Oral Rehabilitation With Implant-Retained Prostheses Following Ablative Surgery and Reconstruction With Free Flaps

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Ablative surgery of the oral tissues may result in significant facial deformity, poor oral function, and psychologic detriment. Immediate surgical reconstruction with vascularized free flaps has become increasingly popular, but the oral rehabilitation of these patients with conventional dental prostheses is usually unsuccessful. The results and clinical experiences of treating a group of 17 patients with ablative surgery, immediate reconstruction with free flaps, and restoration with mandibular implant-retained prostheses are presented after follow-up periods of 6 months to 7 years. Most patients expressed a high degree of satisfaction with their prostheses. General principles and guidelines for the provision of this effective treatment modality are discussed.
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Key words: ablative surgery, dental implants, free flaps, mandibular reconstruction, oral rehabilitation

Neoplastic disease of the oral tissues usually requires aggressive surgical treatment, often combined with radiotherapy. Resection of a complete segment of the mandible results in loss of continuity of the jaw and a lack of bony support for the facial soft tissues. The balance and symmetry of mandibular function is compromised, leading to altered mandibular movements and deviation of the residual fragment medially towards the resected side. Attempts at mandibular reconstruction with metal plates, free bone grafts, and regional flaps have had limited success. The resulting prosthetic problems in these circumstances are formidable and often insurmountable despite the ingenuity of prosthodontists.[1-3] In such cases, significant facial deformity and loss of oral function in terms of impaired mastication, speech, and swallowing results and has a detrimental psychologic impact on the patient.[4] When the resection only involves the alveolar portion of the mandible, or is confined to the associated soft tissues, mandibular continuity is maintained. Although there is less obvious facial disfigurement, there may still be great difficulty in wearing conventional dentures because of altered oral anatomy, obliteration of sulci, and loss of sensory and motor innervation. In addition, tongue function may be significantly affected, making control of a conventional denture difficult.[1] The use of osseointegrated endosseous implants to aid prosthetic treatment following ablative surgery has been

found to be beneficial in some cases.[5,6]

In recent years, immediate surgical reconstruction using vascularized free flaps has revolutionized oral reconstruction after ablative surgery. The composite or osseocutaneous radial forearm flap (RF) may be used reliably to reconstruct the mandible and restore mandibular continuity.[7,8] The pliable fasciocutaneous radial forearm flap may be used to replace soft tissue and is contoured over underlying bone to maintain tongue mobility, lessening the impact of surgery on speech and eating.[9] The iliac crest osseous flap, based on the deep circumflex iliac artery (DCIA), has also been used to reconstruct mandibular defects[10,11] and yields a relatively large volume of well vascularized bone. The skin paddle, however, may be unreliable, and hence the internal oblique abdominal wall muscle can be included in the flap and used in reconstructing the oral mucosal defect. Despite these advances in reconstructive techniques, the prosthetic treatment of these patients using conventional dental prostheses still remains difficult,[10,12] again because of altered anatomy and sensation as well as the variable quantity and quality of flap tissue available to support a prosthesis.

Oral rehabilitation after ablative surgery aims to restore both oral function and facial form to enable a person to recover physically and psychologically to the fullest extent and hence regain the capacity for normal life and employment. It would seem logical to use endosseous implants in conjunction with free flap reconstructive techniques[13,14] in achieving the goal of complete oral rehabilitation. The purpose of this paper is to report on a group of patients who underwent resection of the oral tissues, reconstruction with vascularized free flaps, and rehabilitation with mandibular implant-retained prostheses. This preliminary clinical report investigates the efficacy of this treatment modality and discusses some general guidelines for its provision.

Materials and Methods

The treatment group consisted of 17 patients (6 females and 11 males) with an average age of 55 years (range 11 to 78 years) at the time of major ablative and reconstructive surgery. After histologic examination, 14 patients were diagnosed as having squamous cell carcinoma, one had osteosarcoma, one fibrous dysplasia, and one ameloblastoma. Ablative surgery consisted of segmental mandibular resection in seven patients, rim mandibular resection in six patients, soft tissue resection involving floor of mouth and tongue in two, and buccal mucosa resection in two. Immediate reconstruction with vascularized free flaps was carried out in all the patients except in one child, who had interim reconstruction with a titanium mesh tray some years before placement of a free flap. Ten patients had reconstruction with fasciocutaneous RF flaps alone, and two patients had an osseocutaneous RF flap. Five patients had bony reconstruction with the osseous DCIA flap, with one of these also requiring a fasciocutaneous RF flap for additional soft tissue coverage. Five patients required postoperative radiotherapy, without the use of hyperbaric oxygen

therapy.

