# Dental Prosthetic Reconstruction of Osseointegrated Implants Placed in Irradiated Bone

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Nineteen patients who were treated for oncologic pathology by surgery and radiotherapy (average dose = 57 Gy) received prosthetic reconstruction with 53 implants placed in the residual mandible or maxilla and/or replacement bone graft. Implants were placed within a minimum period of 5 months after radiotherapy. The healing period before placement of the prosthesis also was at least 5 months. Two to six implants were placed as a function of tooth loss and required prosthetic design. Prostheses included both removable and fixed restorations. Two implants were lost as a result of osseointegration failure. Fifteen implants in six patients could not be followed throughout the study because of patient expiration. Patients were followed up to 68 months and for an average of 38 months. No osteoradionecrosis phenomenon was seen in this study. However, caution is urged in placing implants in irradiated bone because of the potential for osteoradionecrosis. Patients should be carefully selected and a strict therapeutic protocol should be followed.
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**Key words:** implants, irradiated patients, prosthetic reconstruction

Ninety percent of oral cancers are epidermoid carcinomas of the oral mucous membrane, and they are most frequently located on the tongue, floor of the mouth, or alveolar mucosa.[1] For most cancers, the most appropriate treatment is surgical excision associated with radiotherapy.[2] Surgical consequences are not negligible; depending on tumor location, significant substance loss can occur in the maxilla, in the mandible, or on the oral floor. If these losses are not compensated, patients face functional and esthetic problems.[3]

Fortunately, in recent few years, maxillofacial reconstruction has evolved and improved considerably. Substance loss in the mandible, with or without interruption of bone continuity, can be compensated by sophisticated techniques using pedicled or microanastomosed flaps (eg, free micro-anastomosed fibula transfer).[4–8] Symmetry of the lower facial area can usually be preserved, and functional problems can be minimized.[3] Despite surgical reconstruction, some problems remain for dental prosthetic reconstruction, since the support area that stabilizes a conventional prosthesis is reduced.[9,10] The presence of scar tissue, nonmucous soft tissue, and modified bone topography, and the absence of adequate vestibule are all obstacles to prosthetic retention and stability.

For these reasons, placement of a conventional removable prosthesis in these patients is very difficult. The use of implants in such situations significantly helps to stabilize the prosthesis. Resection of the maxilla results in a mouth-nose-sinus communication and decreased palatal support, as well as partial loss of the maxillary vestibule.

It is necessary to eliminate mouth-nose-sinus communication to allow acceptable phonation and feeding. Surgical compensation for loss of maxillary substance is not common; compensation by obturator prosthesis is usually more frequent. Its advantages are, among others, that it is noninvasive and it allows for clinical examination for early detection of a possible relapse.[6]

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**Table 1** Therapeutic Protocols and Observation Times for Each of the 19 Patients

| Patient | Age (y) | Dose (Gy) | Waiting period (mo)* | No. of implants | Healing period (mo) | Prosthesis‡ | Observation period (mo) |
|---|---|---|---|---|---|---|---|
| 1 | 66 | 55 | 14 | 2 | 5 | Rem att | 20† |
| 2 | 65 | 56 | 11 | 4 | 6 | Fixed abut | 36† |
| 3** | 45 | 58 | 23 | 2 | 8 | Rem bar | 62† |
| 4 | 55 | 40 | 12 | 3 | 6 | Rem bar | 68 |
| 5 | 56 | 60 | 5 | 3 | 6 | Rem att | 67 |
| 6 | 63 | 50 | 12 | 3–1 | 7 | Rem bar | 17† |
| 7 | 58 | 60 | 12 | 4 | 6 | Fixed abut | 64 |
| 8 | 50 | 45 | 6 | 2 | 6 | Rem bar | 60 |
| 9 | 37 | 60 | 23 | 2 | 5 | Fixed abut | 6† |
| 10 | 53 | 60 | 6 | 4 | 6 | Fixed abut | 50 |
| 11 | 42 | 60 | 12 | 1 | 6 | Rem att | 47 |
| 12 | 59 | 60 | 5 | 4 | 6 | Rem att | 41 |
| 13** | 60 | 60 | 60 | 1 | 7 | Rem att | 41 |
| 14 | 74 | ? | 192 | 1 | 5 | Rem att | 39 |
| 15 | 63 | 74 | 18 | 6–1 | 6 | Fixed abut | 35 |
| 16 | 52 | 60 | 24 | 4 | 6 | Fixed abut | 34 |
| 17 | 47 | 55 | 17 | 3 | 6 | Rem bar | 13† |
| 18 | 66 | 56 | 10 | 2 | 6 | Rem bar | 22 |
| 19 | 58 | 60 | 53 | 2 | 6 | Rem bar | 14 |
| Means/totals | 53 | 57 | 17 | 53–2 | 6 | | 38 |

