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Computer assisted dental rehabilitation in free flaps reconstructed jaws: one year follow-up of a prospective clinical study

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Abstract

Continuity defects in bone after resection of the jaw may cause problems, and osseo-myocutaneous free flaps are the gold standard for their reconstruction. Implant-supported prosthetic rehabilitation is reliable with these microvascular options, although it is still a serious challenge. The aim of this prospective clinical study was to describe the advantages of implants restored according to a computer-assisted surgical protocol. A group of 10 consecutive patients (both sexes) had already been treated and followed up for at least 1 year after prosthetic loading. The NobelGuide protocol had to be modified to adapt the technique for these patients who had had reconstructions. A total of 56 fixtures were installed and, when possible, immediately loaded (overall survival of implants 95%). Every patient was given correct provisional prosthetic rehabilitation, which was most satisfactory as far as chewing, social functioning, and overall quality of life were concerned. Three-dimensional computed tomographic (CT) examination showed a mean (SD) marginal bone loss of 1.06 (0.5) mm. We used a modified technique of computer-assisted implant surgery in jaws that had been reconstructed with free flaps; from these preliminary findings this approach seems valid when it comes to function, improving prosthetic restoration, and aesthetics.

Keywords: Computer assisted implant surgery; Free-flaps; Immediate loading

Introduction

Free flaps from the fibula and iliac crest have proved to be reliable for reconstruction of large bony defects in the mandible and maxilla, and they provide the opportunity for simultaneous reconstruction of the soft tissues on the intraoral and cutaneous sides.[1,2]

Patients with defects in the oral cavity often also present with loss of teeth and alveolar and basal jawbones, which can lead to impaired mastication.

Dental prosthetic rehabilitation, which is a fundamental target of treatment, is possible with microvascular reconstructive options, despite the many anatomical and prosthetic problems that arise. Removable prostheses seem to be uncomfortable because the height and stability of the bone are insufficient, soft tissues are altered, and irradiated patients often have xerostomia. A fixed implant-supported prosthetic restoration could be the best solution for dental rehabilitation in these patients.[3,4] Unfortunately, many problems arise when prostheses based on surgical implants are planned for these rehabilitations.

To reduce these problems we adopted a new protocol for computer-aided placement of implants that was described in a recent paper.[5] This permitted accurate placement of implants using a flapless technique under the guidance of a surgical template generated from preoperative virtual planning of the implant, which allows for precise installation of the implant through a thick layer of soft tissues using a computer-generated surgical guide. This avoids obstacles in

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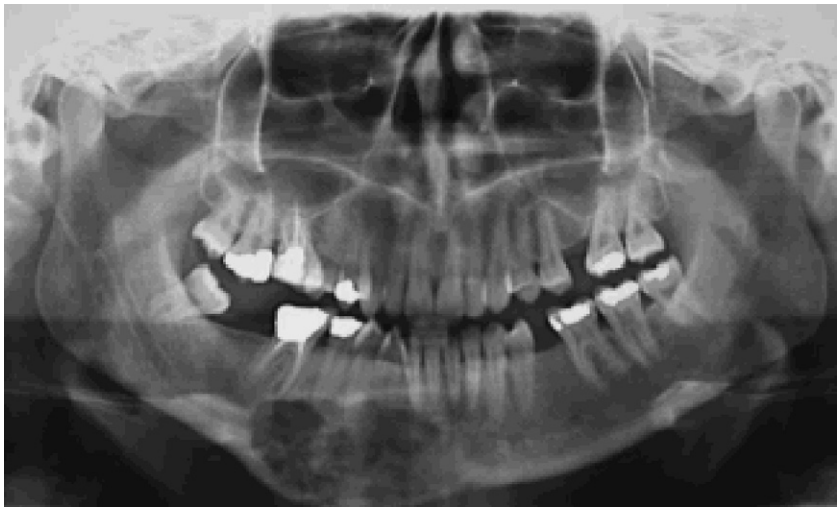

Fig. 1. Panoramic radiograph of an aggressive osteoblastoma of the mandible.

the reconstructed bone such as screws or osteotomy sites. The aim of this prospective clinical study was to present the results achieved 1 year after we had adopted computer-assisted implants for patients who had had reconstruction with free flaps after resections of the jaw for tumours, gunshot wounds, or severe atrophy of the ridge.

Patients, material, and methods

The present study is a prospective clinical trial that was done at the Maxillofacial Surgery Unit, University of Sassari. It had the approval of the local ethics board and the design followed the guidelines of the Declaration of Helsinki.