Patients were subsequently assessed at a joint oral rehabilitation clinic by a team of both surgeons and prosthodontists for formulation of the treatment plan. The criteria for patient selection included patient, surgical, and prosthodontic factors, radiotherapy effects, and timing.[14] Patients were required to be well-motivated, fit for general anesthesia, and overtly disease-free 1 year after the original ablative surgery. Adequate bone quantity and quality for appropriate implant placement was required, along with a suitable peri-implant environment or one that could be achieved through secondary soft tissue surgery. Adequate oral access for the prosthodontic phase of treatment, good oral hygiene, and reasonable patient manual dexterity were also prerequisites. Radiotherapy was an additional reason for delaying implant treatment for 1 year, so as to allow some recovery of the oral tissues.

The Brånemark implant system (Nobel Biocare AB, Göteborg, Sweden) was used in one patient (3.75 mm × 7 mm). Sixteen patients were treated with the IMZ implant system (Friatec AG, Mannheim, Germany). The diameter of the latter implants used was 3.3 or 4.0 mm in a variety of lengths (10 to 15 mm), depending on the bony morphology. The transmucosal abutments used ranged from 2 mm to 8 mm in length, depending on the thickness of the investing soft tissues.

During the period between 1989 and 1995, the oral surgery team placed a total of 69 implants in the reconstructed mandibles of the 17 patients. The number of implants placed ranged from three to six dependent upon the bony morphology and the type of pre-implant surgery. Three patients had 14 maxillary implants placed at this stage to improve the prospects of achieving a satisfactory maxillary prosthesis. A 4- to 6- month stress-free healing interval was allowed to ensure osseointegration prior to exposure of the submerged implants. At this stage, a variety of secondary soft tissue procedures were carried out. These included debulking of excessive soft tissue, vestibuloplasty, and free palatal mucosal grafts to improve the peri-implant soft tissue environment.

After the tissues had healed adequately, secondary impressions were made using an elastomeric material (Impregum, ESPE, Fabrik Pharmazentischer Paparate GmbH, Seefeld/Oberay, Germany) in custom trays to facilitate fabrication of the implant-retained prostheses. Screw-retained fixed prostheses (Fig 1) were fabricated for nine patients (six edentulous and three partially dentate). Eight patients had removable overdentures placed, which included seven edentulous patients and one partially dentate patient (Figs 2a and 2b; Figs 3a to 3c). The prosthetic teeth and matrix were acrylic resin in 15 of the 17 patients, with only 2 having a metal ceramic screw-fixed prosthesis because of limited interocclusal space. Efforts were made to have the intercuspal position coincide with the most retruded mandibular position and thus achieve a balanced articulation, although this was not always possible where there were opposing natural teeth.

After completion of the prosthodontic phase of treatment, the patients were given oral hygiene instruction and kept under regular 6-month review. At the final review visit, the presence or absence of plaque on the implant abutments, the occurrence of gingival hyperplasia, the occurrence of bleeding upon gentle probing, and measurement of the deepest probing depth were recorded for each implant. Probing was carried out using a plastic probe designed to deliver a controlled force of approximately 20 g (Sensor Probe, CPITN, type US, Rota-Dent, St Neots, Cambridgeshire, UK). The superstructure was removed to assess implant mobility clinically. Panoramic radiographs and, where anatomy allowed, periapical radiographs were obtained to assess the bone-implant interface. Using a standard format, patients were asked to assess their implant prostheses in terms of comfort, appearance, mastication, and speech on a scale of 1 to 5 (1 = excellent, 2 = good, 3 = fair, 4 = poor, 5 = very poor).

Results

The patients have been followed for varying periods; the survival table for the mandibular implants in this study is shown in Table 1. Fifteen of the original 17 patients were recently examined in some detail. One patient was lost to review after a follow-up period of 1 year, while another patient died from a myocardial infarction after 18 months of observation. These patients had 10 mandibular and 5 maxillary implants in place that had successfully integrated and were present at their last visit. These implants have been included in the results in the appropriate follow-up periods.

