Ten-Year Experience in Oral Implant Rehabilitation of Cancer Patients: Treatment Concept and Proposed Criteria for Success

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Between 1988 and 1997, 18 irradiated patients (group 1, 83 implants) and 22 nonirradiated patients (group 2, 92 implants) received resection of the cancer-involved mandible and floor of the mouth and subsequently underwent mandibular rehabilitation with endosseous implants. Implant-supported prostheses were placed in 26 patients, while 13 patients received implant-tissue–supported prostheses. Between 1988 and 1991, patients were restored with implant-tissue–supported prostheses (based on 2 to 4 implants). This strategy was later changed because of the development of denture-related lesions. Since 1992, group 1 patients have been restored exclusively with implant-supported prostheses on 5 to 6 implants; group 2 patients have been rehabilitated alternatively with implant-tissue–supported prostheses on 4 implants. Special criteria for determining the success of implant-supported maxillofacial prostheses were developed. With a mean follow-up period of 37 months, 160 implants (91%) were clinically osseointegrated. Both types of restorations provided sufficient oral rehabilitation. However, only completely implant-supported prostheses avoided soft tissue ulcers. The cumulative success rate was approximately 75% after 7 years for group 1 patients and about 86% after 10 years for group 2 patients. The success rates for implants placed after the change in strategy were approximately 86% (group 1) and 94% (group 2) after 5 years. Based on these experiences, it is suggested that irradiated patients should be restored with exclusively implant-supported prostheses, without any mucosal contact.
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Key words: dental implants, irradiation, maxillofacial prosthetics, oral cancer patients, success criteria

Radical cancer surgery, especially in the floor of the mouth, usually results in poor oral function, facial deformity, and psychologic detriment.[1–20] Immediate surgical reconstruction with vascularized or nonvascularized flaps[6,14,20] has become increasingly popular, but without a prosthesis, oral rehabilitation can remain unsatisfactory with regard to mastication, phonetics, and esthetics.[2,5,17] The postsurgical status is characterized by problematic postoperative anatomy, irradiation-invoked vulnerable mucosa, disturbed myodynamics, unfavorable interocclusal relations, and reduced manual dexterity.[1–20] Conventional prosthodontic treatment is frequently not possible.[2,3,17,18] In such situations, endosseous implants that are designed to serve as prosthesis-supporting elements are becoming increasingly effective.[1,3–14,16–20]

The present study was designed to develop, based on clinical experiences, both surgical and prosthetic protocols for the rehabilitation of patients with oral cancer in the mandible and floor of the mouth, and special criteria for determining the success of implant-supported prostheses in these patients.

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Materials and Methods

Forty patients with oral cancer participated in the study following removal of malignant lesions (squamous cell carcinoma) in the mandible and floor of the mouth. Patients were divided into 2 groups. Group 1 comprised all irradiated patients, ie, patients with irradiation of bone and soft tissue and patients with only soft tissue irradiation. Group 2 comprised all nonirradiated patients. From 1988 to 1997, a total of 175 implants were placed in original mandibles or in free or microvascular anastomosed bone grafts in these patients following conventional reconstructive surgery (Table 1). The soft tissue and bone were irradiated in 50 implant sites. For 33 implants, only the soft tissue had been irradiated. Radiation doses ranged between 36 and 72 Gy (bilaterally opposed fields, Co/MeV photons, 4 to 5 fractions of 2 to 2½ Gy/week). Implants were placed no earlier than 13 months after the conclusion of irradiation and no sooner than 2 months after the conclusion of reconstructive surgery. Abutment connection was performed in irradiated patients approximately 6 months after implant placement and in nonirradiated patients between 3 and 6

Table 1 Surgical Data for Group 1 (Irradiated) and Group 2 (Nonirradiated) Oral Cancer Patients