*Interval between the completion of irradiation treatments and the placement of implants (mean 17 months). Patient 14 was excluded from calculation of the mean.
**Patients treated following maxillectomy.
†Deceased.
‡Prosthesis type/connection: Rem att = removable attached; Fixed abut = fixed abutment; Rem bar = removable bar.

Making obturator prostheses can be difficult, and a lack of retention and instability often persist. In the event of failure with a conventional obturator prosthesis, use of osseointegrated implants has been suggested.[11]

Radiography may accompany tumor excision in the maxilla or mandible. In addition to morphologic modifications induced by surgery, xerostomia usually develops as a consequence of radiotherapy. Together, these factors complicate prosthesis design and fabrication. The use of osseointegrated implants to stabilize the prosthesis is attractive despite the risks of osteoradionecrosis.[12–18]

The aim of this article is to present the clinical results for 19 irradiated patients in whom a total of 53 implants were placed, and to discuss the value of some statements concerning the osteogenetic capacity of irradiated bone.

## Materials and Methods

**Patients and Irradiation.** To date, 19 patients (3 females and 16 males) who were between 37 and 74 years of age at the time of implantation have been treated. Thirteen patients were treated after partial marginal mandibulectomy, 4 after segmental mandibulectomy, and 2 after maxillectomy. All were irradiated with $cobalt_{60}$, in doses of 40 to 74 Gy (Table 1). For one patient the dose was unknown, since the treatment dated back to 1977. The minimum waiting period between completion of irradiation and the placement of implants was 5 months.

In patients receiving irradiation after tumor excision in the mandible, the irradiation field was not limited to the tumor bed, but extended to the submandibular or cervical ganglionar areas. This extension of the irradiation field results in total irradiation of the residual mandibular bone, and thus the need for a replacement bone graft.[19] In contrast, after maxillectomy, the irradiation field can remain limited to the tumor bed, and the entire residual maxilla may not necessarily need to be irradiated.[19]

**Placement.** A total of 53 cylindrical implants were placed between 1989 and 1996; 50 of these were placed in the residual mandible, the replacement bone graft, or both. In the maxilla, 3 implants were placed in residual maxillary bone (Figs 1 to 3). Depending on the number and location of tooth loss, 2 to 6 implants were placed in each patient. Of the 53 titanium implants, 42 were coated with hydroxyapatite (HA), and the remaining 11 were uncoated. The healing period prior to prosthetic attachment was at least 5 months.

**Prosthetic Reconstruction.** *Mandible.* Partial or total prosthetic rehabilitations were performed, depending on the number and location of tooth loss as well as the intermaxillary height available. Removable prostheses were connected to the implants with

