

MANDIBULAR RECONSTRUCTION WITH FROZEN AUTOLOGOUS MANDIBULAR BONE AND RADIAL PERIOSTEAL FASCIOCUTANEOUS FREE FLAP: PRELIMINARY REPORT

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The authors present a new method of mandibular reconstruction with frozen autologous mandibular bone. Vascular supply to the neomandible is ensured by the periosteal layer of a microvascular radial periosteal fasciocutaneous free flap, placed so as to envelop the bone and cover the surgical defect. The use of the periosteal layer of the radius to provide new blood vessels to the frozen mandible is an original technical feature that we describe. We describe 2 cases of oral carcinoma involving the mandible, treated with mandibular resection and reconstruction. This technique allows good functional and aesthetic results, avoiding more serious complications related to the use of composite free flaps harvested from distant anatomic donor sites.

KEY WORDS — mandibular reconstruction, periosteal fasciocutaneous free flap.

INTRODUCTION

Mandibular reconstruction after surgical resection of oral and oropharyngeal tumors is a challenging field for head and neck surgeons, considering the difficulties in achieving the double result of complete tumor removal and good functional-aesthetic recovery. In recent decades, reconstructive techniques using pedicled composite flaps¹⁻³ and, more recently, free microvascular composite flaps⁴⁻⁸ have been proposed with success, but they expose the patient to additional complications in the distant donor site of bone harvest. Other reconstructive techniques using alloplastic implants have been described: metallic (vitallium, titanium, chrome, cobalt), plastic (silicone, acrylic), and allogeneic particulate cancellous bone marrow grafts.⁹⁻¹⁶

Other authors¹⁷⁻²⁸ proposed the use of sterilized autologous mandible. According to the principles described in the literature, we modified the technique in 2 surgical cases of mandibulectomy and reconstruction using frozen autologous mandible and a radial periosteal fasciocutaneous free flap.

CASE REPORTS AND SURGICAL TECHNIQUE

Case 1. A 68-year-old man was admitted to our department with an infiltrative, 6-cm, T4 grade 2 squamous cell carcinoma in the anterior floor of the

mouth, extending to the oral tongue and the alveolar ridge, with bulging of the submental area. Ultrasonography and computed tomography revealed tumor infiltration of the submental and submaxillary area and osteolysis of the anterior arch of the mandible (Fig 1).

The patient underwent surgery; after tracheotomy and bilateral functional neck dissection, tumor resection was performed, including the submental and submaxillary area soft tissue and the skin, the floor of the mouth, and the oral tongue. The mandibular arch was resected between the two angles with a Gigli saw (Fig 2), and tumor was removed from the mandibular bone. We harvested the periosteal plane, but the residual external periosteal layer was saved and remained close to the cervical flap. The bone was drilled at the two corners, and titanium miniplates were placed on, but not fixed to, the bone.

The site of mandibular infiltration was cleared of tumor, the cortical bone was milled, and the spongiosa was slightly exposed. During tumor resection, another surgical team was harvesting a periosteal fasciocutaneous forearm free flap, pedicled on the radial artery and the cephalic vein, according to the literature.^{20,21,23,24,28} The resected mandible was immersed in liquid nitrogen (-195°C) for 10 minutes twice, with a 10-minute interval during which it was immersed

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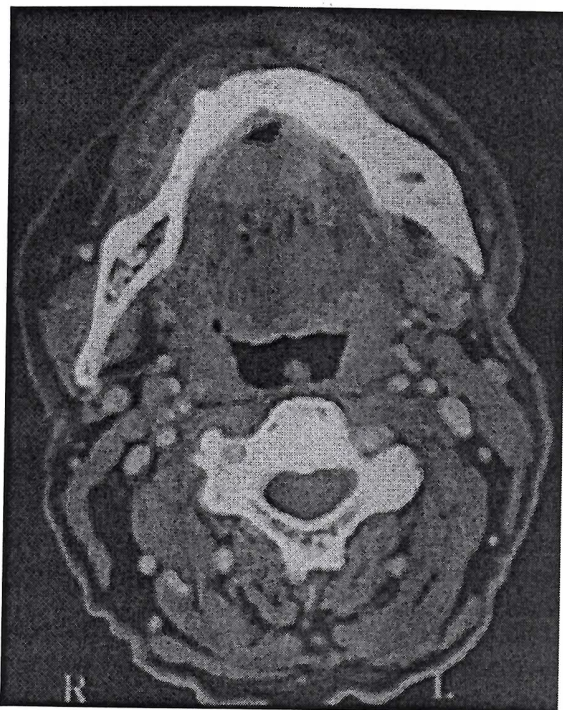


Fig 1. (Case 1) Preoperative scan of T4N2c cancer of floor of mouth.

in gentamicin sulfate solution (Fig 3).

