

Immediate Mandibular Rehabilitation with Endosseous Implants: Simultaneous Extraction, Implant Placement, and Loading

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Purpose: This report of a clinical patient series indicates the relative safety and illustrates the procedures involved in the extraction of remaining teeth followed by immediate implant placement and loading with a simple acrylic resin fixed denture. **Materials and Methods:** Ten consecutive patients who selected tooth extraction and implant-supported fixed denture rehabilitation of the mandible were treated using a 1-visit approach for extraction, implant placement, and restoration. Healthy individuals (10 women) were treated under local anesthesia. Fifty-four implants were placed in 10 patients. Five or 6 Astra Tech implants (11 or 13 mm long) were placed into the edentulous parasymphiseal region of the mandible. Four to 6 implants (48 of 54) were immediately loaded by the fabrication of a simple acrylic resin fixed denture. The criterion for loading was clinical judgment of primary stability, ie, the absence of axial or lateral mobility with physical resistance to rotation. Patients were recalled at 1, 3, and 12 weeks. At 12 weeks, impressions were made for the fabrication of a screw-retained fixed denture. The fixed dentures were completed using conventional fabrication and prosthetic techniques. **Results:** After a period of 6 to 18 months, all 54 implants had survived and were considered 100% successful by independent testing of mobility and radiographic evidence of osseointegration. There were no surgical complications. Fracture and debonding of the acrylic resin provisional denture occurred for 1 patient during the first 12 weeks of treatment. **Discussion:** Advantages to extraction with simultaneous replacement include the maintenance of vertical dimension, elimination of relining procedures and interim denture therapy, and potential improvement of soft tissue healing. **Conclusion:** This therapeutic approach simplifies patient care without apparent additional risk. (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:517-525)

Key words: dental implants, dental prosthesis, immediate loading, immediate placement, mandible

There are 25 to 45 million edentulous individuals in the United States. In some regions, the

prevalence of edentulism among individuals over 65 years of age approaches 50%.¹ The available data concerning endosseous implant utilization indicate that fewer than 500,000 edentulous individuals have had implants placed. Irrespective of the experimental successes for endosseous implants, which repeatedly exceed 95% in the parasymphiseal mandible,²⁻⁶ the public health care utilization of implant treatment of mandibular edentulism may not exceed 5%. One possible explanation for the disparity between the high success rate of this therapy and its low utilization may be the possible perception of low value of a therapy that requires many months for completion and involves considerable expense.

A growing body of data demonstrates that when implants are placed with primary stability in the edentulous parasymphiseal mandible, immediate loading of the implants can be highly successful (Table 1). Given the growing acceptance of 1-stage

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Table 1 Summary of Published Immediate Loading Experience

| Authors | Scope (no. of patients) | Time to loading | Location | No. of implants/prosthesis type | Implant survival (%) |
|------------------------------------|-------------------------|-----------------|-------------------------|---------------------------------|----------------------|
| De Bruyn ⁷ | 20 | 4 to 53 days* | Edentulous mandible | 3/FD | 90 |
| Grunder ^{8†} | 10 | 24 hours | Edentulous maxilla | 4 or 5/FD | 87.5 |
| | | | Edentulous mandible | | 97.26 |
| Chow ⁹ | 27 | At surgery | Edentulous mandible | 5 to 8/FD | 98.3 |
| Chiapasco ¹⁰ | 20 | 0 to 20 days | Edentulous mandible | 4/OD | 97.5 |
| Colomina ¹¹ | 13 | 2 weeks | Edentulous mandible | 5/FD | 96.7 |
| Brånemark et al ¹² | 50 | At surgery | Edentulous mandible | 3/FD | 98 |
| Horiuchi et al ¹³ | 17 | At surgery | 12 mandibles/5 maxillae | 8 to 10/FD | 97.2 |
| Jaffin et al ¹⁴ | 27 | At surgery | 21 mandibles/6 maxillae | 5 to 6/FD | 97 [‡] |
| Gatti et al ¹⁵ | 21 | 2 to 20 days | Edentulous mandible | 4/OD | 96 |
| Cooper et al ¹⁶ | 60 | At surgery | Edentulous mandible | 2/OD | 96.7 |
| Randow et al ^{17§} | 16 | 20 days | Edentulous mandible | 5 to 6/FD | 100 |
| Chiapasco et al ¹⁸ | 226 | 0 to 20 days | Edentulous mandible | 4/OD | 96.9 |
| Tarnow ¹⁹ | 10 | At surgery | 6 mandibles/4 maxillae | 5 of 10 loaded/FD | 97.1 |
| Balshi and Wolfinger ²⁰ | 10 | At surgery | Edentulous mandible | 3 of 8 loaded/FD | 84.7 |
| Schnitman et al ²¹ | 10 | At surgery | Edentulous mandible | 4 of 7 loaded/FD | 96 |
| Salama et al ²² | 2 | At surgery | Edentulous mandible | 5/FD | 95 |

