1 96 171

British Journal of Oral and Maxillofacial Surgery (1996) **34**, 379–385
© 1996 The British Association of Oral and Maxillofacial Surgeons

BRITISH JOURNAL OF ORAL & MAXILLOFACIAL SURGERY

Mandibular reconstruction with full thickness calvarial bone and temporal muscle flap

K. W. Grätz, H. F. Sailer, P. E. Haers, Ch. K. Oechslin

Department of Cranio-Maxillofacial Surgery, University Hospital Zurich, Zurich, Switzerland

SUMMARY. **Eleven patients underwent mandibular reconstruction with pedicled temporal muscle flaps combined with vascularised or free full thickness calvarial bone grafts. Six were primary and five secondary reconstructions. The indications were squamous cell carcinoma ($n=6$), radio-osteonecrosis ($n=4$), and gunshot wound ($n=1$). Five patients also had endosseus implants, either simultaneously or delayed. The only major complications were necrosis of the whole calvarial bone ($n=1$) and permanent facial nerve palsy ($n=1$). The advantages of using full thickness calvarial bone are that it is thick enough to take an endosseous implant, morbidity is low, there is virtually no postoperative pain, the scar is invisible, and there is only one donor area for both hard and soft tissue. Transplantation of full thickness calvarial bone and temporal muscle is a viable alternative to an osseomyocutaneous microvascularised free flap for reconstruction of the mandible when the neck has been previously operated on or irradiated, and anastomosis may be critical.**

INTRODUCTION

The goal of mandibular reconstruction after injury or ablative surgery is restoration of mandibular form and function. Bone grafting, stable osteosynthesis, and a well vascularised soft tissue recipient area are essential.

Apart from reports of heterologous bone transplantation into humans dating from the seventeenth and eighteenth centuries,[1] the first people to undertake systematic research into bone transplantation were Ollier,[2] Heine,[3] and Barth.[4] Lexer[5] published clinical reports about bone grafts, and Axhausen[6] reported experimental research about the interface between the graft and the surrounding tissue. Farmand[7] and Schmoker[8] have published historical reviews.

Calvarium was used as an osseocutaneous flap for covering defects in the skull by Müller,[9] and Koenig.[10] Bardenheuer[11] bridged a mandibular defect with a piece of frontal bone pedicled to the periosteum.

In 1972 Conley[12] designed a flap of temporal muscle and temporoparietal bone that was pedicled to the temporal vessels, and Antonyshyn *et al.*[13] and Casanova *et al.*[14] used the myo-osseous temporal flap in several anatomical and experimental studies. Tessier[15] reported a case in which the ascending ramus had been reconstructed with calvarial bone, and Combelles and Zadeh[16] reconstructed the mandible with a similar flap. Several other authors have also reported mandibular reconstruction with myo-osseous or osseomyofascial temporal flaps with either full or split thickness calvarial bone.[17–23] Wolfe[24] reconstructed the mandible and surrounding soft tissue with calvarial bone and a temporal muscle flap separately, and Matsuba *et al.*[21] and Habal and Rasmussen[25] successfully inserted implants 18 months and 4 years after mandibular reconstruction with cranial bone.

PATIENTS AND METHODS

Eleven patients underwent mandibular reconstruction with full thickness calvarial bone and temporal muscle between January 1991 and March 1993. Six were primary, and five secondary, reconstructions. The indications for operation were squamous cell carcinoma ($n=6$), radio-osteonecrosis ($n=4$), and gunshot wound ($n=1$). There were three women and eight men, mean age 55 years (range 24–68).

Two patients had a pedicled osseomyofacial temporal flap with bone from the parietal area, and in nine separate transplantation was done with free parietal bone and a temporal muscle flap vascularised by the deep temporal arteries. In one bilateral reconstruction (from one ascending ramus to the other) both calvarial bone and temporal muscle were raised on each side. Ten implants were inserted in five patients, in one at the same time as the mandibular reconstruction and in the others 4 weeks to 15 months later.