Fixation of the mandible with miniplates was completed in both corners, and the radial periosteal fasciocutaneous free flap was sutured to cover the reimplanted frozen bone and the anterior oral cavity floor. Arterial and venous microanastomoses were performed with the superior thyroidal artery and the venous thyrofacial trunk with 8 and 10 stitches of Ethilon 8/0. The cervical flap was closed with direct suture (Fig 4).

Case 2. A 59-year-old man presented an infiltra-

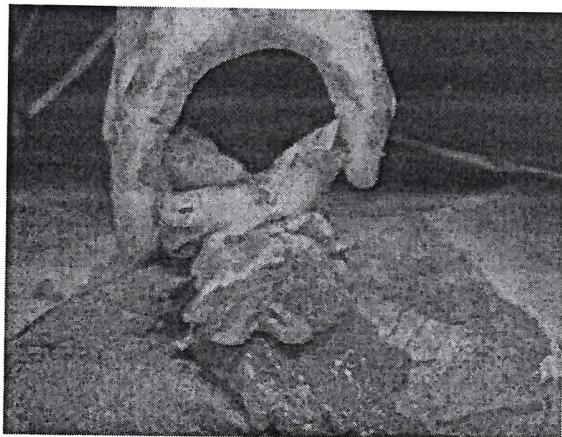


Fig 2. (Case 1) Specimen after neck dissection, tumor resection, and mandibulectomy.

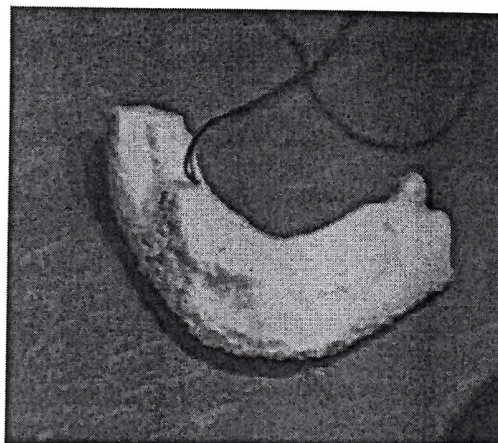


Fig 3. (Case 1) Frozen mandible.

tive, 3-cm, T4 grade 2 squamous cell carcinoma in the left retromolar trigone, extending to the lower alveolar ridge; imaging showed infiltration of the cortical bone and multiple lymphadenopathies in the ipsilateral side of the neck. The patient underwent surgery; after tracheotomy and ipsilateral functional neck dissection, tumor resection was extended to the lateral oral floor, the left margin of the oral tongue, the mandibular branch from the coronoid process to the canine, the retromolar trigone, and the cheek mucosa. The same technique of harvesting the radial periosteal fasciocutaneous free flap and sterilizing and freezing the resected mandible was applied. After fixation, the mandible was covered with the free flap, carefully placed with the periosteum strictly adherent to the bone, and microvascular sutures were placed between the radial and facial arteries and between the cephalic and external jugular veins.

The surgical margins of resection were examined with frozen sections during the procedures, and they were free of disease. No major general or local complications occurred after surgery, and both patients resumed oral feeding on the 12th postoperative day.

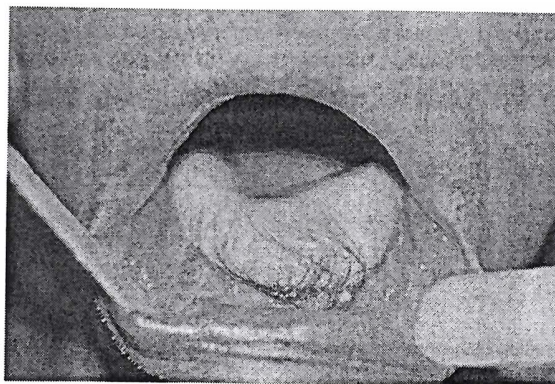


Fig 4. (Case 1) Postoperative clinical aspect.



Fig 5. (Case 1) Postoperative scan shows good mandibular fixation.

Mandibular radiographs showed the correct position of the bones after 1 week.