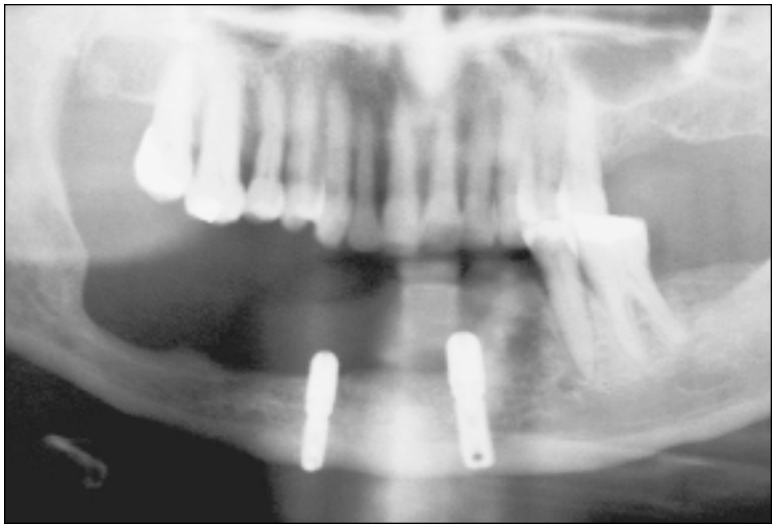

**Fig 1** Placement of two implants in residual mandibular bone.

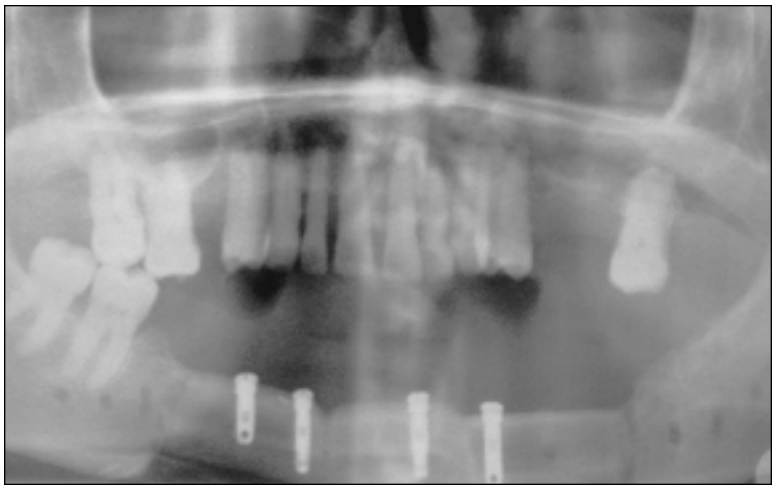

**Fig 2** Placement of four implants in microanastomosed fibula flap.

**Fig 3** Placement of two implants in residual maxillary bone.

Ackerman connection bars and gold staples or with Dalbo-D attachments (Cendres and Metaux, Bienne, Switzerland). The choice of connection depended on the parallelism of the implants, their position in the arch, and the axis formed with the occlusal plane.[20] Fixed prostheses were connected to the implants using an abutment so as to be easily dismantled when necessary.

*Maxilla.* Since it is necessary to seal the resection cavity with a removable obturator, whether it is an integral part of the maxillary prosthesis or attached to it, only removable prostheses were fabricated.[3] Maxillary prostheses are either partial, of the skeletal type, or total, depending on the extent of tooth loss. Connection to the implants was usually provided by Ackerman or Dolder type connection bars and gold staples (Cendres and Metaux).

**Maintenance.** Patients received specific recommendations for daily hygiene. Patients were systematically recalled every 6 months, at which time a radiograph was taken of the implanted areas, and periodontal and prosthetic examinations were conducted.

## Results

Of a total of 19 patients, 6 died (Table 1). The average observation period was 38 months from the time of prosthetic rehabilitation, and the earliest treatment dated back 68 months. Of the 53 implants, 2 were lost in the mandible because of lack of osseointegration, and 15 (13 mandibular and 2 maxillary) were lost after the death of 6 patients related to health problems that did not involve local cancer recurrence. The remaining 36 observable implants were clinically stable. No abnormal osteolytic zone of more than 1.5 mm was detected (Fig 4). In all patients, the gingival tissue around the implant was healthy, and only a 1 to 2 mm decrease in height of the gingival margin was observed (Figs 5a and 5b).

## Discussion

Some authors suggest that the prognosis for cancer patients is not very encouraging, that the technical difficulties are significant and the financial cost high. Therefore, they abstain from any manipulation.[21,22]