Four of the six patients with tumours had had radiotherapy preoperatively or postoperatively 2–3 years before reconstruction (one had 70 Gy, the others 50–60 Gy). The radiotherapy had been with photons generated by a 6 MV linear accelerator with a target dose of 1.80 Gy/fraction five times a week. All six patients had undergone radical dissection of the neck. Three of the four patients with radio-osteonecrosis had adjuvant treatment with hyperbaric oxygen.[26]

Table 1 – Details of patients who underwent reconstruction

Case no.	Age (years)	Sex	Diagnosis	Type of reconstruction	Type of flap
1	53	Male	Radio-osteonecrosis	Primary	Free
2	54	Male	Squamous cell carcinoma	Secondary	Pedicled
3	68	Female	Squamous cell carcinoma	Secondary	Pedicled
4	57	Male	Squamous cell carcinoma	Primary	Free
5	64	Male	Squamous cell carcinoma	Primary	Free
6	37	Male	Squamous cell carcinoma	Secondary	Free
7	67	Female	Radio-osteonecrosis	Primary	Free
8	63	Male	Radio-osteonecrosis	Primary	Free
9	52	Female	Squamous cell carcinoma	Secondary	Free
10	62	Male	Radio-osteonecrosis	Primary	Free
11	24	Male	Gunshot wound	Secondary	Free

Table 2 – Complication after 11 mandibular reconstructions

Complication	After operation for cancer			After operation for radio-osteonecrosis
	Primary	Secondary		
		Free flap	Pedicled flap	
Facial nerve palsy:				
Temporary	1	1	1	1
Complete	0	0	1	0
Infection and fistula	1	0	0	1
Necrosis of calvarial bone	1	0	0	0

Surgical technique

The hair is removed from an area 2 cm wide from ear to ear, and a skin flap including the parietotemporal fascia is raised along the avascular layer over the pericranium. The pericranium is incised in the supraorbital area so that the lateral aspect of the orbit and the zygomatic arch can be seen. The zygomatic arch is cut at the lateral orbital wall and in front of the tuberculum. The zygomatic complex remains pedicled to the masseter muscle and is moved laterally or removed. The coronoid process is removed either inside or outside the mouth. The temporal muscle is dissected in a subperiostial plane and mobilised (Fig. 1). At the same time a craniotomy is made on the non-dominant side with four to six burrholes. The calvarium is removed, shaped, and repositioned in the mandibular defect which has been defined precisely by positioning both mandibular fragments correctly with a temporary external fixation device. The bone graft is immobilised with miniplates or lag screws (Fig. 2). In primary reconstructions the bone graft is fixed directly to the stainless steel reconstruction plate.

The temporal muscle flap is moved within the mouth along the inner aspect of the ascending ramus and wrapped around the calvarial bone graft (Fig. 3.). When a myo-osseofascial temporal flap (in which the parietotemporal fascia is preserved with the superficial temporal vessels) is used, only a part of the temporal muscle is involved and the whole flap is moved laterally to the zygomatic arch towards the mandibular defect (Fig. 4).

The parietal cranial bone defect is filled with split thickness calvarial bone or with slices of lyophilised cartilage[27 28] and bone morphogenetic protein paste (BMP) (Fig. 5).[29 30] The zygomatic complex which was either moved laterally or removed is repositioned and immobilised with wire. The contour of the temporal fossa is restored with chips and slices of lyophilised cartilage which are covered with a pericranial rotation flap (Fig. 6).

RESULTS

Photographs and computed tomograms (including three dimensional reconstructions and conventional radiographs) were made postoperatively (Fig. 7). In all cases of secondary reconstruction we did a ^{99}mTc scintigram. Seven days postoperatively both transplanted pedicled calvarial bone grafts showed scintigraphic uptake.

All implants showed evidence of osseointegration and in three patients dentures supported by the implant could be inserted (Fig. 8).

There was only one permanent facial palsy (case 2), which was probably caused by the placement of the anterior incision in the parietotemporal fascia; this was lower than usual to permit rotation of the pedicled calvarial bone into the mandibular defect. As a result excessive traction may have been exerted on the soft tissues which would have damaged the nerve. One patient with radio-osteonecrosis underwent resection and immediate reconstruction (case 7), and developed a complete fistula. The fistula healed initially but then recurred, probably as a result of inflammation caused by a loose screw. The distal screws were removed during revision of the recipient site, and we could see that the mesial end had healed completely. Therefore, we put two miniplates into the distal part for osteosynthesis. One patient (case 4) who had undergone primary reconstruction required