RESULTS

In the first case, the histologic reports showed complete tumor resection with safe margins. Two lymph nodes on the first level on the right side of the neck presented extracapsular spread and tumor infiltration of the surrounding tissues (fat, skin, and muscular fibers; pT4pN2b stage IVA).²⁹ The patient refused postoperative radiotherapy.

In the second case, the histologic report showed safe surgical margins of resection. Focal metastases

occurred in 3 lymph nodes on the second level (pT4pN2b stage IVA). The patient underwent radiotherapy starting on postoperative day 52 and lasting 5 weeks. The radiotherapy was administered in 2 opposing fields at 80° and 280° up to a dose of 50 Gy with spinal cord protection after 36 Gy. Then a boost was administered to the first cervical level up to the total dose of 60 Gy.

Intraoperative observation evidenced a limited mandibular infiltration in both cases, but obviously the bone has not been analyzed.

Twenty-four and 12 months later, the patients are free of disease. Computed tomography (Fig 5) and bone scans, with technetium 99m methylene diphosphonate of 560 MBq activity, of the reimplanted mandibles show regular vascular activity in the bone marrow across the joining sutures (Fig 6).

DISCUSSION

Since the beginning of the 20th century,²⁵ mandibular reconstruction has been one of the biggest challenges for head and neck surgeons. In case of extensive tumor infiltration of the bone, a complete resection of the mandible with safe margins is mandatory and a composite osteocutaneous microvascular free flap is the gold standard for reconstruction.⁵⁻⁷

When the mandible does not present massive involvement, the possibility of reconstruction with the same sterilized bone as an autologous implant is attractive, as the reconstruction would avoid the need to harvest and mold a bone from a distant donor site with possible related complications.

This article presents the preliminary results of 2 cases of mandibulectomy in which a marginal resection would not have been adequate but in which the structure of the bone was not deeply compromised.

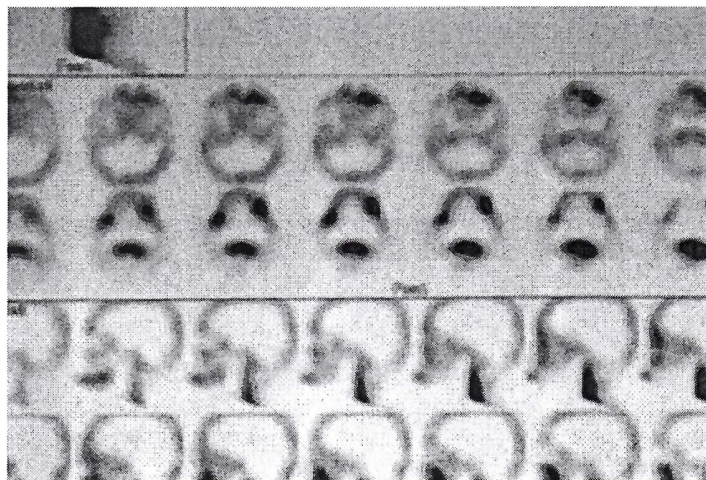


Fig 6. (Case 1) Postoperative bone scan of mandible.

In accordance with the literature, we consider operable with marginal mandibulectomy only cases with no bone infiltration or minimal cortical invasion.^{30,31} For more extensive bone invasion, a segmental mandibular resection is mandatory, as well as an adequate bone reconstruction if indicated. A few years ago we started to consider the use of autologous frozen sterilized mandible for reconstruction. Candidates for this procedure are those patients who show limited bone invasion before surgery and a good residual mandibular structure or patients who despite preoperative imaging show bone infiltration during operation.

The surgical technique consists of immediate mandibular reimplantation after the bone has been immersed in liquid nitrogen and sterilized. Reconstruction is completed with a radial periosteal fasciocutaneous free flap.

The main feature of this technique is to harvest the radial periosteum that remains close to the forearm flap. It provides a good nutritional vascular supply to the inner side of the mandible and a new colonization of osteoblastic cells through the new pedicle of the radial artery.

If oncologically correct, a careful dissection that saves the external periosteum of the mandible, close to the cervical flap, provides protection and nutrition to the outer side of the bone. The increased blood supply at the extremities of the resected bone shown in the bone scan is probably related to the alveolar vessels and to the periosteal layers.

The second surgical skill needed is perfect suturing of the flap on the residual mucosa of the oral cavity to avoid salivary leakage or infection.

