# A prospective study of immediately loaded single implant-retained mandibular overdentures: Preliminary one-year results

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**Statement of problem.** The cost of rehabilitation of the problematic mandibular complete denture with implant-retained overdentures or implant-supported fixed prostheses is beyond the financial scope of many compromised denture patients. Therefore, a more affordable treatment alternative is desirable.

**Purpose.** The purpose of this preliminary study was to investigate the predictability of simplifying mandibular overdenture treatment using single-stage surgery and immediate prosthetic loading of a single implant.

**Material and methods.** Twenty-eight patients with a mean age of 69.8 years and problematic mandibular dentures were treated. The primary complaints among the patients referred to the clinic for treatment related to poor retention of the mandibular denture, instability, denture sores, and phonetic problems. A single implant (Branemark TiUnite Mk III) was placed into the mandibular midline, achieving primary stability. A ball attachment was placed and the retentive cap incorporated into the existing denture. The patients were recalled at 3 and 12 months. Clinical assessments, radiographs made with custom film holders, and stability measurements by both manual and resonance frequency analysis methods were recorded. All complications, failures, maintenance, and reasons for failure to follow-up were noted. Visual analogue scale questionnaires were used to record patient satisfaction. A 1-way repeated-measures ANOVA was used to determine differences between means in the following categories: general satisfaction, social life, mastication of hard food, comfort, and fit ($P$=.05).

**Results.** Three implants did not achieve sufficient primary stability to be immediately loaded and were, therefore, treated with a 2-stage delayed loading protocol. The 25 immediately loaded implants were all surviving at the 12-month recall. Patient satisfaction was high, with a significant increase in all comfort and functional parameters ($P$ values ranged from <.001 to .07).

**Conclusions.** These preliminary 1-year results indicate that immediate loading of a single oxidized surface implant used to retain a mucosa-borne overdenture is a safe, reliable, and cost-effective treatment. (J Prosthet Dent 2007; 97: S126-S137.)

## Clinical Implications

The results of this study indicate that the immediately loaded single implant-retained overdenture may be the entry level option for the rehabilitation of the edentulous mandible in selected patients.

Rehabilitation of the completely edentulous mandible using implants to retain a fixed prosthesis is a predictable long-term treatment modality.[1,2] High implant success rates have also been achieved by Engquist et al[3] (99%), Johns et al[4] (96.2%), and Bergendal et al[5] (100%), using 2 or more implants to anchor an overdenture. Two implant-retained overdentures with separated implants have been reported with similar implant success rates (97-100%) and functional improvement.[5-8] There is consensus that 2 implants splinted[9-11] or unsplinted[6,12,13] in the interforaminal region of the mandible is sufficient to support an overdenture.[14,15] Indeed, the McGill consensus statement suggested that the 2-implant overdenture should be the first choice of treatment for the edentulous mandible.[16] Another systematic review, however, failed to show sufficient evidence to

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support a single universally superior treatment modality for the edentulous mandible.[17]

The success of these treatment modalities, while excellent, is unfortunately outside the financial scope of many compromised edentulous patients. A cost comparison study between an unsplinted 2-implant retained mandibular overdenture and a conventional complete mandibular denture showed the direct cost of the overdenture to be 2.4 times the cost of the complete denture.[18] It is, therefore, desirable for clinicians to be able to offer a significant functional improvement of the problematic mandibular complete denture in a cost-effective manner. Concomitantly, a reduction in the overall time frame of clinical, technical, and maintenance procedures needed to achieve this goal would be advantageous.

Use of a single implant with a 2-stage approach placed in the symphyseal midline to retain an overdenture has been documented by Cordioli et al[19] with excellent success, according to the success criteria of Albrektsson et al.[20] The concept of immediate loading,[21] whereby implants with adequate primary stability are occlusally loaded with a provisional prosthesis at the same clinical visit[13,22] or soon after,[23] is appealing to both dentist and patient, providing faster treatment time and simplified logistics. Use of early or immediately loaded unsplinted implants to retain mandibular overdentures has been reported with excellent implant success rates (100%).[13,23] Recently, emphasis has been placed on the effect of surface modifications to enhance the integration process.[24-27] Clinical studies have shown a higher failure rate with immediately loaded machined implants compared to those with a modified surface.[28,29] The oxidized surface (TiUnite; Nobel Biocare AB, Goteborg, Sweden) has been studied at both the basic research level and clinically.[24-27,30,31] Albrektsson et al[24] demonstrated a higher bone-to-metal contact compared to the machined surface, as well as significantly higher removal torque values in a rabbit model. Henry et al[25] also showed higher removal torque values in greyhound dogs. Rompen et al[26] showed maintenance of the initial stability of implants with an oxidized surface compared to a significant decrease in the stability of machined implants measured with resonance frequency analysis (RFA) over a 6-week period in the dog mandible. Glauser et al[27] showed a similar pattern in immediately loaded maxillary posterior implants in a clinical study. In a clinical prospective study on immediate loading of machined implants placed in all jaw regions, Glauser et al[32] reported a failure rate of 17.3% after 1 year. The same group, using a similar protocol and implants with an oxidized surface, experienced only a 3% failure rate.[31]