	Group 1	Group 2	Total
No. of patients	18	22	40
1988 to 1991	2	4	6
1992 to 1997	16	18	34
Irradiation dose			
≤ 36 Gy irradiation	9	0	9
37 to 50 Gy irradiation	5	0	5
> 50 Gy irradiation	4	0	4
Mean interval: cancer resection to implant placement (mo)	44 (range 12 to 186)	36 (range 6 to 159)	39 (range 6 to 186)
Mean interval: end of irradiation to implant placement (mo)	48 (range 13 to 189)		
Mean interval: mandible reconstruction to implant placement (mo)	31 (range 8 to 168)	21 (range 3 to 132)	25 (range 3 to 168)
Mean age at implant placement (y)	55 (range 44 to 70)	56 (range 43 to 75)	55 (range 43 to 75)
No. of implants	83	92	175
Implant type			
Frialit-2 (Friatec)	53	27	80
Brånemark (Nobel Biocare, Göteborg, Sweden)	24	29	53
Ankylos (Hanau, Germany)	0	6	6
IMZ (Friatec)	6	30	36
Implant layer			
Hard and soft tissue irradiated (Gy)	50	0	50
Soft tissue irradiated (Gy)	33	0	33
No irradiation	0	92	92
Vestibuloplasty (mucosal or skin graft)	8	9	17
Implant position			
Interforaminal	73	72	145
Molar/premolar	10	20	30
Mandible left/right			
Mean time until implant exposure (mo)	5.5 (range 3 to 10)	3.2 (range 3 to 6)	4.2 (range 3 to 10)
Exposed implants/patients	83/18	92/22	175/40

months after implant placement. To date, 39 patients have been restored. Of these, 26 patients have received implant-supported restorations, without any mucosal contact. Thirteen patients have received implant-tissue–supported prostheses (Table 2). The prostheses were fabricated by using telescopic, fixed, bar-retained, or ball-retained attachments. In 1 female patient, it was necessary to remove all implants, because of a secondary mandibular fracture postimplantation. No prosthetic rehabilitation was possible for this patient.

From 1988 to 1991, the number and position of implants was determined by surgical criteria. In irradiated patients (group 1), the implants were placed in a prosthetically unfavorable position in a nonirradiated iliac crest bone graft (the bone graft was used to reconstruct the mandible after irradiation was completed) to avoid the use of irradiated original bone sections of the mandible as implant sites. In nonirradiated patients (group 2), the implants were placed in original mandibular bone. In each patient, 2 to 4 implants were placed. An implant-mucosa–supported prosthesis was fabricated in both groups (Fig 1). This strategy was changed in 1992 because of the development of denture-related lesions.

Since 1992, the number and position of the implants have been determined according to both surgical and prosthetic criteria. In irradiated patients (group 1), implants are now placed in the irradiated mandible as well as in nonirradiated grafts. Treatment strategy is based primarily on prosthetic design (type of suprastructure) and secondarily on surgical aspects (number of implants and implant positioning). Irradiated patients have been restored with implant suprastructures supported by 5 or 6 implants. In cases of favorable interocclusal relations, implant-supported telescopic copings or cantilevered prosthetic restorations were fabricated. In situations where difficult interocclusal relations existed (mandible deviations, etc), only implant-supported telescopic copings were utilized (Fig 2). Nonirradiated patients (group 2) were restored with implant-mucosa–supported prostheses on 4 implants; where difficult anatomic conditions existed, patients received implant-supported restorations.

To evaluate this treatment concept, special criteria for evaluating the success of implant-supported maxillofacial prostheses were created.[21,22] These criteria consider difficult surgical and prosthetic conditions, taking into account the compromised anatomic conditions in oral cancer patients and the patient's subjective evaluation of the prosthetic rehabilitation as well. They also emphasize the prosthetic utilization of implants and the avoidance of prosthesis-related lesions.

1. Mobility: Periotest of a single, not blocked implant ≤ 10.
2. Position: The implant is prosthetically satisfied. Sufficient oral hygiene is possible. No implant-related trauma of the perioral soft tissue. The implant allows prosthesis placement with sufficient stability, occlusion, phonation, mastication, and cosmetically sufficient support of the perioral soft tissue.
3. Annual radiography: No peri-implant translucence. Vertical bone resorption between 2 recall intervals ≤ 4 mm. More than one third of the implant length is osseointegrated.
4. Further challenges: No pain, no persistent infection, no neuropathy, paresthesia, or nerve injuries; no prosthesis-related lesions in irradiated patients; and patient satisfaction with their rehabilitation in terms of esthetics and function.