The two patients who lost implants were reconstructed with osseocutaneous RF flaps and received external-beam radiotherapy (60 Gy fractionated dose) to the neck and primary site 6 weeks after the original surgery. One of these patients lost three Brånemark 3.75 mm × 7.0 mm implants, all placed in the free flap bone. One implant failed to integrate, and two were lost after loading. The other patient received a blow to the jaw during the implant healing phase, which resulted in a fracture of the free flap bone through one of the implant sites. This was treated by removal of the implant (IMZ 3.3 mm ×10 mm) and immobilization of the fracture with a miniplate to allow uneventful healing.

Overall, 65 of the original 69 mandibular implants have survived after a mean follow-up period of 32 months (range 6 to 84 months). The survival rate of implants for patients reconstructed with fasciocutaneous RF flaps and osseous DCIA flaps was 100%, while for those managed with osseocutaneous RF flaps it was 64% (Table 2). It should be noted, however, that four implants have been converted to “sleepers” because of an unfavorable position or inclination that presented a prosthetic problem. In the maxilla, 13 of the original 14 implants remain successfully in function, resulting in a survival rate of 93% after a mean follow-up period of 20 months (range 13 to 28 months).

Detailed clinical examination of the 52 implants available for inspection revealed that 48% (25) had plaque present on the surface of their transmucosal abutments. Bleeding upon probing occurred in 27% (14) of the implants examined, and peri-implant mucosal hyperplasia was associated with 11% (6) of the implants. A probing depth of 3 mm or less was detected in 67% (35), while 27% (14) had a probing depth of 4 to 5 mm. A probing depth of 6 mm or more was recorded for 6% (3) of the implants examined. These deep probing depths were found in two overdenture patients who had hyperplasia of the peri-implant mucosa associated with loose abutments. When the abutments were removed, cleaned, and replaced, the peri-implant mucosa spontaneously returned to health within a 3-month review period. One patient with a fixed prosthesis had persistent hyperplasia of the peri-implant tissues associated with a bulky free flap; this patient has since had secondary soft tissue surgery to reduce the thickness of the flap.

After removal of any superstructure joining the implants, it was found that all of the functioning implants were clinically firm and nonmobile and gave a percussive note indicative of bony ankylosis. Radiographic evaluation of the bone-implant interface proved difficult, as the orthopantomograms often lacked clarity anteriorly. Periapical radiographs were not reproducible and could not always be obtained because of trismus and distortion of the intraoral anatomy, making proper film placement difficult. Quantitative data on the amount of bone loss occurring adjacent to the implants cannot therefore be presented, although the bony response around the implants was observed to be favorable in general (Figs 2b and 3c).

At the last review, all of the implant-retained prostheses were judged by the prosthodontist to be functioning satisfactorily. Most patients expressed a high degree of satisfaction with their implant prostheses, and only 1 of the 15 questioned was unhappy with the results of the prosthetic treatment. This patient suffered from depression, although there were some prosthetic errors with the conventional maxillary denture that necessitated remaking the prostheses. The main complaint of patients was the prolonged period that they were required to be without a prosthesis while the healing phase was in progress. The distribution of patient scores for comfort, appearance, mastication, and speech for implant-retained prostheses is shown in Table 3.

Discussion

The results of this study compare favorably with other studies in which delayed implantation with ceramic implants was carried out in vascularized osseous DCIA flaps,[10] and immediate placement with titanium implants was performed in vascularized fibula and osseous DCIA flaps.[15,16] Comparison of different studies is problematic because of differences in methodology and the criteria used to define success, although osseointegration in the nonirradiated patient is no longer an issue. Radiotherapy may have a significant impact upon the viability of the potential implant bed, although some success has been reported both with and without

adjunctive hyperbaric oxygen therapy.[15-20] The effects of radiotherapy on the long-term success of endosseous implants placed in vascularized free flaps are not clear, as this type of tissue bed is quite different from both nonvascularized free tissue grafts and the intact edentulous jaws. Further long-term studies are required to clarify this poorly documented field.