*Implants were loaded immediately after surgery by relined denture.

†Included 66 of 99 implants placed immediately after tooth extraction.

‡Excluding machined implants.

§Comparative study: 16 immediately loaded cases versus 11 conventionally loaded cases.

OD = overdenture; FD = fixed denture.

surgery and the published success for immediate loading, the process of rehabilitation of the edentulous mandible can be considered in the context of individuals who face extraction of remaining teeth, interim complete dentures, and subsequent implant therapy. While the staging of implant therapy using interim partial dentures and subsequent implant placement into extraction sockets is possible, the further possibility of extraction and simultaneous implant placement with immediate loading must also be considered.

It was the aim of this clinical patient series to define the limitations for treatment, refine the prosthetic procedures for immediate loading using a simple acrylic resin fixed denture, and evaluate the relative safety and efficacy of this approach to mandibular dental rehabilitation. It was a further goal to use existing implant components and instruments and to limit the total number of implants to 5 or 6, thereby allowing the immediate loading of 4 to 6 primarily stable implants. In this manner, interim removable denture use is avoided.

MATERIALS AND METHODS

Patient Selection

Ten patients, all women ranging in age from 32 to 73 years, were identified in the screening of new

patients seeking care at the University of North Carolina Department of Prosthodontics during the period of September 1998 to December 2000. All patients were in good general health and were able to undergo dental extraction and implant placement under local anesthesia. Because of the presence of existing teeth, all mandibles were of sufficient bone volume (greater than 15 mm inferior-superior height) and sufficient bone density.

Treatment Planning

Each patient underwent a comprehensive oral examination and review of medical and dental history. A panoramic radiograph was obtained and diagnostic casts were made. Additional tomograms were made in select cases at the request of individual surgeons. A final cast for a complete maxillary denture or an immediate complete maxillary denture was mounted on a semiadjustable articulator using a facebow transfer, and the mandibular diagnostic cast was mounted with a centric relation record utilizing a stabilized record base. The complete denture was fabricated and a mandibular fixed denture extending from the left mandibular second premolar to the right mandibular second premolar was processed (Fig 1). A polyvinylsiloxane interocclusal index was made to record the articulation of the maxillary complete denture and the mandibular fixed denture prior to processing.