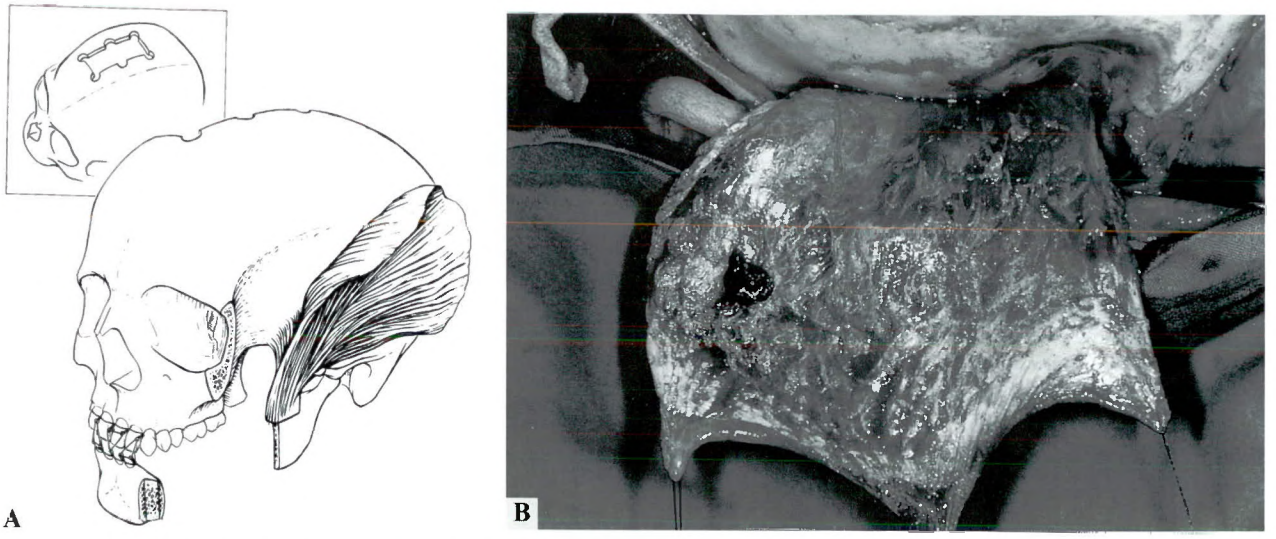


Fig. 1A – Diagram showing the dissected temporal muscle after removal of the zygomatic arch and the cranial bone defect after harvesting the full-thickness calvarial bone for reconstruction of the mandible.

Fig. 1B – Temporalis muscle flap raised and mobilised. The zygomatic arch has been removed.



Fig. 2 – Insertion of the cranial bone graft with lag screws. The temporal muscle is seen on the upper border of the mandible.

radiotherapy postoperatively because of extracapsular spread of tumour into two regional lymph nodes. A cutaneous fistula developed during the course, which resulted in serious dehiscence in the area of the AO reconstruction plate. Conservative treatment was unsuccessful so the bone was removed through an extraoral approach 6 months after reconstruction, and the soft tissue defect filled with a deltopectoral flap. Histological examination showed inflammation of the bone with extensive spongy fibrosis.

There was only one complication in a donor area: a seroma formed and had to be aspirated. There were no infections or neurological problems.