This procedure is feasible, but requires specific experience in microsurgery and composite free flap harvesting. In agreement with the results of the literature,^{19-21,24,25} we consider there to be virtually no risk of recurrence in the implanted mandible after adequate treatment, and the risk of flap failure is limited. As with other microvascular free flaps, there are no contraindications to postoperative radiotherapy.³² We administered irradiation only to the second patient, because the first refused postoperative treatment, and we encountered no damage to the bone or flap failure.

The main oppositions to reimplantation of the mandible are the question of safety from residual tumor cells and the question of the vitality of the bone after sterilization.^{17,23} According to the literature, the efficacy of freezing in killing the residual tumor cells and thereby preserving the possibility of reimplantation of the bone is confirmed.^{23,24,26,28} Another op-

tion, using allogeneic mandibular bone in selected cases of reconstruction, is well known.^{14,16}

Sailer^{15,16} and Dougherty et al²⁰ in the 1980s proposed implanting mandibular segments after freezing. Other authors^{17,22,23,26} performed irradiation after freezing of the mandible to minimize the risk of reimplantation of tumoral cells. We believe 2 immersions of 10 minutes in liquid nitrogen is sufficient to sterilize and allow immediate implantation of the resected bone for mandibular reconstruction.^{19,20,23,24,26,28} A vascular supply for the reimplanted mandible is another necessity and a second critical step. Sailer and Dougherty et al proposed a surgical technique without any free flap and no periosteal flap replacement. This method has a limited application: only to cases with a large amount of residual mucosa in the oral cavity, allowing a good reconstruction with no retraction of scars and little mandibular gap, and avoiding reabsorption of the reimplanted bone. Other authors have described different techniques of sterilization of the mandible for reimplantation.^{17,22,23,26} In our experience, implantation of free bone in soft tissue with no periosteal vascular supply represents a foreign body that can be rejected or reabsorbed.

The main feature of the technique we describe is an immediate reconstruction with restoration of the vascular supply to the resected mandible by means of the radial periosteal fasciocutaneous free flap. In this way any surgical defect of the oral cavity is repaired and the continuity of large segments of the mandible is restored. Mandibular resection can potentially extend between the two angles, preserving the ascending branches attached to the pterygoid muscles and to the temporomandibular joints, which give stability and mobility to the jaw. The lines of suture on the resected bone are fixed through miniplates and screws.

Righini et al²⁷ present another technique using a composite osteofasciocutaneous radial free flap to reinforce the reimplanted resected frozen mandible, which involves more work in molding the radial resected bone and runs the risk of eventual possible comorbidity in a distant bone donor site, as well as other reconstructive techniques with fibula, scapula, and iliac crest free flaps. In this article we note that the periosteal layer of the radius applied to the mandible guarantees vitality of the mandible.

We consider this technique of mandibular reconstruction a good choice in cases of tumors with limited mandibular infiltration. It avoids more complex methods with composite free flaps harvested from distant bone donor sites. The same technique in the case of extended mandibular tumor involvement allows reconstruction with an allogeneic mandible in

which the periosteal layer of the radial free flap would provide vitality.^{11,12,14-16}

According to our experience of mandibular recon-

struction, we consider this technique of using frozen autologous bone easier than other well-known solutions with composite free flaps and more reliable than those using alloplastic devices or myocutaneous flaps.