Despite the relatively small patient numbers, the results suggest a number of guidelines for treatment of this group of patients. With respect to the type of vascularized flap used, and based on this study, the fasciocutaneous RF flap provides good soft tissue coverage after ablative surgery. The osseocutaneous RF flap provides relatively little bone for implant placement, so that only short implants may be used. It should be noted that the only implant failures in this study were associated with implants placed in this irradiated flap. Where a large bony defect is to be reconstructed, the DCIA vascularized flap gives the best volume of bone that may be contoured appropriately to restore mandibular continuity, although the fibula may be used successfully.[14] Full use should be made of the patients' residual mandible for placement of implants, either on the unresected side or beneath any flap that is reconstructing an overlying soft tissue defect.

Plaque was present on a portion of the implant abutments despite oral hygiene instruction using a variety of mechanical aids. However, the patients were considered to have achieved good levels of oral hygiene in light of the difficulty of gaining access to the implant abutments that often results from the postsurgical distortion of the oral anatomy with loss of proper sulcus depth. While regular programmed hygiene visits were not scheduled, as in some centers, such visits were prescribed on an "as needed" basis by the prosthodontists. Further hygienic support would no doubt have achieved an improvement in plaque scores and peri-implant mucosal health, and is strongly advocated.

Visual assessment of the health of the peri-implant mucosa in terms of color or morphology was complicated by the presence of skin and/or mucosal grafts. In addition, soft tissue coverage by removable overdentures may have an effect on color and morphology of the peri-implant mucosa, especially if worn throughout the night.[21] The peri-implant hyperplasia found in some cases may be the result of a plaque-induced inflammatory response or related to loose titanium abutments. In patients with overdentures, it may be simply an overgrowth of the tissues into the dead space around the bars. Hyperplasia has not been a major problem during the follow-up of this group of patients.

Bleeding upon probing around the implants with a plastic controlled pressure probe was recorded, as it was considered the best clinical method available to detect the presence of inflammation.[22] Analysis of pocket depths is problematic because of the highly variable soft tissue thickness, consistency, and architecture found adjacent to implants after reconstructive free flap surgery. The most satisfactory soft tissue responses were found in sites where secondary soft tissue surgery had been effective

in creating a well-defined band of thin (2 mm), nonmobile, keratinized, peri-implant mucosa, and this has been adopted as a treatment goal.

A number of the implants that were placed could not be used because of positional problems. The surrounding mucosa was allowed to heal over them to convert them to "sleepers." More detailed investigations and careful treatment planning are required to avoid this situation.[23,24] Use of the diagnostic wax-up/trial prosthesis to confirm prosthetic tooth positioning is mandatory. From this, a radiographic template may be fabricated to assess available bone volume, and hence to decide upon the most appropriate implant dimensions, numbers, and positioning. The value of surgical guides in translating the treatment plan into reality cannot be overemphasized. Surgical reconstruction with delayed implantation has the advantage over immediate implantation[16] in that these investigations and treatment-planning stages may be carried out. Hence, more effective control over implant positioning may be exercised to ensure a successful prosthetic result.

There is insufficient evidence to suggest that one type of superstructure or prosthesis is superior to another, although some clinical impressions may be given with respect to these issues. There are several factors that may be considered in the choice between a fixed or a removable implant-retained prosthesis.[25,26] Fixed prostheses are often thought to be the preferred choice of most patients, although the present study did not provide sufficient data to contribute to this hypothesis. The fixed prosthesis is completely implant-supported, which may have a beneficial stimulating effect on the supporting bone. These prostheses do not contact the oral mucosa, and thus the problems of denture-related mucosal ulceration are avoided. This is especially important in patients with xerostomia, who often have dry, fragile oral mucosa that is very susceptible to trauma. However, a greater number of implants and more precise placement are required for a fixed prosthesis when compared to its removable counterpart. Where there is substantial residual alveolar ridge, this is usually achievable and, indeed, because interocclusal space is favorable, a fixed prosthesis is indicated.