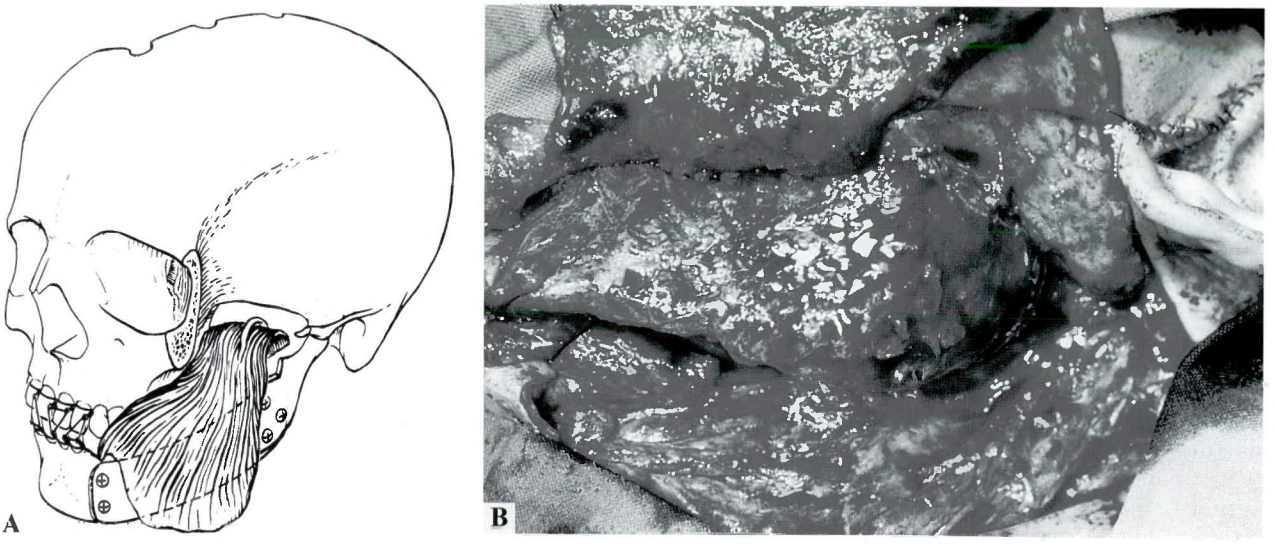


Fig. 3 – Diagram (A) and operative photograph (B) showing the temporal muscle wrapped around the transplanted cranial bone graft.

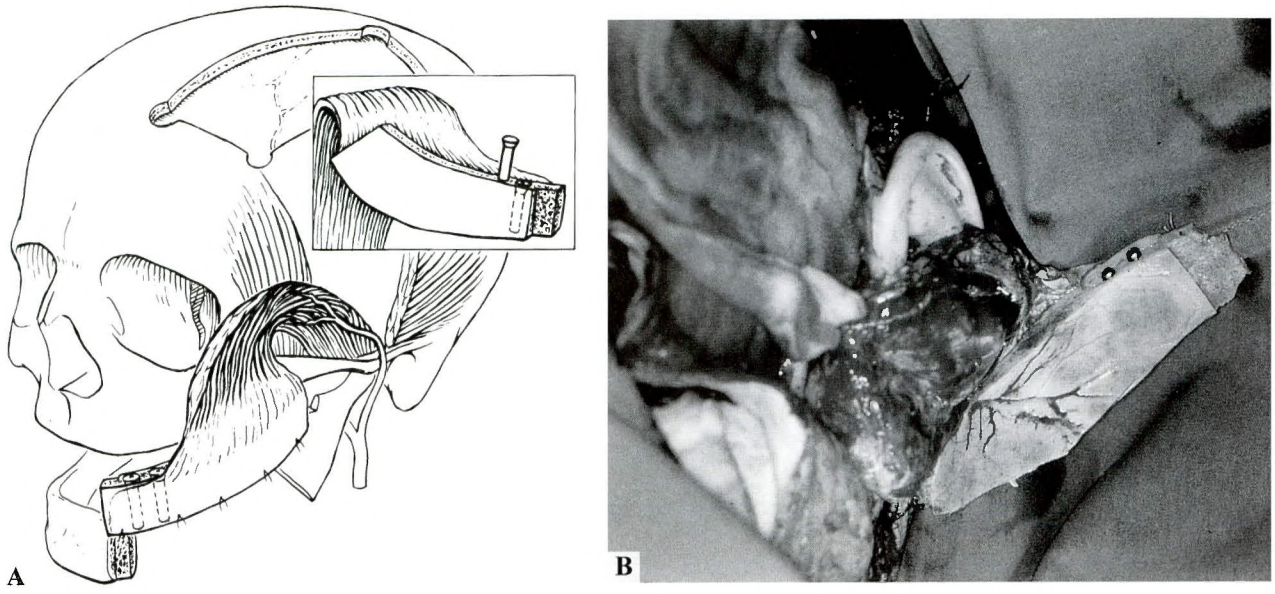


Fig. 4 – Diagram (A) and operative photograph (B) showing the myo-osseofacial temporal flap with enosseous implants which is transported laterally to the zygomatic arch towards the mandibular defect.



Fig. 5 – The cranial defect reconstructed with slices of lyophilised cartilage.

DISCUSSION

Transplanted bone heals when the graft is saved from potential death by revascularisation.[31] The direct relation between vascularisation and osteogenesis was first described by von Haller in 1763.[32] It is essential that free bone grafts for reconstruction of the lower jaw should be inserted into a well vascularised site, and if that is not possible then vascularised soft tissue should be transferred as well. In addition complete immobilisation in close contact with the remnants of the jaw is necessary to ensure complete healing.

The main problem when using calvarial bone pedicled to the parietotemporal artery, deep temporal fascia, and temporal muscle, lies in the difficulty of transporting a piece of bone of the correct shape and size into the oral cavity without damaging the facial nerve, particularly if the defect extends from the middle of the ascending ramus to the symphyseal area. It is also technically difficult to fix the bone graft in the correct position.[24] Therefore, we prefer to transfer the pedicled temporal muscle and the free calvarial bone separately. This ensures the security of the frontal branch of the facial nerve which runs side by side with the branches of the superficial temporal artery in the parietotemporal fascia.[33 34]

Another advantage of taking free calvarial bone grafts is that the bone can be taken from the part where the shape and thickness are best suited to mandibular reconstruction, rather than being compromised by the necessity to raise a pedicle.