Surgical Procedures

After obtaining informed consent, patients were given a loading dose of amoxicillin (2 g stat) and 800 mg of ibuprofen prior to the procedure. All procedures were performed using local anesthesia. Teeth were extracted with care to limit socket expansion or cortical bone fracture. Mucoperiosteal flaps extended distal to the left and right mental foramina. Alveolectomies to reduce the residual sockets and to provide sufficient dimension for abutment and prosthesis placement were performed with rongeurs and dental burs. Standard dental implant osteotomies were created using drilling sequences recommended for placement of Astra Tech dental implants (3.5 or 4.0 mm; Astra Tech, Lexington, MA). Special attention was directed toward achieving inter-implant parallelism to facilitate the subsequent restoration. Implants were placed to the level of the residual alveolar crest. Two dehiscences were treated with autogenous bone harvested during the alveolectomy and resorbable membranes (Biomend; Sulzer Dental, Carlsbad, CA). Cover screws were placed into any implants lacking primary stability and requiring bone augmentation, and these were left to heal beneath the mucosa (Fig 2). In 2 instances, an implant lacked resistance to further rotation but was axially stable, and healing abutments were placed without loading of the implant. In all other implants, 6-mm healing abutments (modified to accept cemented prostheses) were screwed to place with finger pressure and the mucoperiosteum was adapted to the transmucosal abutment and sutured with Gore sutures (W. L. Gore, Flagstaff, AZ) or 4-0 chromic gut sutures. More recently, solid abutments of prepared configuration have been made available for the purpose of providing a restorative platform for cemented restorations (Fig 3). A panoramic radiograph was made following the procedure.

Immediate Loading Procedures

For 9 of the 10 implant prostheses, a newly fabricated denture bearing the second left premolar to second right premolar teeth was hollowed using an acrylic bur and oriented to the transmucosal abutments by occlusion and intimate contact with the posterior residual alveolar ridges (Figs 4a to 4c). With the denture stabilized by the patient's occlusion, autopolymerizing acrylic resin was used to register the position of the abutments. The denture flanges were trimmed away and the posterior segments removed, and the reline procedure was refined to capture the margins of the transmucosal abutments (Fig 4d). Rubber dam was applied clinically to shield the suture line and tissues from the acrylic resin. The relined denture was trimmed to provide access for cleaning, and the occlusion was verified to provide bilaterally equivalent contacts in



Fig 1 Articulated casts with diagnostic denture tooth waxing. The planning for immediate placement and loading following tooth extraction is dependent upon precise tooth location relative to existing tooth sockets and subsequent implant placement. Planning requires that accurate diagnostic casts be mounted at a verified vertical dimension of occlusion using stabilized record bases for mounting in maximum intercuspation or centric relation. The mandibular molars are not included in the interim prosthesis and the occlusion is balanced.



Figs 2a and 2b Implants placed into and between extraction sockets. Note that 1 implant in the canine extraction socket attained primary stability but is within a significant residual defect. In such cases, the implant site was grafted with autogenous bone from the alveolectomy or a suitable bone-grafting substitute. Such implants were not loaded but left to heal in a transmucosal healing position using a healing abutment as shown (arrow).





Fig 3 Evaluation of implant and abutment placement for immediate loading following extraction of remaining teeth. When more teeth and a more significant alveolectomy were involved, tissue redundancy could be observed. Here, new solid abutments with a machined restorative surface offer an expanding conical form to maintain this tissue below the restorative margins and a slight tapered axial wall to promote and simplify the reline procedure involved in provisional denture fabrication.

Figs 4a to 4d Stepwise conversion of a custom-made immediate denture. The processed denture for immediate loading has full extension without molar teeth.



Fig 4a The first step requires hollowing of the denture to clear the abutments and fully seat it along the unaffected posterior edentulous ridges.



Fig 4b The denture is relined to capture the position of the abutments in polymerized acrylic resin, and the flanges are removed.



Fig 4c The interim fixed denture is refined by relining and contouring.



Fig 4d The completed denture is polished and cemented to provide a cleansible form and surface (shown here at 6 weeks after cementation).

centric relation and to provide balance, if occluding a new complete denture. Attention at implant placement avoided parallelism problems that could not be reconciled by minor extraoral adjustment of the abutment. Care was taken to avoid tissue exposure to heat associated with exothermic setting of the acrylic resin material. In a similar manner, one denture was connected to the implants bearing 20-degree uni-abutments using a reline procedure to pick up titanium interim cylinders (Fig 5). This prosthesis was retained with 6 gold screws.

