteoinductive, and osteogenetic potential.[18] The drawbacks are complications that are related to harvest and donor-site morbidity. Bone grafts function as scaffolds that are gradually resorbed and substituted by living bone. Their "take" depends on the recipient bed and, when local vascularity is poor, creeping substitution is not possible and the graft is lost.[19]

For a severely atrophic maxilla, Chiapasco et al combined interpositional bone grafts with a Le Fort I osteotomy to improve intermaxillary relations.[20] However, they excluded patients with extensive scarring because of the high risk of maxillary necrosis, and instead used reconstruction with a FFF.[20]

Free flaps

The size of a critical-sized bone defect is a matter of debate. Schemitsch pointed out that not only size matters but also anatomical location, condition of soft tissues, age, and comorbid conditions.[21] Allsopp et al made a systematic review to identify a cut-off value between grafts and vascularised flaps in the reconstruction of a bony defect, but could not find any convincing evidence to pinpoint a value, though they did concede that vascularised transplants outperform grafts as their length increases.[22] Benlidayi et al showed that, even in a healthy animal model with greater healing potential than a human and with optimal soft tissue conditions, free bone flaps maintain their microscopic architecture better than grafts because they do not degenerate with resorption and substitution.[23] We have identified three main indications for using microvascular flaps for reconstruction of the alveolar ridge in patients without tumours.

The first is hard tissue atrophy - generalised severe atrophy of the jaw (class V–VI according to Cawood and Howell).[1]

The second is soft tissue atrophy, as when the recipient bed has depleted vascularity and atrophic or scarred soft tissues such as in patients with cleft palate, after trauma, or after multiple operations. Thirdly, we use them for localised penetrating defects of the alveolar ridge more than 3 cm long.

We use four bony flaps for these conditions:

1. *The MFC flap:* which is ideal for localised defects. Gaggl et al were to our knowledge the first to describe its use in the reconstruction of the alveolar ridge in 2008.[8] Its advantages over the FFF are lower donor site morbidity and much greater flexibility in size, design, and indications. The cuff of soft tissue is thin, like the gingiva. Grafts harvested from the iliac crest can then be added to the MFC with a reduced risk of resorption, despite poor vascularity at the recipient site, if the vascularised femoral periosteum of the MFC flap covers them.

The MFC flap is suitable for placement of an implant because of the thin cortical layer. The bone is soft, and this must be borne in mind when inserting dental implants. For this reason, we delay loading the implants for six months. Patients can then usually bear weight immediately and make a full recovery of power and range of movement in a matter of weeks. We refrain from dissecting the infrapatellar branch of the saphenous nerve to avoid sensory disturbance in the infrapatellar area.

2. *The FFF:* for which the primary indication is generalised severe atrophy in the maxilla and the mandible (class V–VI according to Cawood and Howell).[1] We also use it for bridging continuity defects in severely atrophic mandibles. It offers plenty of bone of excellent quality for placement of an implant, and can be cut to follow the curves of the alveolar ridge.[24]

It is not suitable for normal mandibles unless it is "double-barrelled",[7] and is not an option if the peroneal artery is the dominant or sole supply to the foot, as is sometimes the case in patients with peripheral vascular disease.[25] Donor-site morbidity consists of pain and disturbance of gait, whereas complications are seromas, sensory and motor lesions, and prolongation of recovery.[7]

3. *The DCIA flap:* which is well-suited for reconstruction of defects up to 10 cm long in the alveolus and the basal bone in normal mandibles. We also use it for reconstructing maxillary defects that extend up to the midline (alveolus and palate). It is associated with more serious donor site morbidity than the MFC or the FFF flaps (dysaesthesia, pain, disturbance of gait, hernia, and seromas), but this depends on the volume of the muscle cuff. It may be quite bulky or difficult to raise with a small soft tissue component, particularly in overweight patients, so its volume can be excessive for reconstruction of defects of the alveolar ridge.

4. *The scapula flap:* because it is flat, it is suitable for covering palatal and alveolar defects that extend beyond the midline, and subtotal or total maxillary defects. However, only the lateral margin and the tip offer enough height for placement of implants, and even those areas can be too thin in

Table 2
Specific indications for a bony flap according to the size and morphology of the bony defects and the jaws involved.

Bony defect	Flap
1. Localised defects of alveolar bone in both jaws	Medial femoral condyle
2. Generalised severe atrophy of the alveolar bone in both jaws	Free fibular
3. Continuity defects in the severely atrophic mandible	Free fibular
4. Localised defects of alveolar and basal bone <10 cm in length in normal mandibles	Deep circumflex iliac artery
5. Defects of alveolus and palate < midline in the maxilla	Deep circumflex iliac artery
6. Defects of alveolus and palate > midline, subtotal and total in the maxilla	Scapular

small patients. Soft tissue is nearly always bulky, and inserting dental implants can be technically challenging (Table 2).

Contraindications to implants and flaps

Good oral hygiene is essential to prevent breakdown of the wound, infection of the transplant, and peri-implantitis. Poor oral hygiene and acute osteomyelitis are absolute contraindications to microvascular flaps for reconstruction of the alveolar ridge and insertion of implants, and severe bruxism and parafunctional habits can cause mechanical failure of the implants. In patients with recurrent osteomyelitis, several treatments with antibiotics may have selected multidrug-resistant bacteria, and dental implants can then harbour a biofilm that is impossible to eradicate and acts as a reservoir that perpetuates the cycle of infection. In such cases a conventional mucosa-supported denture resting on the neoalveolus is a safer option.