When the temporal muscle flap is raised separately it is possible to use the whole muscle to give additional soft tissue bulk in the floor of the mouth and the vestibulum. The whole graft is covered with well vascularised muscular tissue at the recipient site, and this permits good healing independently of the local vascularisation which may have been compromised by local radiotherapy or previous infection.[35] The use of calvarial bone was suggested more by its proximity to the recipient area (which avoids the need for a second operation site as when iliac crest is used)[36] than by its mesenchymal origin.[37]

The use of microvascular free osteomyocutaneous flaps has resulted in considerable improvements in both the aesthetic and functional aspects of mandibular reconstructions when the recipient site is poorly vascularised and there are serious soft tissue defects

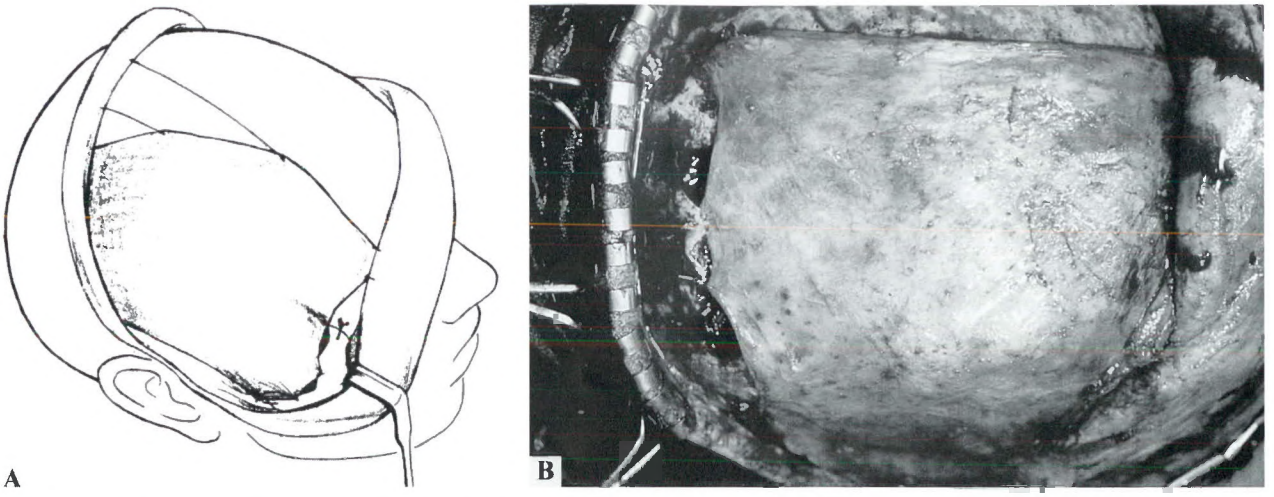


Fig. 6 – Diagram (A) and operative photograph (B) showing the pericranium rotation flap covering the chips and slices of lyophilised cartilage for recontouring the temporal fossa.