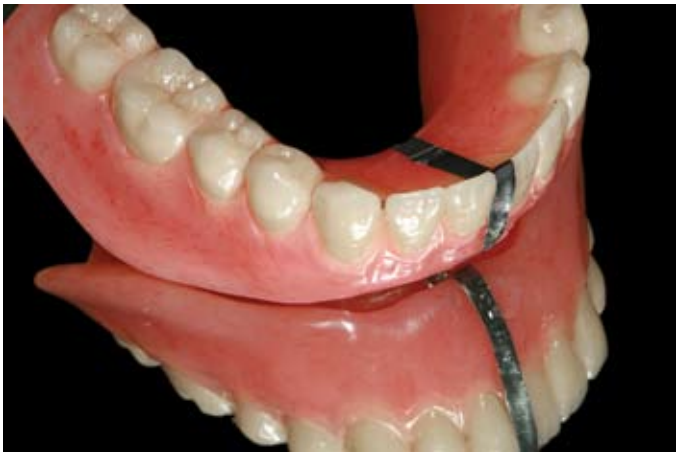
Resonance frequency analysis was first proposed by Meredith et al[33] in 1996 and involved excitation of a transducer beam over a range of frequencies. A frequency response analyzer subsequently analyzed the response of the beam based on the stiffness of the beam, implant, and bone interface. Resonance frequency is expressed as an implant stability quotient (ISQ) with values from 1 to 100. RFA is currently used in clinical research to monitor implant stability.[34] Clinical studies have shown a correlation between decreasing RFA values and failing implants.[35,36] With RFA, it is also possible to indicate a failing implant before the failure is clinically manifested[36] and, if due to occlusal overload, regain stability by unloading the implant.[35] It has been suggested that an ISQ of 60 reflects the lower limit when performing immediate loading; however, caution must be exercised where bruxism or a crown-to-implant ratio is greater than 1:1.[31] Conversely, Glauser et al[36] showed no difference in initial stability between implants that finally failed and implants that remained stable. However, after 2 months, the failing implants showed a mean ISQ of 43, and the successful implants maintained stability at an ISQ of approximately 68. The aim of this study was to determine the predictability of simplifying mandibular overdenture treatment using single-stage surgery and immediate prosthetic loading of a single implant.

## MATERIAL AND METHODS

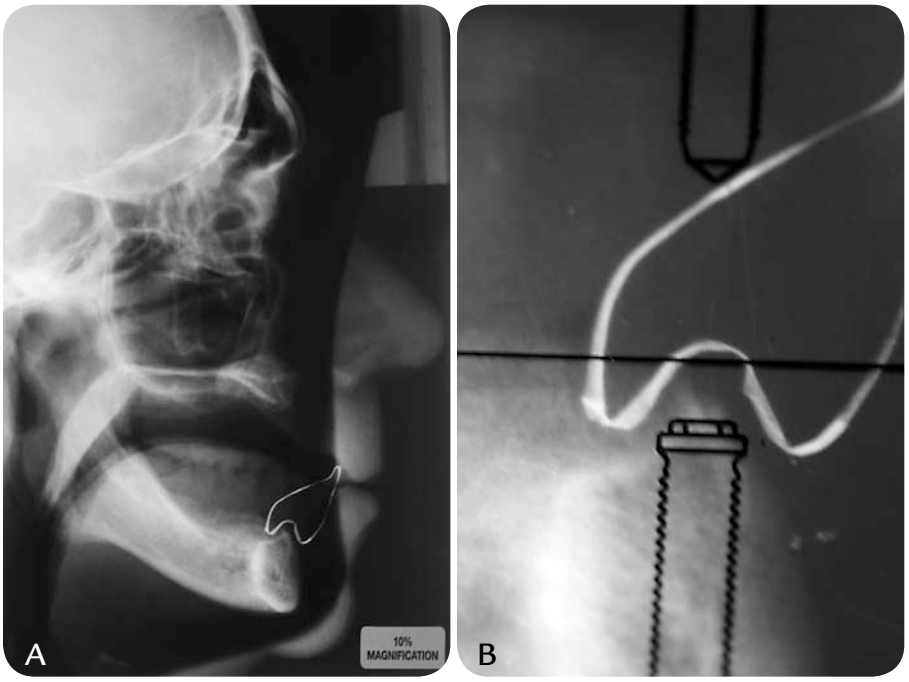
Twenty-eight edentulous subjects, 8 men and 20 women, 50 to 89 years of age (mean age 68 years), who had been completely edentulous for at least 1 year, were included in the study. All patients signed an informed consent form in accordance with the Declaration of Helsinki (1989). Ethical approval for the project was granted by The Human Research Ethics Committee of the University of Western Australia. Inclusion criteria dictated that the patient be completely edentulous for at least 12 months, have a maladaptive mandibular denture, and have enough bone for an implant length of at least 10 mm and diameter of 4 mm. Exclusion criteria included drug/alcohol abuse, a health condition precluding surgery, logistic or physical reasons that could affect follow-up, psychiatric problems, disorders to the implant area related to a history of radiation therapy to the head and neck, neoplasia, or bone augmentation to the implant site. Smokers were encouraged to stop smoking but were not excluded from the study.