Removable mandibular overdentures[21] may give improved support for the facial tissues by the use of a flange and may entail fewer problems with phonetics and saliva control. A removable prosthesis gives improved access for oral hygiene and more scope to correct discrepancies in dental arch relationships. The gross loss of hard and soft tissues resulting from ablative surgery may be more easily restored using the acrylic resin matrix of a removable overdenture in comparison to its fixed counterpart. However, after ablative surgery there may be problems with oral access that make insertion and removal of an overdenture difficult for the patient. Many of these patients have no previous denture-wearing experience and, with loss of neuromuscular function after ablative surgery, adaptation to a removable prosthesis may be extremely difficult.

The opposing arch should always be considered in treatment planning, along

with the presence or absence of natural teeth, residual alveolar ridge form, previous denture-wearing experience, and extent of ablative surgery (especially affecting tongue function). Success in the mandible with an implant-retained prosthesis may not always be matched by a conventional maxillary denture. Some of the patients studied have had difficulty in coping with their conventional maxillary denture in this situation. Presumably, this is the result of relatively high occlusal forces generated from the mandibular implant prosthesis and a lack of neuromuscular function following surgery affecting muscular control of a maxillary denture. Great care in fabricating the opposing conventional prostheses is required, especially with respect to effective border seal and balanced articulation. There may be a case of prescribing implant-retained prostheses in both arches in these circumstances; this has been carried out in three patients in this study group.

There is a lack of standardized, generally accepted, and validated methods of measuring levels of patient satisfaction/dissatisfaction with dental prostheses. Therefore, a relatively simple questionnaire was used in this study that involved patient-based measures of comfort, mastication, speech, and esthetics. The favorable levels of oral function and esthetics resulting from the implant-retained prostheses fabricated in this patient group are supported by the findings of other studies.[27,28]

Conclusions

1. The use of implant-retained prostheses after ablative surgery and immediate reconstruction with free flaps can fulfill the goal of oral rehabilitation.
2. Most patients expressed a high degree of satisfaction with their implant-retained prostheses in terms of comfort, oral function, and appearance.
3. Oral rehabilitation after ablative surgery and free flap reconstruction is a complex multidisciplinary treatment modality, requiring a coordinated hospital-based team approach.

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Table 1 Patient Data and Mandibular Implant Survival

Follow-up years/ Patient	Age (y)	Surgery type	Radiotherapy	No. of lower implants placed	Prosthetic design	No. of implants lost	No. of sleepers	Survival rate (%)
6–7								
1	14	DCIA/OC	no	4	P fp	0	0	100
2	59	RF/OC	yes	5	C ro	3	0	40
4–5								
3	71	RF/FC	no	4	C fp	0	0	100
4	68	RF/FC	yes	4	C ro	0	2	50
3–4								
5	51	RF/FC	no	4	C ro	0	0	100
2–3								
6	37	DCIA/OC	no	4	P ro	0	0	100
7	76	RF/FC	no	4	C ro	0	0	100
8	45	RF/FC	no	4	C ro	0	0	100
9	77	RF/FC	yes	4	C fp	0	0	100
1–2								
10	43	RF/FC	no	3	P fp	0	0	100
11	60	RF/FC	no	3	C ro	0	0	100
12	54	DCIA/OC and RF/FC	no	4	C fp	0	0	100
13	70	RF/FC	no	5	C fp	0	0	100
14	60	RF/OC	yes	6	C ro	1	1	67
< 1								
15	64	DCIA/OC	no	3	P fp	0	1	67
16	50	DCIA/OC	no	4	C fp	0	0	100
17	54	RF/FC	yes	4	C fp	0	0	100
Totals								
17				69		4	4	

RF = radial forearm flap; DCIA = iliac crest flap; FC = fasciocutaneous flap; OC = osseocutaneous flap; P or C = partial or complete arch; fp = fixed prosthesis; ro = removable overdenture.

Table 2 Summary of Mandibular Implant Survival Data According to Type of Surgical Management

Surgical type	No. of patients	No. of implants	No. of lost implants	Survival (%)
RF/FC	10	39	0	100
DCIA/OC	5	19	0	100
RF/OC	2	11	4	64
Totals	17	69	4	94

RF/FC = radial forearm flap/fasciocutaneous; DCIA/OC = iliac crest flap/osseocutaneous; RF/OC = radial forearm flap/osseocutaneous.