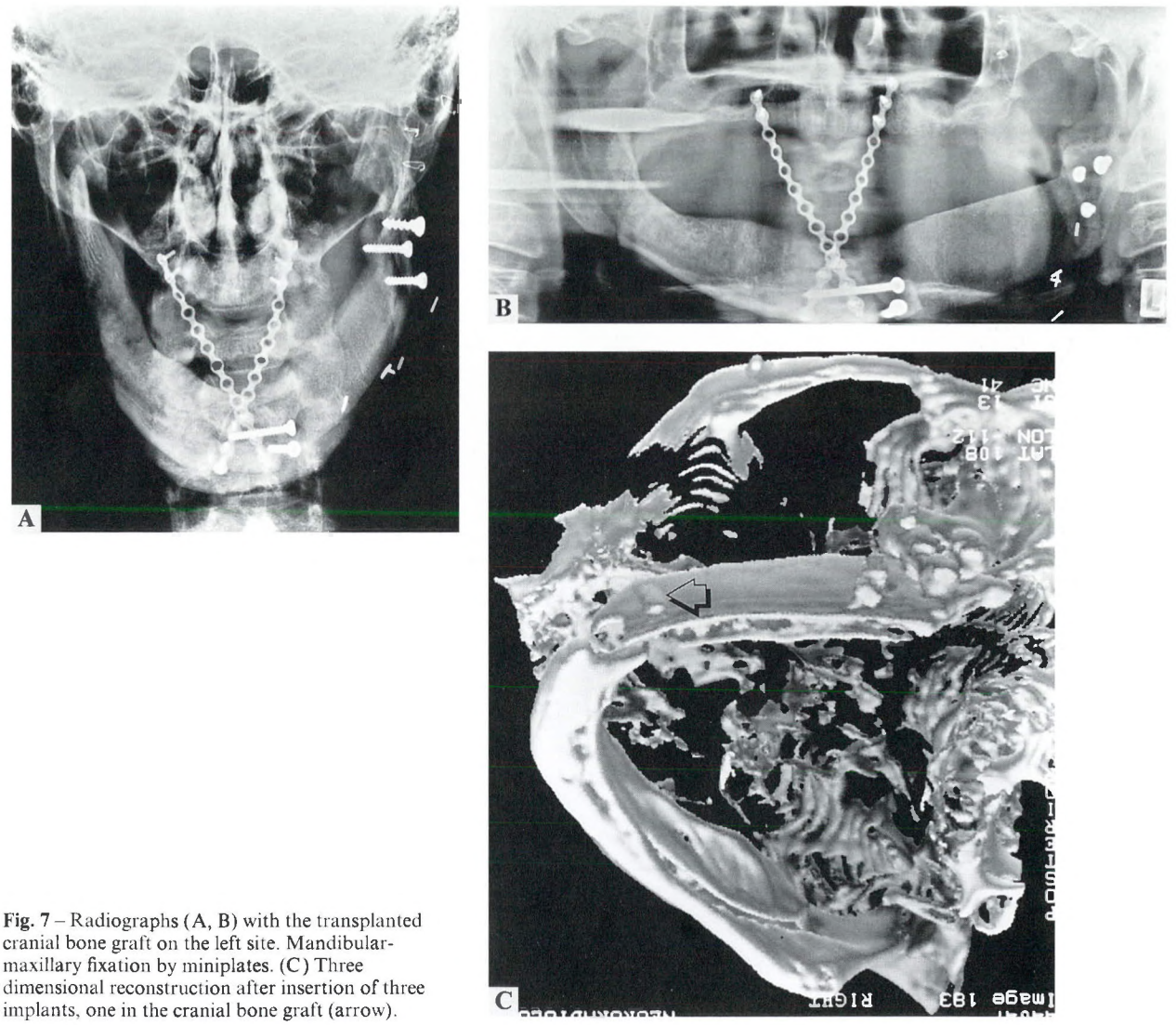


Fig. 7 – Radiographs (A, B) with the transplanted cranial bone graft on the left site. Mandibular-maxillary fixation by miniplates. (C) Three dimensional reconstruction after insertion of three implants, one in the cranial bone graft (arrow).