Among a group of 47 patients whose jaws had been reconstructed, 10 consecutive patients (6 male 4 female) aged 34–65 years with 12 reconstructed ridges (cancer $n = 6$ (Fig. 1), gunshot wound ($n = 3$), and severe atrophy of the ridge ($n = 1$)) had already been treated and followed up for at least a year. Implants were inserted 6 months after reconstruction of gunshot wounds, after a year in patients operated on for cancer but not irradiated ($n = 2$), and after 2 years in irradiated patients ($n = 4$). Patients' data were recorded, including age, sex, site of defect, rehabilitation, implants, and immediate or delayed loading (Table 1 and Fig. 2).

Inclusion criteria for implant treatment were: good prognosis after resection of the tumour; no signs of recurrence; good oral hygiene; no periodontal disease in the residual dentition; and the patient's motivation for prosthetic rehabilitation.

Exclusion criteria were: patients with a poor prognosis; patients with no signs of recurrence of oral carcinoma, but still misusing alcohol, or still smoking; and patients who did not comply with treatment.

Immediate prosthetic loading was used in 6 patients, and it was delayed 4 months after insertion of the implant

Table 1
Patients and their treatments.

Case no.	Age (years)/sex	Diagnosis	Site of defect	No. of implants	No. of implants in reconstructed bone	Complications
1	65/M	Oral cancer	Mandibular arch	5	5	Reduced mobility of tongue
2	70/M	Gunshot wound	L mandible	5	3	1 implant failed
3	36/F	Osteoblastoma	R mandible	3	3	None
4	45/F	ORN	Mandibular arch	6	6	1 implant failed
5	44/F	Severe atrophy	Maxillary arch	6	6	1 implant failed
6	37/M	Gunshot wound	L maxilla/mandible	8	7	Frame fractured, implant not loaded
7	38/M	Gunshot wound	Anterior maxilla, mandibular arch	10	9	Overgrowth of soft tissue
8	65/M	Oral cancer	L lateral mandible	5	2	None
9	70/F	Oral cancer	Mandibular arch	5	5	Overgrowth of soft tissue
10	53/M	Osteoblastoma	Mandibular arch	5	5	None

ORN = osteoradionecrosis.
All were reconstructed with fibular free flaps except Case 6, where an iliac crest flap was used in addition, and Case 7, where a double free flap was used.
Cases 1, 8, and 9 were treated with radiotherapy.
Cases 1, 3, 8, 9, and 10 were treated by immediate loading; in the rest it was delayed.

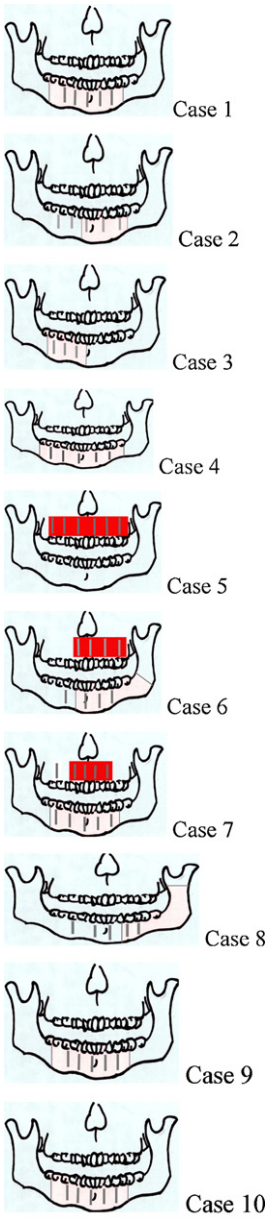

Fig. 2. *Case 1*: full arch mandibular reconstruction with fibular free flap. Five implants inserted in reconstructed mandible. *Case 2*: left half mandibular reconstruction with fibular free flap. Three implants inserted in reconstructed mandible. *Case 3*: right half mandibular reconstruction with fibular free flap. Three implants inserted in reconstructed mandible. *Case 4*: full arch mandibular reconstruction with fibular free flap. Five implants inserted in reconstructed mandible. *Case 5*: full arch reconstruction of the maxillary alveolar ridge. Six implants inserted in reconstructed alveolar ridge. *Case 6*: left half mandibular reconstruction with fibular free flap. Four implants inserted in reconstructed mandible. Left half maxillary reconstruction with iliac crest free flap. Four implants inserted in reconstructed maxilla. *Case 7*: full arch mandibular reconstruction with fibular free flap. Five implants inserted in reconstructed mandible. Anterior maxillary reconstruction with fibular free flap. Four implants inserted in reconstructed maxilla. *Case 8*: reconstruction of left ramus and mandibular arch with fibular free flap. Two implants inserted in reconstructed mandible. *Case 9*: full arch mandibular reconstruction with fibular free flap. Five implants inserted in reconstructed mandible. *Case 10*: full arch mandibular reconstruction with fibular free flap. Five implants inserted in reconstructed mandible.