All patients were asked to limit their diet to liquids for the first week following therapy. A 0.2% chlorhexidine gluconate mouthrinse was prescribed for the first 3 weeks. During the second and third weeks, patients were asked to avoid any hard breads or foods requiring excessive tearing or incising in their diet. Following the 21-day evaluation, patients were unrestricted in their diet. Hygiene was reinforced and a



Figs 5a and 5b Fabrication of a screw-retained interim fixed denture on immediately placed implants. (Left) After placement of 20-degree uni-abutments, temporary titanium cylinders were placed with gold screws. (Right) Using autopolymerizing acrylic resin, the temporary titanium cylinders were then indexed within a hollowed-out purpose-made interim denture and carefully contoured and polished.

| Table 2 Patient Data | | | | | |
|----------------------|-----|------------------------|-----------------------------------|---|---------------------------------|
| Patient no. | Age | No. of implants placed | No. of implants loaded at surgery | Opposing dentition | Complications |
| ILD001 | 50 | 6 | 4 | Complete denture | None |
| ILD002 | 57 | 5 | 5 | Complete denture | None |
| ILD003 | 73 | 5 | 4 | Natural dentition | Fractured provisional, debonded |
| ILD004 | 70 | 5 | 5 | Fixed partial denture/ removable partial denture | None |
| ILD005 | 67 | 6 | 5 | Complete denture | Fractured provisional, debonded |
| ILD006 | 55 | 6 | 6 | Complete denture | None |
| ILD007 | 71 | 6 | 5 | Implant prosthesis | None |
| ILD008 | 55 | 6 | 6 | Natural dentition | None |
| ILD009 | 71 | 5 | 4 | Immediate complete denture | None |
| ILD010 | 32 | 4 | 4 | Implant prosthesis | Fractured acrylic tooth |

water irrigation device was recommended along with proximal brushes and superfloss. After 3 months of healing, 20-degree uni-abutments were placed and fixed dentures were fabricated using gold cylinders cast into gold alloy frameworks that were veneered with acrylic resin and acrylic resin denture teeth. Standard clinical and laboratory procedures were used.

RESULTS

For 10 consecutively treated patients, 54 implants were placed into the parasymphiseal mandible immediately following extraction. Thirty-four

implants were placed directly into extraction sites. Forty-eight implants achieved primary stability following placement (Table 2). All patients tolerated surgery well and proceeded to controlled prosthetic loading immediately after panoramic radiography. Patients were dismissed with good hemostasis in the absence of direct pressure on the suture line. None of the patients experienced pain or discomfort during the extended prosthetic aspect of this single-visit therapy. Patients reported no uncontrolled pain or discomfort during the first 72 hours or thereafter. Limited swelling and ecchymosis were observed at the 7-day visit. All patients showed excellent primary wound healing at the 21-day follow-up visit.

Figs 6a to 6c Radiographic history of immediate implant placement and loading following extraction of intact remaining teeth.

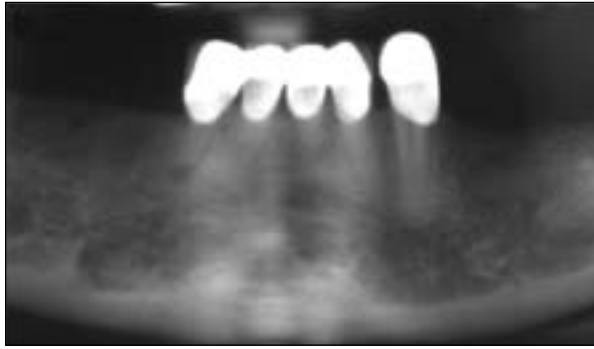


Fig 6a Preoperative image.