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REFERENCES

1. Conley J. Use of composite flaps containing bone for major repairs in the head and neck. *Plast Reconstr Surg* 1972;49:522-6.
2. Gullane PJ, Holmes H. Mandibular reconstruction. New concepts. *Arch Otolaryngol Head Neck Surg* 1986;112:714-9.
3. Siemssen SO, Kirkby B, O'Connor TPF. Immediate reconstruction of a resected segment of the lower jaw, using a compound flap of clavicle and sternomastoid muscle. *Plast Reconstr Surg* 1978;61:724-35.
4. Daniel RK. Mandibular reconstruction with free tissue transfers. *Ann Plast Surg* 1978;1:346-71.
5. Deschler DG, Hayden RE. The optimum method for reconstruction of complex lateral oromandibular-cutaneous defects. *Head Neck* 2000;22:674-9.
6. Disa JJ, Cordeiro PG. Mandible reconstruction with microvascular surgery. *Semin Surg Oncol* 2000;19:226-34.
7. Soutar DS, Widdowson WP. Immediate reconstruction of the mandible using a vascularized segment of radius. *Head Neck Surg* 1986;8:232-46.
8. Urken ML, Cheney ML, Sullivan MJ, Biller HF. Atlas of regional free flaps for head and neck reconstruction. New York, NY: Raven Press, 1995:119-305.
9. Boyne PJ. Restoration of osseous defects in maxillofacial casualties. *J Am Dent Assoc* 1969;78:767-76.
10. Hilger PA, Adams GL. Mandibular reconstruction with the A-O plate. *Arch Otolaryngol* 1985;111:469-71.
11. Lowlicht RA, Delacure MD, Sasaki CT. Allogenic (homograft) reconstruction of the mandible. *Laryngoscope* 1990;100:837-43.
12. Marx RE, Kline SN, Johnson RP, Malinin TI, Matthews JG II, Gambill V. The use of freeze-dried allogeneic bone in oral and maxillofacial surgery. *J Oral Surg* 1981;39:264-74.
13. Osborn DB, Lilly GE, Thompson CW, Jost T. Bone grafts with surface decalcified allogeneic and particulate autologous bone: report of cases. *J Oral Surg* 1977;35:276-84.
14. Perrott DH, Smith RA, Kaban LB. The use of fresh frozen allogeneic bone for maxillary and mandibular reconstruction. *Int J Oral Maxillofac Surg* 1992;21:260-5.
15. Sailer HF. Reconstruction of the mandible by means of a similar allogenic lyophilized mandibular segment. I. Morphological and immunological studies in monkeys. *J Maxillofac Surg* 1980;8:294-5.
16. Sailer HF. Reconstruction of the mandible by means of a similar allogenic lyophilized mandibular segment. II. Clinical application. *J Maxillofac Surg* 1980;8:303-8.
17. Bradley PF. A two-stage procedure for reimplantation of autogenous freeze-treated mandibular bone. *J Oral Maxillofac Surg* 1982;40:278-84.
18. De Fries HO, Marble HO, Sell KW. Reconstruction of the mandible. Use of a homograft combined with autogenous bone and marrow. *Arch Otolaryngol* 1971;93:426-32.
19. Dong YJ, Zhang GZ, Wang SP, Li Z. The use of immediate frozen autogenous mandible, for benign tumour mandibular reconstruction. *Br J Oral Maxillofac Surg* 1996;34:58-61.
20. Dougherty TP, Rafetto LK, Edwards RC, Caudillo RJ, McInnes G. Reimplantation of freeze-treated bone in immediate reconstruction of the mandible. *Am J Surg* 1982;144:463-5.
21. Harding RL. Replantation of the mandible in cancer surgery. *Plast Reconstr Surg* 1957;19:373-83.
22. Jisander S, Aspenberg P, Salernmark L, Wennerberg J. Mandibular reconstruction by secondary reimplantation of resected segments: a preliminary report. *Int J Oral Maxillofac Surg* 1995;24:288-92.
23. Leipzig B, Cummings CW. The current status of mandibular reconstruction using autogenous frozen mandibular grafts. *Head Neck Surg* 1984;6:992-7.
24. Marciani RD, Bowden CM Jr. Reimplantation of freeze-treated mandibular bone. *J Oral Surg* 1975;33:261-7.
25. Orell S. Surgical bone grafting with os purum, os novum, and boiled bone. *J Bone Joint Surg* 1937;19:873-85.
26. Plezia RA, Weaver AW, Pietruk T, Gilbert HD. Evaluation of osteogenesis following immediate and delayed reimplantation of frozen autogenous mandibular bone. *Oral Surg Oral Med Oral Pathol* 1983;56:341-50.
27. Righini S, Balestri J, Destito D, et al. A new method for mandibular reconstruction: the "over lay" free flap. Preliminary report. *Head Neck Oncology 1st World Congress*. Bologna, Italy: Monduzzi, 1998:703-7.
28. Weaver AW, Smith DB. Frozen autogenous mandibular stent-graft for immediate reconstruction in oral cancer surgery. *Am J Surg* 1973;126:505-6.
29. Sobin LH, Witteking C. TNM classification of malignant tumours. 6th ed. New York, NY: Wiley-Liss, 2002.
30. De Vicente JC, Recio OR, Pendàs SL, Lopez-Arranz JS. Oral squamous cell carcinoma of the mandibular region: a survival study. *Head Neck* 2001;23:536-43.
31. Ash CS, Nason RW, Abdoh AA, Cohen MA. Prognostic implications of mandibular invasion in oral cancer. *Head Neck* 2000;22:794-8.
32. Stavrianos SD, McLean NR, Fellows S, et al. Microvascular histopathology in head and neck oncology. *Br J Plast Surg* 2003;56:140-4.