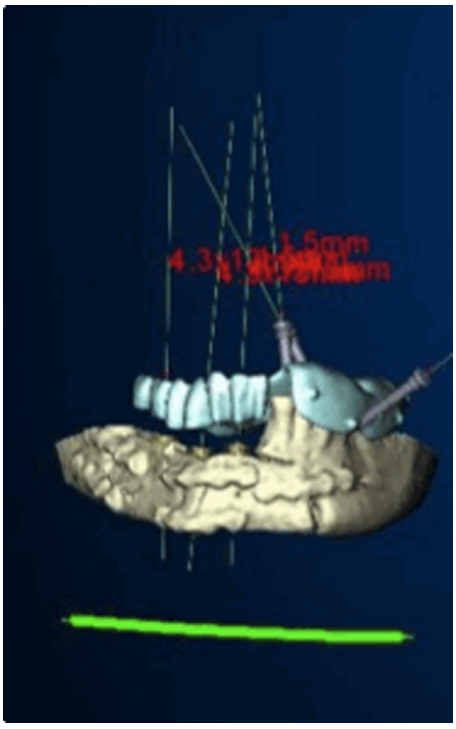

Fig. 3. Three-dimensional computed tomographic virtual implant planning in a fibular free flap.

in 4. The prosthetic rehabilitation was done according to a modified NobelGuide protocol (Procera Software; Nobel Biocare, Gothenburg, Sweden) as described previously (Figs. 3 and 4).[5] A total of 56 fixtures were installed (Replace Tapered Groovy; Nobel Biocare); the length of the implants ranged from 8 to 16 mm, and the diameter was 3.5, 4.3, or 5 mm. Implants were loaded with a screw-retained prosthesis either immediately or after 4 months when the insertion torque was <35 Newton cm (Ncm).

In 6 patients the implants were inserted using a torque of 35–45 Ncm, and the prefabricated prostheses were placed and functioned immediately. In 4 patients loading was delayed. After 3 months impressions of the fixtures were taken in 3 of them, and a new a metal and acrylic resin provisional

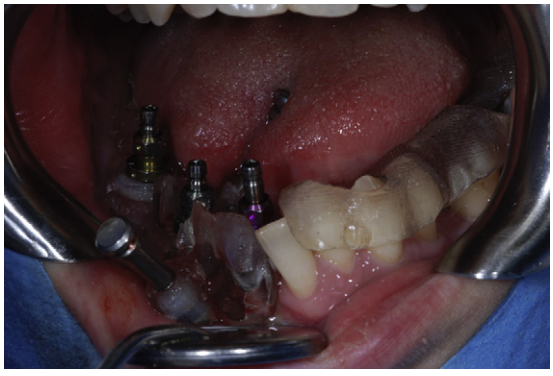

Fig. 4. Computer-assisted insertion of an implant in the reconstructed mandible.

prosthesis manufactured. For 1 patient who had had a gunshot wound, the anatomy of the oral cavity did not enable clinicians to make an impression of the fixture. The prefabricated acrylic resin provisional prosthesis was then modified and fitted to the implant, and the actual position of the fixture and interocclusal rapport were recorded. A second master model was made, and a new metal resin provisional prosthesis was manufactured.

Each patient had individualised treatment of the peri-implant soft tissue. The vestibular fornix needed remodelling before implants could be inserted in 5 patients, and 3 of them also required a fibromucosal graft of the palate at the same time. After insertion of the implants, two patients had fibromucosal grafting of the palate 4 months after loading. One patient (who had also had a gunshot wound, and who had had both maxillary and mandibular reconstruction with two fibular free flaps) was treated with skin grafts on to the neomandibular ridge together with fibromucosal grafts on to the upper jaw at the time that the implants were placed. One patient required a localised mucosal graft of the hard palate around a single implant 1 month after the implant had been inserted. In 6 patients the prosthesis was used to shape the thick, reconstructed soft tissues.