Table 2 Prosthetic Data for Group 1 (Irradiated) and Group 2 (Nonirradiated) Oral Cancer Patients

	Group 1	Group 2	Total
Prosthesis type	17	22	39
Telescopic copings	9	7	16
Bar-supported overdentures	2	9	11
Cantilevered prostheses	6	5	11
Ball-attachment–supported overdenture	0	1	1
Base metal: gold	11	19	30
Base metal: titanium	6	3	9
Implant-mucosa–supported prostheses	2	11	13
Exclusively implant-supported prostheses	15	11	26
No implant-supported prosthesis possible	1	0	1

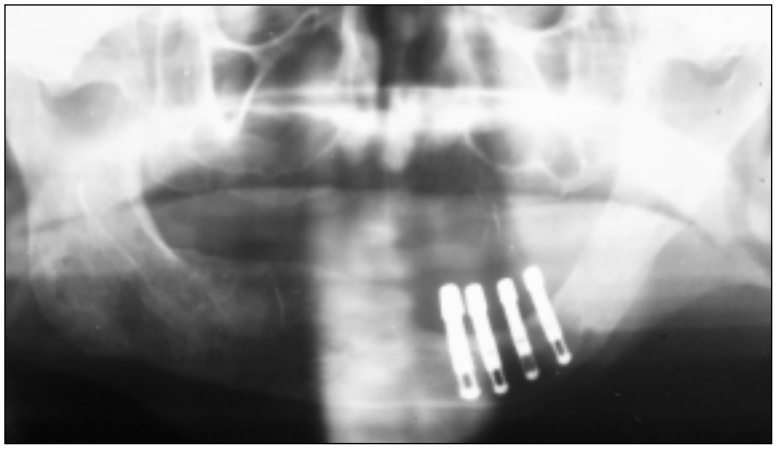

Fig 1 Orthopantomogram. To avoid implant placement into the original, irradiated (40 Gy) right mandible, 4 IMZ implants (Friatec, Mannheim, Germany) were unfavorably, unilaterally placed in a mandible reconstructed by an iliac bone graft.

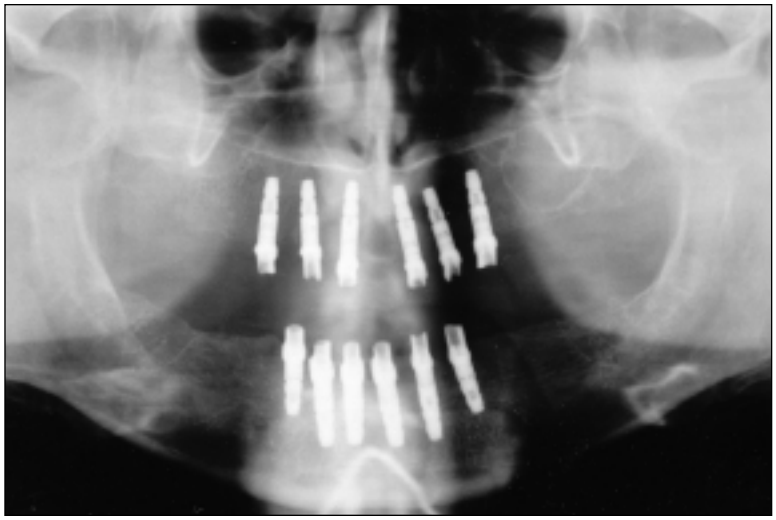

Fig 2 Orthopantomogram. The patient received 6 Frialit-2 screw implants (Friatec) placed in prosthetically favorable positions in the maxilla and the original irradiated (70 Gy) mandible.