Table 3 Distribution of Patient Assessment Scores (%) for Implant-Retained Prostheses

	Excellent	Good	Fair	Poor	Very poor
Comfort	27	60	7	7	0
Appearance	27	60	14	0	0
Mastication*	36	43	7	7	7
Speech	7	67	20	7	0

*Mastication scores are based on the responses of only 14 patients, as 1 patient was unable to ingest food by mouth because of problems in swallowing.

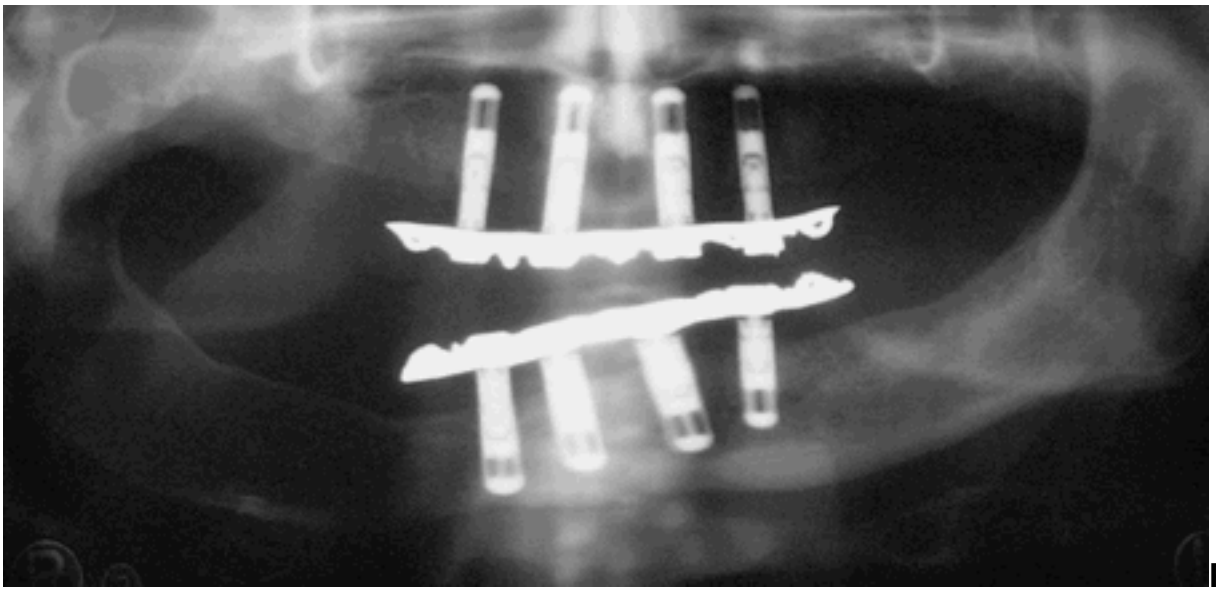

Fig. 1 Panoramic radiograph of an implant-supported, screw-retained acrylic resin metal fixed prosthesis following mandibular reconstruction with an osseocutaneous DCIA flap and fasciocutaneous RF flap.

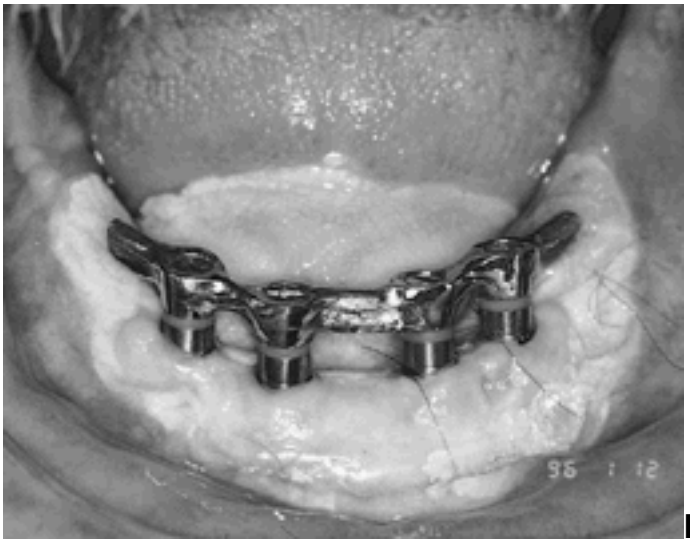

Fig. 2a Intraoral view of a complete mandibular implant-retained overdenture case, with Hader bar/clip superstructure, following mandibular reconstruction with a fasciocutaneous RF flap.