All patients were enrolled in an implant maintenance programme. Clinical follow-up was 3, 6, and 12 months postoperatively. Radiological follow-up (orthopantomograph) was obtained immediately postoperatively (Fig. 5), and with CT cone beam analysis 0 and 12 months after loading.

After 12 months all patients were asked to complete a quality of life scale, functional assessment, and denture satisfaction form.

Outcome measures

Outcome measures were: survival of implants, radiographic changes in aspects of the marginal bony level in soft tissues (probing pocket depth (PPD) and bleeding on probing BOP)) and patients' satisfaction. Marginal bone loss was the difference between the day of loading and 12 months later measured on three-dimensional CT scans. Measurements of changes in bony levels were evaluated mesially and distally from the vestibular and palatal site to each implant. The distance between the top of the shoulder of the implant and the most coronal point of direct bone-to-implant contact was measured. The mean mesial/distal value was recorded for every site, palatal/lingual or vestibular. Marginal bone remodelling was the difference between the reading at the examination and the baseline value. A mean was calculated of the height of the bone both mesially and distally for each implant. An independent radiologist measured the height of the bone in each case. Mean PPD and BOP were measured 6 months and 12 months after loading.

Implants were considered successful after 12 months if the following criteria had been met: no pain or mobility under an unscrewing torque of 20 Ncm; no persistent pain; no peri-implant infection with suppuration; and no continuous peri-implant radiolucency.

Results

Postoperative recovery after placement of implants was uneventful for all patients, though 1 patient complained of transient discomfort during the first week. At least 12 months' follow-up was recorded in all cases. Three implants were lost during the healing period, and the overall implant survival was 94.6%. One implant was not loaded because of the anatomical conformation of the reconstructed mandible. Each patient had correct provisional prosthetic rehabilitation with highly satisfactory masticatory function, social function, and overall quality of life. Radiological three-dimensional CT showed mean (SD) marginal bone loss of 1.06 (0.5) mm at the palatal/lingual site and 1.10 (0.5) mm at the vestibular site after 12 months' prosthetic follow-up.

All patients presented with healthy soft tissues, stable probing depths, and good BOP values after 1 year. Mean (SD) PPD and BOP after 12 months were 4.7 (0.8) and 16 (5)%. Patients' satisfaction was scored as good in most cases.

Some biological and mechanical complications were recorded in 1 patient who fractured the distal implant of a fibular reconstruction 15 days after loading. The implant was removed, and the fracture was reduced and fixed rigidly under local anaesthesia in the outpatient clinic. Two patients presented 4 months after connection of the abutment with an overgrowth of granulomatous soft tissue around the abutments that caused pain, bleeding during brushing, and aesthetic problems. The granulomatous tissue was excised and replaced with palatal mucosal grafts. One patient who had had reconstructions of the floor of the mouth, vestibular fornix, and arch of the mandible presented with inability to chew caused by reduced mobility of the tongue and inferior lip after prosthetic restoration. Remodelling of the fornix and soft tissues improved the masticatory function. One patient fractured the marginal prosthesis, and this was repaired.

Discussion

Dental restorations based on implants in free-flap reconstructions provide enough stabilisation of the prosthesis, even in patients with anatomical irregularities of the hard and soft tissues. It is possible to compensate for small local deficiencies in the soft tissue and contribute to an improved aesthetic result. Implants also improve functional aspects, and reduce the risk of mechanical irritation with consequent ulceration and discomfort.[5,6]

Nevertheless, insertion of prosthetic-based implants is still a serious challenge in these difficult cases. Placement of implants involves many problems because of the limited opening of the scar-contracted oral cavity and the presence of a large amount of soft tissue that covers the underlying bone,

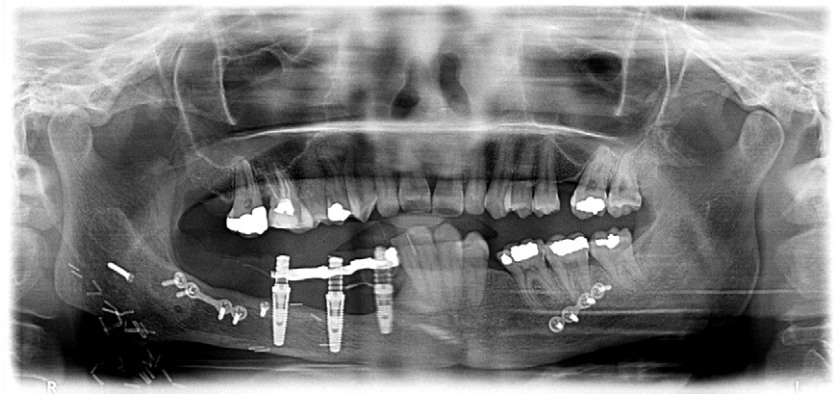

Fig. 5. Panoramic radiograph after immediate loading.

but gives little information about its profile. Other problems result from scars, and the thickness of the soft tissues impairs the prosthetic procedures.