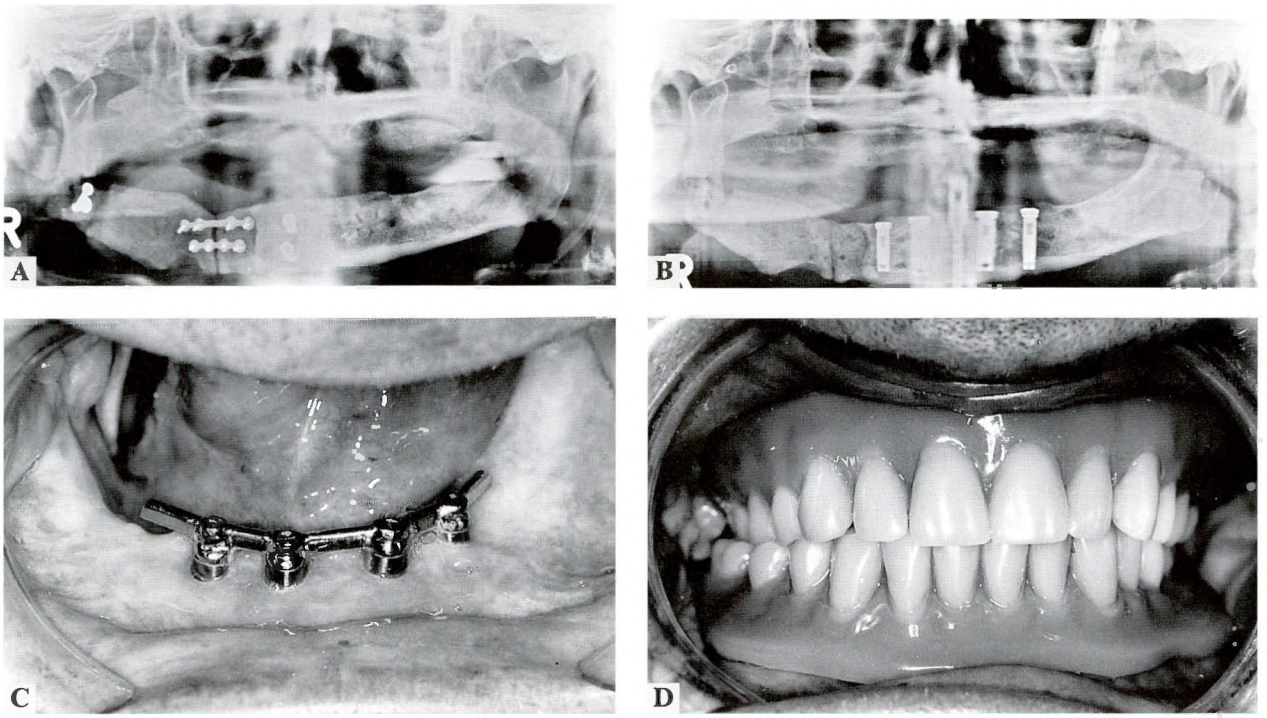


Fig. 8 – (A) Panorex radiographs after operation and (B) 1 year after placement of implants, (C, D) the denture supported by the implant.

and loss of bone.[38] However, we have achieved good results with free or pedicled calvarial bone grafts in our patients, nine of whom had had previous operations or irradiation. The avoidance of both microanastomoses in irradiated or scarred tissue and of remote donor sites are advantages.

References

1. Chase SW, Herndorn Ch. The fate of autogenous and homogenous bone grafts. A historical review. J Bone Joint Surg 1955; 37: 809–41.
2. Ollier XEL. De l'osteogenese chirurgicale. Verhandlung des 10. int. med. Kongresses zu Berlin 1891: 412–39.
3. Heine B. Über die Wiedererzeugung neuer Knochenmassen und Bildung neuer Knochen. J Chir Augenheilk 1836; 24: 513–9.
4. Bart E. Histologische Untersuchungen über Knochenreplantationen. Beitr Path Anat 1895; 17: 65–142.
5. Lexer E. Die freien Transplantationen. Enke, Stuttgart: 1924.
6. Axhausen G. Die histologischen und klinischen Gesetze der freien Osteoplastik auf Grund von Tierversuchen. Langenbecks Arch Chir 1909; 88: 23–145.
7. Farmand M. Die Unterkieferrekonstruktion. Swiss Dent 1988; 9: 7–26.
8. Schmoker R. Die Unterkieferrekonstruktion. Ein geschichtlicher Überblick. Swiss Dent 1989; 10: 23–34.
9. Müller W. Zur Frage der temporären Schädelresektion an Stelle der Trepanation. Zentralblatt Chir 1890; 17: 65–6.
10. König F. Der knöcherne Ersatz grosser Schädeldefekte. Zentralblatt für Chirurgie 1890; 27: 497–501.
11. Bardenheuer. Über Unterkiefer- und Oberkieferresektion. Langenbecks Arch Chir 1892; 44: 604–11.
12. Conley J. Use of composite flaps containing bone for major repairs in the head and neck. Plast Reconstr Surg 1972; 49: 522–6.
13. Antonyshyn O, Colcleugh RG, Hurst LN, Anderson C. The temporalis myo-osseous flap: An experimental study. Plast Reconstr Surg 1984; 77: 406–13.
14. Casanova R, Cavalcante D, Grotting JC, Vasconez LO, Psillakis JM. Anatomic basis for vascularized outer-table calvarial bone flaps. Plastic Reconstr Surg 1986; 78: 300–8.
15. Tessier P. Autogenous bone grafts taken from the calvarium for facial and cranial applications. Clin Plast Surg 1982; 9: 531–8.
16. Combelles R, Zadeh J. Le lambeau temporal musculo-osseux. Etude anatomique technique, experimentale et chirurgicale. Rev Stomatol Chir Maxillofac 1984; 85: 351–4.
17. Choung PH, Nam JW, Kim KS. Vascularized cranial bone grafts for mandibular and maxillary reconstruction. J Cranio-Max-Fac Surg 1991; 19: 235–42.
18. Coleman S, Buncke HJ, Alpert BS, Hing DH, Lineaweaver W, Chater N. Reconstruction of the mandible with full-thickness vascularized cranial bone graft. Surgical Forum 1985; 36: 556–7.
19. Kamiji T, Fujikawa M, Honda T, Higasa H, Sekiguchi J, Ohmori K. Restoration of the mandible by full-thickness calvarial bone flap. Ann Plast Surg 1992; 29: 438–43.
20. Kumar P, Bhatnagar SK, Husain M. Mandibular reconstruction by myo-osseous temporalis muscle (outer-table of skull) flap. Brit J Oral and Max-Fac Surg 1987; 25: 9–14.
21. Matsuba HM, Hakki AR, Little JW, Spear SL. The temporal fossa in head and neck reconstruction: Twenty-two flaps of scalp, fascia and full-thickness cranial bone. Laryngoscope 1988; 98: 444–9.
22. Munoz FI, Juncosa AM, Carrillo FO. Vascularized parietal bone flap. J Cranio-Max-Fac Surg 1990; 18: 158–63.
23. Musolas A, Colombini E, Michelena J. Vascularized full-thickness parietal bone grafts in maxillofacial reconstruction: The role of the galea and superficial temporal vessels. Plast Reconstr Surg 1991; 87: 261–7.
24. Wolfe AS, Berkowitz S. Plastic surgery of the facial skeleton. Boston/Toronto, Little, Brown and Company: 1989; 220–21.
25. Habal MB, Rasmussen RA. Osseointegrated implants in cranial bone grafts for mandibular reconstruction. J Craniofac Surg 1993; 4: 51–7.
26. Haers PE, Grätz KW, Schenk B, Sailer HF. Hyperbaric oxygen therapy as an adjuvant in maxillofacial surgery. XVIIth Annual Meeting of EUBS, Basel, 1992, pp 161–2.
27. Sailer HF. Transplantation of lyophilized cartilage in maxillofacial surgery. Basel, Karger: 1983.
28. Sailer HF. Longterm results after implantation of different