Conclusions

Reconstructing missing parts of the masticatory system with microvascular flaps and implant-borne prostheses is a complex undertaking. It implies major surgery and multiple interventions, considerable financial costs, time out of work, and donor site morbidity.

Even if restitution to its original condition is not achievable, compromised aesthetics and orofacial function can improve, and patients' feedback is encouraging. We therefore feel that the long-term benefits of an improved quality of life outweigh the risks and the burden of treatment.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

No ethics approval or patients' permission was required for this paper. Patients' permission was not required as no identifying information is included.

References

1. Cawood JI, Howell RA. A classification of the edentulous jaws. *Int J Oral Maxillofac Surg* 1988;**17**:232–6.
2. Emami E, De Souza RF, Kabawat M, et al. The impact of edentulism on oral and general health. *Int J Dent* 2013;**2013**:498305.
3. Gaggl A, Bürger H, Virnik SA, et al. An intraoral anastomosing technique for microvascular bone flaps in alveolar ridge reconstruction. First clinical results. *Int J Oral Maxillofac Surg* 2009;**38**:921–7.
4. Brandtner C, Bürger H, Hachleitner J, et al. The intraoral anastomosing technique in reconstructive surgery of the face — a consecutive case series of 70 patients. *J Craniomaxillofac Surg* 2015;**43**:1763–8.
5. Wolff KD, Hölzle F. *Raising of microvascular flaps. A systematic approach*. Berlin: Springer; 2005.
6. Urken ML, Cheney ML, Sullivan MJ, et al. *Atlas of regional and free flaps for head and neck reconstruction*. Philadelphia: Lippincott Williams & Wilkins; 1996.
7. Kerawala C, Newlands C. *Oral and maxillofacial surgery*. Oxford: Oxford University Press; 2010.
8. Gaggl AJ, Bürger HK, Chiari FM. Free microvascular transfer of segmental corticocancellous femur for reconstruction of the alveolar ridge. *Br J Oral Maxillofac Surg* 2008;**46**:211–7.
9. Brandtner C, Hachleitner J, Bottini GB, et al. Microvascular medial femoral condylar flaps in 107 consecutive reconstructions in the head and neck. *Br J Oral Maxillofac Surg* 2016;**54**:614–8.
10. Wong VW, Higgins JP. Medial femoral condyle flap. *Plast Reconstr Surg Global Open* 2016;**4**:e834.
11. Wolfart S. *Implant prosthodontics. A patient-oriented strategy*. Quintessence Publishing International; 2016. p. 138–78.
12. Esposito M, Grusovin MG, Felice P, et al. The efficacy of horizontal and vertical bone augmentation procedures for dental implants −a Cochrane systematic review. *Eur J Oral Implantol* 2009;**2**:167–84.
13. Esposito M, Felice P, Worthington HV. Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. *Cochrane Database Syst Rev* 2014;**5**:CD008397.
14. Chrcanovic BR, Abreu MH. Survival and complications of zygomatic implants: a systematic review. *Oral Maxillofac Surg* 2013;**17**:81–93.
15. Esposito M, Worthington HV. Interventions for replacing missing teeth: dental implants in zygomatic bone for the rehabilitation of the severely deficient edentulous maxilla. *Cochrane Database Syst Rev* 2013;**9**:CD004151.
16. Gaggl A, Schultes G, Kärcher H. Distraction implants: a new operative technique for alveolar ridge augmentation. *J Craniomaxillofac Surg* 1999;**27**:214–21.
17. Krenkel C, Grunert I. The Endo-Distractor for preimplant mandibular regeneration. *Rev Stomatol Chir Maxillofac* 2009;**110**:17–26.
18. Elsalanty ME, Genecov D. Bone grafts in craniofacial surgery. *Craniomaxillofac Trauma Reconstr* 2009;**2**:125–34.
19. Oppenheimer AJ, Mesa J, Buchman SR. Current and emerging basic science concepts in bone biology: implications in craniofacial surgery. *J Craniofac Surg* 2012;**23**:30–6.
20. Chiapasco M, Brusati R, Ronchi P. Le Fort I osteotomy with interpositional bone grafts and delayed oral implants for the rehabilitation of extremely atrophied maxillae: a 1-9-year clinical follow-up study on humans. *Clin Oral Implants Res* 2007;**18**:74–85.
21. Schemitsch EH. Size matters: defining critical in bone defect size! *J Orthop Trauma* 2017;**31**(Suppl. 5):S20–2.

22. Allsopp BJ, Hunter-Smith DJ, Rozen WM. Vascularized versus non-vascularized bone grafts: what is the evidence? *Clin Orthop Relat Res* 2016;**474**:1319–27.

23. Benlidayi A, Gaggl A, Buerger H, et al. Comparative study of the osseous healing process following three different techniques of bone augmentation in the mandible: an experimental study. *Int J Oral Maxillofac Surg* 2014;**43**:1404–10.

24. Chiapasco M, Romeo E, Coggiola A, et al. Long-term outcome of dental implants placed in revascularized fibula free flaps used for the reconstruction of maxilla-mandibular defects due to extreme atrophy. *Clin Oral Implants Res* 2011;**22**:83–91.

25. Oxford L, Ducic Y. Use of fibula-free tissue transfer with preoperative 2-vessel runoff to the lower extremity. *Arch Facial Plast Surg* 2005;**7**:261–5.