To determine whether the treatment strategy fulfills the modified criteria for success in maxillofacial implant reconstruction, the following examination was performed. During implant recall appointments (1 to 3 months for irradiated patients, 3 to 6 months for nonirradiated patients), patients were asked to give their subjective evaluation of prosthesis stability, function, and esthetic improvement. Prosthesis-related lesions and implant-related lesions were evaluated. Treatment complications (neuropathy, continuous pain, infection, implant failure) were noted. Oral hygiene was evaluated according to Quigley and Hein[23] and peri-implant pocket depth (Plast-o-Probe Sonde according to Mühlemann[24]) and implant stability were measured (Periotest, Siemens, Erlangen, Deutschland).[25] Peri-implant bone resorption was measured by a comparison of radiographs (orthopantomogram).[26] On the basis of the clinical examination, cumulative success rate (accomplishment of the modified criteria for success) was evaluated by the product-limit-estimates method according to Kaplan-Meier.

Results

With a mean follow-up period of 37 months, 160 endosseous implants (91%) were osseointegrated without any complications (Table 3). Wound disturbances with bone and cover-screw denudation occurred in 4 group 1 patients (3 of these patients have been smokers). Following systemic antibiotic coverage (ampicillin or lincomycin) and artificial feeding through a gastrointestinal tube, bone coverage occurred by secondary intention.

The Quigley-Hein Plaque Index ranged between 0 and 3. A peri-implant inflammation caused by plaque was observed around 1 implant in 6 patients (four group 1 and two group 2 patients).

Table 3 Results of Combined Implant-Prosthetic Rehabilitation

	Group 1	Group 2	Total
Implants in situ/patients	73/17	87/22	160/39
Prosthetically provided	73/17	87/22	160/39
Prosthetically not providable	0/0	0/0	0/0
No implant-supported prosthesis possible	1	0	1
Prosthetic adaptation problems	1	1	2
Patients' satisfaction with their prosthetic rehabilitation	17	22	39
Prosthesis-related soft tissue trauma			
Exclusively implant-supported prostheses	None	None	None
Implant-mucosa–supported prostheses	Often	Sometimes	
Implant-related perioral soft tissue trauma	None	None	None
Plaque Index (Quigley-Hein)	0 to 3	0 to 3	0 to 3
Failing implants/patients	10/6	5/4	15/10
Peri-implant bone resorption each year (mm)	0.1 to 0.2	0.1 to 0.2	0.1 to 0.2
Periotest (mean scores)	–4.5 (range –2 to –7)	–3.5 (range –1 to –6)	–4 (range –1 to –7)
Mean peri-implant pocket depths (mm)	5 (range 3 to 7)	4 (range 2 to 6)	4.5 (range 2 to 7)
Mean follow-up (mo)	37 (range 6 to 84)	37 (range 6 to 117)	37 (range 6 to 117)

The inflammation was eliminated by plaque control and antiseptics combined with oral (ampicillin) and local (metronidazol) antibiotics, respectively. Oral hygiene instructions and motivation were also reinforced. Except for these 6 patients, oral hygiene was satisfactory, not only for those having implant-tissue–supported prostheses, but also for those with implant-supported prostheses.

Peri-implant pocket depths were greater in patients with peri-implant split-thickness skin grafts than in those patients whose implants were surrounded by peri-implant mucosa. Periotest values and the peri-implant bone resorption measurements were nearly equal in both groups. During implant treatment, no neuropathy, nerve injuries, continuous pain, or infections were observed.

A total of 15 implants (9%) had to be removed (10 implants in 6 irradiated patients and 5 implants in 4 nonirradiated patients) (Table 4). In 7 patients, implants had failed before prosthetic restoration (primary implant failure). Of these, in 1 patient 5 implants had to be removed because of a mandibular fracture 1 week following implant placement. In another patient, 2 implants did not osseointegrate because of biomechanical overloading by a provisional restoration during the healing period. Reasons for implant failure were unknown in 5 patients. In 3 patients, implants failed after prosthetic restoration (secondary implant failure) because of biomechanical overloading or microbiologic infection. Although there was a twofold increase in implant failure in irradiated patients, there was no statistical significance in the increased failure rate. All other implants osseointegrated without complications and were prosthetically loaded.

In spite of prosthetic stability, 2 patients were unable to adapt to their restorations. All other patients were satisfied with regard to the stability and function of their prostheses and the resulting esthetic improvement.