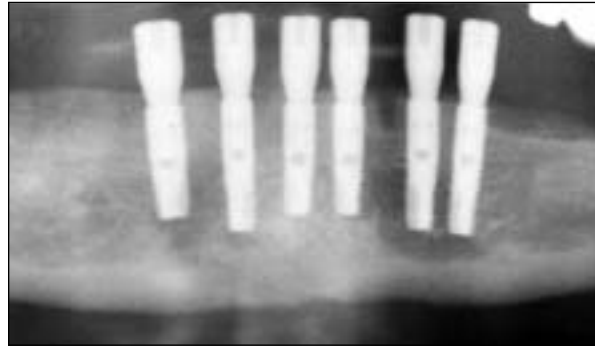


Fig 6b Immediate postoperative image with abutments placed for cement-retained provisional restoration.

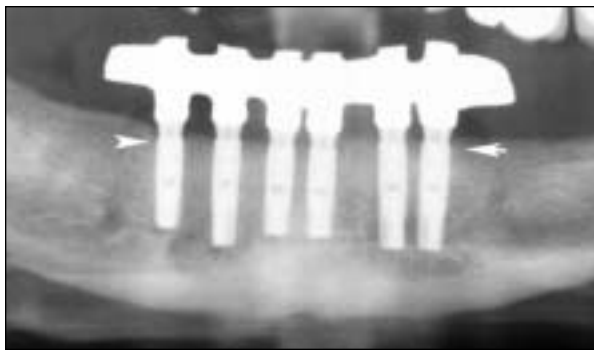


Fig 6c Six-month posttreatment image. Note that the level of bone is maintained at the implant-abutment interface. Note the healing around the left implant. Arrows indicate maintained crestal bone.

At the 3-month visit, all 54 implants were individually tested and shown to fulfill the criteria established for implant success.²³ To date, these implants loaded by a conventional metal/acrylic resin fixed denture remain asymptomatic and successful.

The radiographic surveys completed by panoramic radiography revealed good healing of bone within the extraction sites and at the implant interface. The cortical bone levels appeared to be maintained at the machined cortical bevel that approximates the implant-abutment interface (Fig 6). Thus, bone responses to the implants placed and loaded immediately are similar to the responses measured at unsplinted, rapidly loaded implants placed by a 1-stage procedure^{16,24} and implants placed and restored using a 2-stage approach.²⁵

DISCUSSION

Temporal aspects of dental implant loading require clear definition. It is important that these definitions

(1) have meaning of significance to patients and (2) have meaning that is relevant to biology. It is proposed that the term *immediate loading* should refer to situations where implant placement with primary stability and prosthetic loading with a provisional prosthetic tooth occur at the same clinical visit. Immediate loading is temporally irrelevant with respect to osseointegration. Biologically, primary stability is essential. Loading should occur immediately following (hours and not days) implant placement to eliminate possible disruption of the blood clot during the important early stages of healing.

Early loading refers to implants placed with primary stability and loaded with a provisional prosthesis at a subsequent clinical visit prior to attaining osseointegration. Early loading should not perturb initial healing (blood clot formation, cellular infiltration, epithelialization). Early loading should also follow the onset of osteogenesis, because current biologic knowledge suggests that bone formation is enhanced by mechanical stimulation. Therefore, early loading should occur only after approximately 3 weeks of healing.

If implants are not immediately loaded or loaded early, then conventional-loading or delayed-loading protocols are invoked. *Conventional loading* refers to implant placement (typically achieving primary stability) and healing for 3 to 6 months in a submerged or non-submerged mucosal orientation. This time frame reflects the requirement for osteogenesis and woven bone remodeling to load-bearing lamellar bone and acknowledges the original recommendations of Brånemark or Schroeder.^{26,27} More recently, suggestions of 6 to 8 weeks healing at topographically enhanced surface implants have been put forth.^{28,29}

Delayed-loading protocols are an important aspect of implant therapy. Delayed loading refers to extended healing periods (more than 3 months) invoked when implants are placed without primary

stability, into bone of low density, into extraction sockets without significant primary bone-to-implant contact, or with a simultaneous bone regeneration procedure. There are few guidelines for these procedures, but recommendations typically range from 6 to 12 months.