The classic approach to implants in patients with osseous free flaps is based on radiological assessment, and surgical guides are made from casts to allow for adequate insertion of implants. Despite the ideal perspective, the use of this type of surgical template does not permit accurate endosseous positioning of implants because of the difficulty in defining the position of the underlying bone precisely without raising a flap, and the impossibility of fixing the template to the bone once the thick musculomucosal flap has been raised.

We have previously described the modified computer-assisted surgical protocol that we used to rehabilitate jaws reconstructed with free flaps.[5] We think that, with this technique, implants could be positioned exactly where they were virtually planned to go. Precise prosthetic guidance of the position of the implant is achieved with minimal error when the computer-generated template is seated correctly and the anchor pins are fixed correctly into the jaw. It is possible to insert implants in minimal amounts of bone and avoid removal of the screws and plate.

Another advantage of this technique is that it gives the option of placing a provisional restoration prosthesis developed from the template at the end of the operation.[7,8] The prosthesis can be loaded immediately if there is adequate torque on insertion, and this reduces discomfort for the patient, shortens the operating time, and begins early remodelling with overgrowth of soft tissues.

The preliminary data from this study seem to confirm these benefits. More importantly, all patients reported an improvement in their quality of life, better masticatory function, and improved facial aesthetics.

Marginal changes in bone have shown data comparable with normal mean marginal changes in bone around implants inserted in fibular free flaps using a classic unguided approach.

Some problems arise when soft tissue is specifically analysed. It is clear that normal attached gingiva and alveolar mucosa differ from soft tissues that have been reconstructed with skin and muscle. The main problem with the reconstruction of intraoral soft tissues with skin is the hyperplastic/inflammatory response of the skin and subcutaneous tissues around the abutments of the implants. This phenomenon, which has been already described by other authors,[9] was apparent in all patients whose prosthetic loading was delayed during the healing period of the implants; in some cases, the problem was overcome 1 or 2 months after loading. There is no unique solution to this problem. In some cases, the mucosa was harvested from the hard palate and grafted around the implants after removal of the skin with the aim of obtaining an adequate zone of firmly attached and keratinised mucosa around the implants. In some cases, only the remodelling of soft tissue obtained by the prosthesis was sufficient to change the thickness, which resulted in attached peri-implant tissue. In other cases, skin or mucosal grafts were associated with remodelling and deepening of the fornix.

The long transmucosal path may generate problems during prosthetic treatment and oral hygiene. The possibility of analysing the soft tissue path with three-dimensional software allows clinicians to plan longer implants rather than simply longer shoulders to the abutments, which moves the microgap between the platform and abutment of the implant to just under the margin of soft tissue.

Our results confirm our hypothesis that the surgical template obtained by virtual planning of the implant gives a certain prosthetic advantage and, in some cases, is the only way to obtain a fixed implant-supported prosthesis in these complex cases.

However, this surgical and prosthetic protocol presents some operative problems, because of the unavoidable need to adapt a technique normally used to treat normal patients with wide mouth opening and normal anatomy. Patients who have had extended facial reconstructions have limited mouth opening; flat reconstructed ridges; reduced mobility of the

tongue and lips; thickened, retracted mucosa; and scars on the skin.

These operative problems can be difficult, and specific surgical training and knowledge about how to choose the best solution for every single case are required. Some prosthetic problems arise at the time of loading, particularly after gunshot wounds. These stem from difficulties in making an accurate prosthetic and aesthetic analysis before the implants are placed in patients with thick ridges and few anatomical reference points. For this reason, the prosthesis should be modified immediately at the moment of prosthetic loading, or after a few months, to improve occlusal contacts, prosthetic plans, and aesthetics.

We think that the advantages of this protocol (prosthetic-guided insertion of implants, a non-invasive surgical approach, and immediate loading) are definite surgical and prosthetic assets. We are encouraged by the preliminary results, and think that computer-assisted implant surgery in patients who have had reconstructions with osteomyocutaneous free flaps provides a good opportunity for clinicians and patients to achieve the best prosthetic restoration, improved aesthetics and masticatory function, and reduced prosthetic volumes, in patients with fundamental anatomical changes.

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