Exclusively implant-supported prostheses (fixed prostheses or telescopic restorations) did not cause any trauma to the surrounding soft tissue. Prosthesis-related pressure lesions were observed only after initial rehabilitation and correction of the base of implant-tissue–supported prostheses or bar-supported, ball-attachment, or telescopic prostheses. Denture-related lesions were more marked in irradiated patients than they were in nonirradiated patients. No osteoradionecrosis developed.

Table 4 Analysis of Implant Failure

	Patient (initials)/group									
	HB/1	JB/1	HJ/1	HE/1	LP/1	EE/1	NB/2	JP/2	HR/2	HS/2
Sex	M	M	M	M	F	F	F	M	F	M
No. of failing implants	1	1	1	1	1	5	1	2	1	1
Brånemark	1	1	0	0	0	0	1	2	1	0
Frialit-2	0	0	0	1	1	5	0	0	0	0
Ankylos	0	0	0	0	0	0	0	0	0	0
IMZ	0	0	1	0	0	0	0	0	0	1
Implant location										
Interforaminal	0	0	1	1	1	5	1	2	1	1
Premolar/molar	1	1	0	0	0	0	0	0	0	0
Implant layer										
Original bone	x	x	x	x	x	—	x	—	x	—
Grafted bone	—	—	—	—	—	x	—	x	—	x
Peri-implant mucosa	x	x	x	x	x	x	x	—	x	—
Skin graft	—	—	—	—	—	—	—	x	—	x
Irradiated hard tissue (Gy)	40	36	72	50	50	0	0	0	0	0
Irradiated soft tissue (Gy)	40	36	72	50	50	36	0	0	0	0
Prosthetic restoration										
Bar-supported	—	—	x	—	—	—	—	—	x	—
Cantilevered	x	—	—	—	—	—	—	—	—	—
No restoration	—	x	—	x	x	x	x	x	—	x
Reason for implant failure										
Biomechanical overload	—	—	x	—	—	—	—	x	—	—
Microbiologic infection	x	—	—	—	—	—	—	—	x	—
Mandible fracture	—	—	—	—	—	x	—	—	—	—
Unknown	—	x	—	x	x	—	x	—	—	x
Interval between placement and failure (mo)	27	6	12	6	6	0.25	3	6	27	6

Based on the special criteria for determining the success of implant-supported maxillofacial prostheses, the cumulative success rate was approximately 75% at the 7-year interval for irradiated patients and approximately 86% at the 10-year interval for nonirradiated patients. With regard to implants placed after the strategy change, the success rates were approximately 86% for group 1 patients and 94% for group 2 patients after 5 years (Figs 3 and 4).

Discussion

There are few reports of implant placement in oral cancer patients. The indication for implant placement, especially in irradiated patients, has been controversial.[1–19,21,22,25,27–30] Some authors still consider implant placement in irradiated patients to be contraindicated.[15,22,30] Others have suggested that hyperbaric oxygen therapy should precede implant surgery to decrease an anticipated loss of implants.[9,16] However, osseointegration has been reported without hyperbaric oxygen, especially in the mandible.[4,8,10,13,18,19]

While patients in the present series were not treated with hyperbaric oxygen, there is an encouraging success rate of clinically osseointegrated implants in both irradiated and nonirradiated patients. This experience concurs with other studies concerned with implantation following cancer surgery and irradiation without any hyperbaric oxygen.[4,8,10,13,18,19] Irradiation itself does not necessarily affect clinical implant integration.

In contrast to other studies addressing surgical or prosthetic rehabilitation,[2–4,9,13–17,19] in this study implant success was based on both surgical and prosthetic aspects. Contrary to other studies, in this patient series the success of implant-supported maxillofacial prostheses was determined by special criteria and not by standard criteria. These special criteria take into account both the compromised anatomic conditions and the special requirements of dental implants in oral cancer patients. The special criteria would seem to be necessary to assess a combined surgical and prosthetic implant protocol for oral cancer patients.