In the present study, the aforementioned definition of immediate loading was adopted, and every implant placed with primary stability was loaded at the same clinical visit as the implant placement. A sufficient number of implants were placed to permit immediate loading of a fixed denture, should 1 or 2 implants not achieve primary stability. Significantly, this clinical patient series is the first report of immediate extraction and tooth replacement using immediately loaded dental implants. The requisite alveolectomy (necessary to provide occlusogingival dimension for tooth replacement and sufficient labiolingual mandibular dimension for placement of 3.5-mm-diameter implants) prior to placement of implants into extraction sockets following removal of mandibular incisors and first premolars often obliterated the extraction sockets if previous loss of periodontal attachment and bone resorption had occurred. In other cases, only 3 to 4 mm of the socket remained, and it was largely eliminated by the osteotomy procedure or obliterated by a 3.5-mm- or 4.0-mm-diameter implant. When canines were extracted or when dehiscences were present following extraction, a significant portion of the implant did not achieve primary bone contact or primary stability. Sufficient autogenous bone was available from the alveolectomy for direct augmentation; however, the implants that did not attain primary stability were not immediately loaded.

This report, like that of Randow and coworkers,¹⁷ sought to limit the number of implants used in immediate therapy instead of expanding the complexity and cost of treatment by use of additional implants during the immediate loading period. In this manner, a test of the immediate loading concept with respect to conventional implant therapy could be approximated, although it fails to replicate the rigorous clinical comparison of Randow and coworkers. This limitation of implant number during therapy is congruent with an overall goal to expedite and simplify treatment so as to increase the general use of implants in mandibular dental rehabilitation.

Several other reports have used as many as 10 implants for immediate loading protocols. Both studies using 10 implants used threaded implants exclusively or as a large segment of the study group. Given the role of surface roughness in favoring osseointegration, the authors speculate that more conventional numbers of implants may be used for

immediate loading of the edentulous mandible. Bone density of the edentulous mandible favors osseointegration, and there appears to be high success when any of the various surface topographies are used for conventional implant therapy.

When considering immediate loading, implant design may play a more important role. In the absence of controlled comparative clinical data, the role of surface topography is presently acknowledged in facilitating osseointegration, in increasing the rate of bone formation, and in assuring osteoconduction via improved blood clot retention.³⁰ Surface roughness also increases primary stability, as measured using resonance frequency energy.³¹ In this study, the implants used possess a titanium dioxide grit-blasted surface of defined biologic and clinical behavior. Previously, a similar implant possessing the identical surface modification was used to achieve 96.2% success following 1-stage placement and immediate loading beneath soft relined mandibular overdentures.¹⁶ Other topographically enhanced implant surfaces exist and have been shown to promote more rapid bone formation and greater bone-to-implant contact at earlier times (see Cooper³⁰). Chiapasco and associates¹⁸ demonstrated a high success rate when rapidly loading mandibular parasymphiseal implants via a bar overdenture. When sandblasted/acid-etched ITI implants (Straumann, Waldenburg, Switzerland) were used for treatment using a similar protocol, Jaffin and colleagues reported similarly high success rates.¹⁴ Interestingly, the failures reported were for machined-surface implants. However, when loaded at 20 days versus conventional therapy, machined-surface implants provided 100% success.¹⁷ When 6 to 10 machined-surface implants were used, often with implants placed distal to the mandibular foramina and with assurance of fixation exceeding 40 Ncm, immediate loading was highly successful.¹³