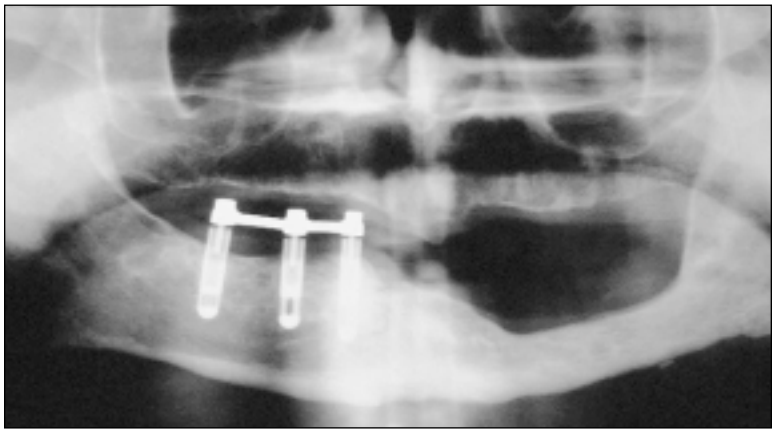

**Fig 4** Orthopantomogram 4 years after prosthetic reconstruction.

**Fig 5a** Placement of snap-type fastening devices for total prosthesis.

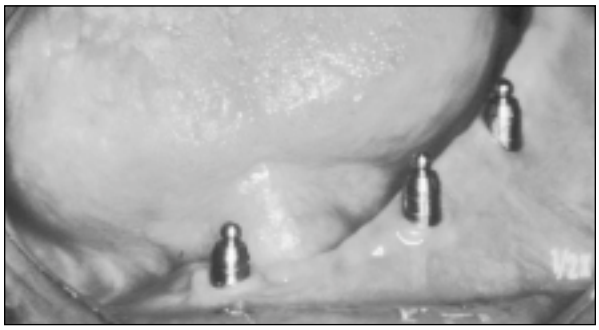

**Fig 5b** The patient shown in Fig 5a, 3 years after prosthetic rehabilitation.

While it is true that these patients' oral conditions are often severely compromised, that work conditions in the mouth are difficult, that the techniques used are sophisticated, should they therefore be denied the right to decent survival conditions, social rehabilitation, and good mental health? Treatment of these patients has provided much satisfaction, both from a technical and an interpersonal relation point of view. Considering the results to date, the authors believe that it is worthwhile to provide these patients with a prosthesis.

A prosthesis is not placed routinely in all patients treated for oral cancer. A medical examination is performed before placement of any implants, and the disease must be in remission and its prognosis favorable. Only patients who express the desire, are willing to dedicate time and money (Belgian social security partially reimburses patients for these implants), and most of all, will commit to rigorous hygienic controls, are treated with a prosthesis. Only when conventional prosthetic rehabilitation is not functional is an implant-supported prosthesis proposed.[23–25]

Depending on the medical examination and patient's selection, implants were always placed during the second surgical stage, ie, at least 6 months after the first surgery (excision of the tumor) was performed. In addition, when a bone graft is used, it is safer not to traumatize it and to ensure its integration with the residual bone before implantation. For patients in whom the bone has been irradiated, it is necessary to wait until vascularization has partly recovered and neo-osteogenesis appears, usually within 3 to 6 months after radiotherapy.[26,27]

There is much controversy relative to the waiting period. According to Jacobsson,[12] there must be a minimum period of 9 months between irradiation and implant placement. Granström et al[14] proposed that the success rate of implants in an irradiated zone depends, among other factors, on the waiting period before placement, which should range from 6 to 18 months. Taylor and Worthington[13] consider 2 years to be a minimum waiting period.

In a study of 20 irradiated patients with implant-supported craniofacial prostheses, Tolman and Taylor[28] reported an 85% success rate. In 2 of the 20 patients, the prosthesis was placed 4 months after radiotherapy, and no implants were lost over an observation period of 24 to 36 months. In a study by Brogniez and coworkers,[18] an intraoral prosthesis was placed in 4 patients after a waiting period after radiotherapy of 5 to 6 months, and no implants were lost. There does not seem to be a direct relationship between implant loss and the waiting period before placement.

The exact mechanism of bone damage resulting from radiation is still not well understood. Baker[29] proposed the following hypothesis. As a consequence of radiation, an alteration takes place in the blood vessel walls, provoking ischemia and decreasing extravascular cell vitality. Osteoblasts are the first to be affected, as osteoblastic function is rapidly sterilized. Osteocytes are affected in a second phase, followed by osteoclasts (large polynucleated cells that are more resistant to radiation). This could explain why there are more resorption lacunae in the irradiated bone.