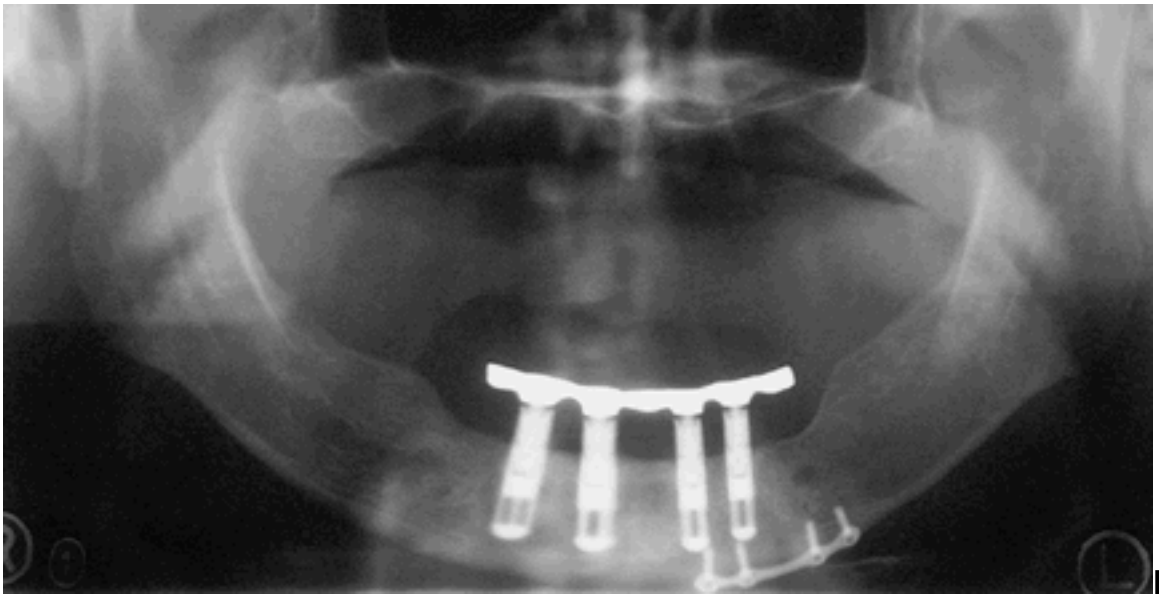

Fig. 2b Panoramic radiograph of patient shown in **Fig 2a**.

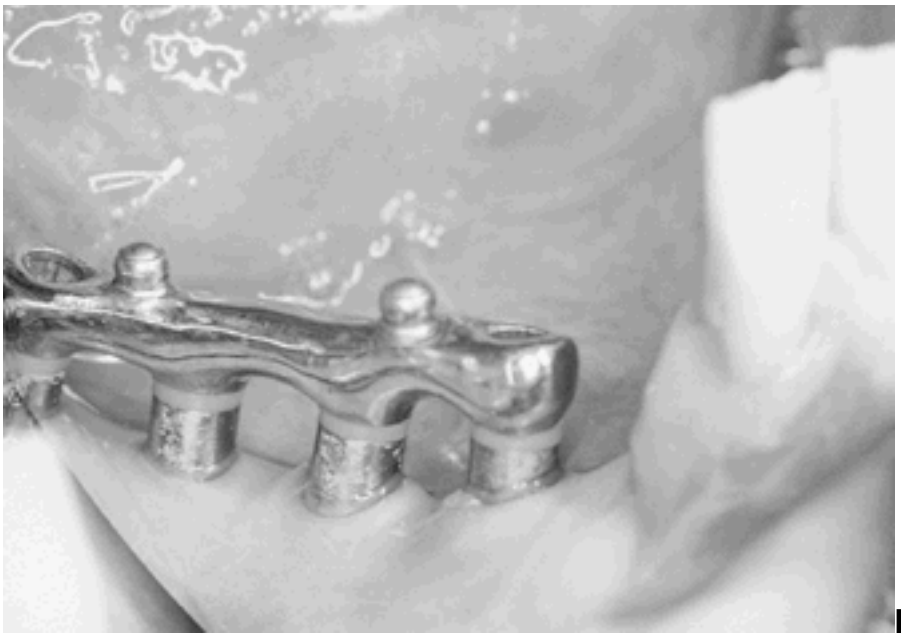

Fig. 3a Intraoral view of the superstructure of a partial mandibular implant-supported overdenture, with bar/stud attachments, after mandibular reconstruction with an osseocutaneous DCIA flap.