lyophilized bone and cartilage for reconstruction in craniofacial surgery. In: Montoya AG, ed: Craniofacial Surgery 4. Manduzzi Editore, 1992: 69–72.
29. Kolb E, Sailer HF. Purification and application of bone morphogenetic protein. Preliminary clinical results. J Cranio-Max-Fac Surg 1992; 20 (Suppl 1): 49.
30. Sailer HF, Kolb E. Application of purified bone morphogenetic protein (BMP) in cranio-maxillo-facial Surgery. BMP in compromised surgical reconstructions using titanium implants. J Cranio Maxillofac Surg 1994; 22: 2–11.
31. Hentz UR, Pearl RM. The irreplaceable free flap: Part I. Skeletal reconstruction by microvascular free bone transfer. Ann Plast Surg 1983; 10: 36–42.
32. Von Haller A. Experimenta de ossium formatione. Opera minora. Lausanne, 1763.
33. Stuzin JM, Wagstrom L, Kawamoto HK, Wolfe SA. Anatomy of the frontal branch of the facial nerve: the significance of the temporal fat pad. Plast Reconstr Surg 1989; 83: 265–71.
34. Yasargil MG, Reichmann MV, Kubik S. Preservation of the fronto temporal branch of the facial nerve using the interfascial temporalis flap for pterional craniotomy. J Neurosurg 1987; 67: 463–66.
35. Richards MA, Poole MD, Godfrey AM. The serratus anterior/rib composite flap in mandibular reconstruction. Brit J Plast Surg 1985; 38: 466–77.
36. Sailer HF. Ergebnisse der Resektion und Simultanrekonstruktion des Unterkiefers bei Osteomyelitis und Radioosteomyelitis. Kiefer- und Gesichtschirurgie. Schriftenreihe SGKG 1988; 1: 30–4.
37. Zins JE, Whitaker LA. Membranous versus endochondral bone: Implications for craniofacial reconstruction. Plast Reconstr Surg 1983; 72: 778–84.
38. Testelin S. Historique de la reconstruction mandibulaire micro-chirurgicale. Ann Chir Plast Esthet 1992; 37: 241–5.

The Authors

K. W. Grätz
H. F. Sailer
P. E. Haers
Ch. K. Oechslin
Department of Cranio-Maxillofacial Surgery, University Hospital Zurich, Zurich, Switzerland.

Correspondence and requests for offprints to K. W. Grätz

Paper received 28 July 1994
Accepted 8 November 1994