Osteoradionecrosis (ORN) is one of the most problematic complications of radiotherapy. Marx[30] has defined ORN as a metabolic and tissue failure caused by irradiation. Hypoxia, low cell count, and hypovascularity lead to tissue alteration, which can be amplified by traumatic aggression and infection.

Many authors, including Marx and Ames,[31] Mansfield et al,[32] Granström et al,[33] Granstrom,[34] and Larsen,[35] recommend the use of hyperbaric oxygen (HBO), which has long been used as a therapeutic adjunct to antibiotic agents in the treatment of ORN. HBO is believed to increase osteogenesis and the healing of soft tissues, as well as the neovascularization process in cases of chronic hypoxia.[36] In 1993, Larsen et al[37] showed a difference of 13.9% in mean percent of integration after 4 months in the osseointegration surface of irradiated and nonirradiated animals. This difference dropped to 6.38% when animals received HBO before and after implantation.

Recently, Franzén et al[38] published encouraging results regarding implants placed in irradiated mandibular bone without the use of HBO. Of 20 implants placed in the mandibles of 5 irradiated patients who had received an average dose of 40.3 Gy, only 1 implant was lost after 3 to 6 years of observation. Likewise, Eckert et al[39] have reported a 99% survival rate for a total of 89 implants placed in the mandibles of 18 patients irradiated with an average dose of 60 Gy without HBO treatment; these patients were observed over a period of 12 years. However, the results are less favorable when implants are placed in the maxilla: 64% survival for 22 implants placed in the maxillae of 6 patients.[39] Survival rates for implants in the mandible for these two investigators correspond to the results of the present study, in which a 95% survival rate in the mandible, excluding implants lost as a result of death of patients, was realized (Table 1). The number of implants placed in the maxilla in this study is too small to draw conclusions.

It would appear that use of adjunctive HBO is not necessary for osseointegration in an irradiated environment.[40]

Table 2 divides patients into three groups according to the type of reconstruction performed: partial reconstruction (PR), total fixed reconstruction (TFR),

**Table 2** Patient Distribution According to Type of Prosthetic Restoration

| Restoration type* | No. of patients | Dose (Gy) | Waiting period (mo) | No. of implants | Observation period (mo) |
|---|---|---|---|---|---|
| PR | 7 | 56 | 22 | 11 | 39 |
| TFR | 5 | 62 | 14 | 22–1 | 43 |
| TRR | 7 | 53 | 16 | 20–1 | 34 |
| Total/mean | 19 | 57 | 17 | 53–2 | 38 |

*PR = partial reconstruction; TFR = total fixed reconstruction; TRR = total removable reconstruction.

and total removable reconstruction (TRR). The number of completely edentulous patients was higher than the number of partially edentulous patients. In fact, the surgical procedure often results in complete tooth loss. The number of implants used was different for each of the groups. In the authors' clinical experience, partial reconstructions require fewer implants than total removable reconstructions, which in turn need fewer implants than total fixed reconstructions. Patients with total removable reconstructions were more numerous than those with total fixed reconstructions; removable prostheses are less expensive and usually require fewer implants.

In some patients, it was observed that the intermaxillary space available did not allow the placement of a resin base and artificial teeth, but only allowed the replacement of teeth. This observation may be linked to the radiation dose the patients received during radiotherapy. Patients who have been subjected to high-dose radiation treatment present significant side effects: fibrosis, hyposialia, tissue fragility, and so forth.[29] Significant fibrosis results in a smaller oral opening and a reduced facial vertical dimension. This explains why fixed reconstruction is necessary in some patients.

## Conclusion

Based on the clinical results of this investigation, bone irradiation is no longer a contraindication for prosthetic reconstruction. Caution is advised when placing implants in an irradiated environment so as not to precipitate osteoradionecrosis. Patient selection must be strict, as must the therapeutic protocol applied. Systematic follow-up of patients is mandatory. HBO treatment may be the therapeutic adjuvant of choice, but it is not indispensable. Reconstruction techniques are relatively complicated and are applied only in conditions that are difficult. However, these prostheses can provide much satisfaction in terms of human relationships.

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