The superiority of implant-supported prostheses in the mandible to tissue-supported prostheses

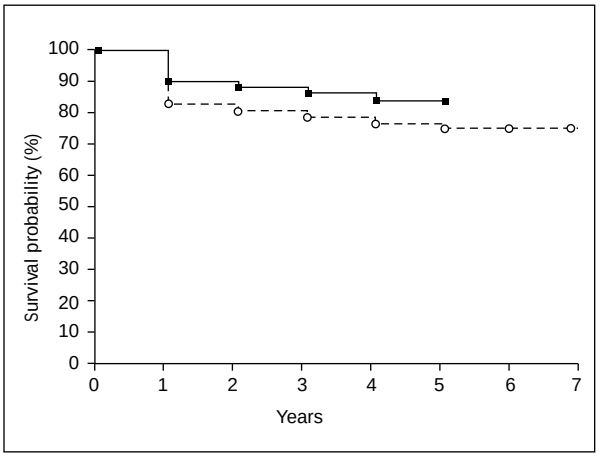

Fig 3 Group 1 survival analysis according to Kaplan-Meier. Criteria for non-success: modified criteria for success are not realized. The curve at the top (squares) represents implants placed in irradiated patients after the treatment concept change in 1992 (n = 77). The lower curve (circles) represents all implants placed in all irradiated patients (n = 88).

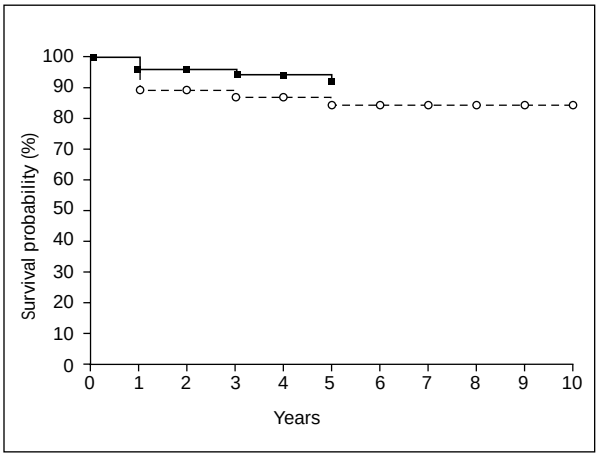

Fig 4 Group 2 survival analysis according to Kaplan-Meier. Criteria for non-success: modified criteria for success are not realized. The curve at the top (squares) represents implants placed in nonirradiated patients after the treatment concept change in 1992 (n = 80). The lower curve (circles) represents all implants placed in nonirradiated patients (n = 92).

in the mandible was noted by Komisar in 1990.[2] The present experience demonstrates that both implant-supported and implant-tissue–supported prostheses can be used to provide functional, stable, and esthetically satisfactory rehabilitation. But only totally implant-supported prostheses circumvented any mucosal lesions. Prosthetically related pressure lesions, which increase the risk of a septic osteoradionecrosis and which dictated a change in treatment strategy in 1992, were seen only in cases of implant-mucosa–supported prostheses. According to the present study, implant-tissue–supported mandibular prostheses, as advocated by other authors,[12] can only be recommended to a limited degree.

The success rate achieved in this investigation, especially after the change in treatment plan in 1992, emphasizes the value and practicability of an implant treatment concept that relates anatomic-morphologic situations to specific surgical and prosthetic treatment plans. This relationship is designed to reduce treatment complications,[31] especially the risk of osteoradionecrosis and recognition of the difficulty of oral rehabilitation in cancer patients.

Conclusions

On the basis of positive results with implant-supported prostheses, surgical and prosthetic implant rehabilitation has become recognized as an accepted treatment option for tumor patients. Irradiated jaws themselves present few contraindications for the placement of endosseous implants whenever the conceptual requirements are maintained. Special criteria for success should preferably be used to evaluate implant-supported maxillofacial prostheses. Oral rehabilitation is possible after the removal of malignant tumors in the lower portion of the oral cavity, using either restorations supported completely by 5 or 6 implants, or implant-tissue–supported restorations based on 4 implants. However, prior to implant surgery, the prosthetic design concept should be determined so that the number of implants and implant positions can be ascertained. Totally implant-supported prostheses do not derive support from the mucosa and are recommended following irradiation. Implant-tissue–supported prostheses may be an option for nonirradiated patients.

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