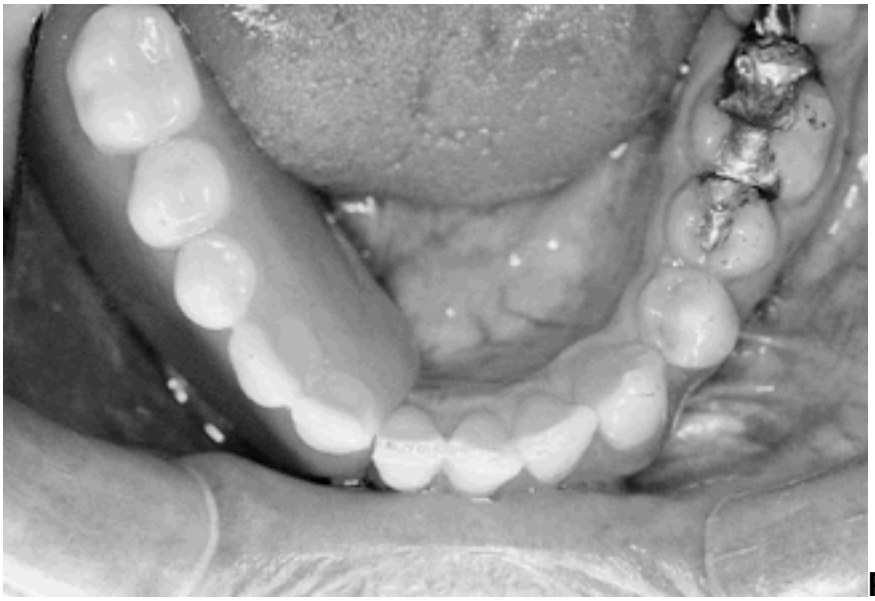

Fig. 3b Intraoral view of prosthesis worn by the patient shown in **Fig 3a**.

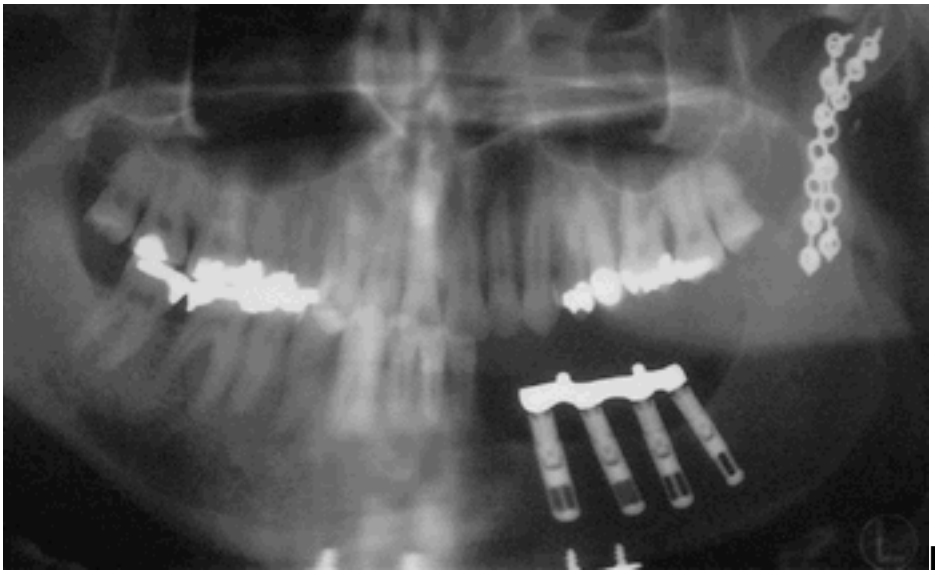

Fig. 3c Panoramic radiograph of patient shown in **Figs 3a and 3b**.