The protocol illustrated in this report integrated the use of 2-component implants for a 1-stage, immediate loading protocol. The use of 2-component systems (implant + abutment) was intentional and was based on 2 clinical possibilities. The first clinical variable that favors the use of a 2-component system is the possible absence of bone for primary stability. When using a 2-component system, the implant can (1) remain unloaded in a transmucosal position using a healing abutment or (2) be placed in a submucosal position using a cover screw. This flexibility was viewed as a positive aspect of the protocol and limited the need for detailed radiographic interpretations when addressing the parasymphiseal mandible. The second clinical variable that favors the use of a 2-component system for 1-stage surgery

is the polymorphic nature of attached mucosa and gingiva. A 2-component system allows decisions about abutment dimensions to solve discrepancies in tissue/component relationships. In this report, a conus implant-abutment connection was used specifically to facilitate the assembly of the components at the surgical visit. The biomechanical nature of the conus interface permits finger tightening without torque control or risk of disturbing the implant in place. The behavior of the conus interface further assures that the components will remain in a stable relationship with one another during the 3-month healing phase. Finally, the solid nature of the abutments used here precludes any accumulation of bacteria during the healing period. This may contribute to the excellent soft tissue healing response seen universally among the enrolled patients.

The introduction of a dedicated immediate-loading implant system for the edentulous mandible (Brånemark Novum; Nobel Biocare, Yorba Linda, CA) further indicates great interest in this topic.¹² The Novum System is well documented, with over 70 consecutive cases reported to be successful. The approach illustrated here differs considerably and merits some comparison. First, the Novum requires a dedicated surgical instrumentation. Second, the Novum system uses a unique 5.0-mm-diameter implant. Third, the Novum system is presently available in 1 dimension. Related to this, it is not recommended for Class II or Class III maxillo-mandibular skeletal relationships. Fourth, the Novum system provides a definitive prosthesis the day of surgery. In contrast, the present approach to immediate treatment of edentulism involves no additional instrumentation and can be adapted to an extended spectrum of anatomies. This custom approach further requires a custom prosthodontic solution for each patient. The similarity of the 2 approaches may be seen in the recognition of the biologic capacity of the parasymphyseal region of the mandible and in the shared goal of increasing the treatment of mandibular edentulism.

At this time, the present clinical patient case series indicates good success for the first 10 subjects. It may be impossible to conduct a clinical study showing statistically different success rates for this immediate procedure versus a conventional approach (in that hundreds of age- and sex-matched individuals would require treatment in a controlled comparative clinical study, because there may be so few failures in either group). In additional subjects treated since completion of this clinical patient series, similar success has been observed in the short

term. However, whether or not the present results may be extended to a larger population that includes systemically compromised individuals or smokers merits careful consideration.

This protocol may directly address perceptions of long treatment times and the limited value of expensive therapy by offering a single-visit solution to provisional replacement of a failed mandibular dentition by avoiding any mandibular complete denture. The potential cost savings to patients cannot be predicted; however, the reduced number of patient visits, the reduced morbidity associated with fewer surgical interventions, and the facilitated functional rehabilitation offered by this protocol may represent important reductions to potentially key barriers to accepting this therapy. When the expense of a fixed denture supported by 4 to 6 implants remains a limiting factor, treatment of mandibular edentulism using an overdenture supported by 2 implants placed by a 1-stage procedure³² or by placement with immediate loading using a soft relined material should be considered.²⁴

CONCLUSION

This report contributes to a growing body of literature that supports immediate loading of endosseous titanium screw-type implants as an expedited treatment of mandibular edentulism. In selected healthy patients, significant time and clinic visits may be saved by simultaneous extraction, implant placement, and restoration with a simple acrylic resin provisional prosthesis. The use of existing components, surgical instrumentation, and simple provisional restoration techniques offers this opportunity to clinicians and patients. The reduction in postoperative visits, an absence of postoperative complications, and the enthusiasm of patients who receive this treatment suggest that approaches to simplifying implant rehabilitation of the mandible may increase patient acceptance of an extremely successful, but currently poorly accepted, therapy.

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