Preoperative panoramic and conventional lateral cephalometric radiographs with the dentures in situ, with a thin strip of lead foil outlining the outer surface of the denture in the midline position, were used for radiographic evaluation of the proposed implant placement site to avoid potential complications with important anatomy in this region[37,38] (Figs. 1 and 2, A). Determination of the implant length and angulation was made with radiographic overlays (Fig. 2, B).

The primary complaints among



1 Lead foil adapted to external surface of denture in midline.




2 A, Lateral, cephalometric view of denture and lead foil in situ. B, Closer view of radiographic overlay to plan implant position and dimension.

the patients referred to the clinic for treatment related to poor retention of the mandibular denture, instability, denture sores, and phonetic problems. All existing dentures were evaluated with the California Dental Association (CDA) quality evaluation system.[39] The dentures were required to be assessed as satisfactory for all categories, including consideration of esthetic tooth position, size and shade, adequate extension of the denture bases with an absence of tissue irritation, even masticatory forces present with centric occlusion in harmony with centric jaw relation, and, at the correct occlusal vertical dimension, acceptable stability and retention of the mandibular denture consistent with that achievable considering the residual ridge. Refabrication of both dentures was indicated if these criteria were not met. The components used were regular platform implants with a diameter of 4 mm (Branemark Mk III TiUnite; Nobel Biocare AB). A 4.5-mm-diameter ball attachment with a plastic cap and rubber O-ring (Nobel Biocare AB) provided the prosthetic anchorage.

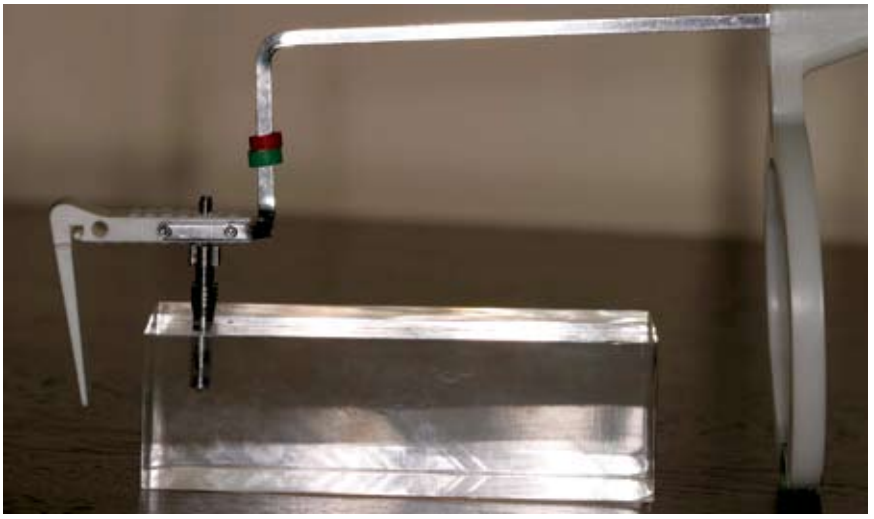
All patients were provided with a single implant of greater than 10 mm in length inserted in the mandibular midline. Single-dose prophylactic antibiotic coverage (2 g of amoxicillin or 600 mg of clindamycin) was given orally 1 hour prior to surgery.[40] A mouth rinse, chlorhexidine 0.2%, (Savacol; Colgate, Sydney, Australia) was given just prior to administration of the local anesthetic. Bilateral mental nerve blocks and local infiltration in the labial and lingual sulcus was administered with lignocaine 2% (Lignospan Special; Septodont, Cedex, France) and 1:80 000 epinephrine. Bupivacaine 0.5% (Marcain; Astra Zeneca, North Ryde, Australia) and 1:200 000 epinephrine were additionally injected regionally to prolong the postoperative analgesia.

A minimal crestal incision was made and a mucoperiosteal flap was raised, both on the labial and lingual aspects, to enable adequate visualization of the lingual aspect of the mandible and to evenly divide the available keratinized tissue. This enabled the abutment to be surrounded by attached gingiva. One patient, with a broad band of keratinized mucosa, had the implant inserted with a flapless tissue punch approach. The osteotomy was prepared using a standard dense bone drilling protocol, according to the manufacturer's directions, and all sites were tapped with a 4-mm-diameter screw tap (Nobel Biocare AB) to the full implant length. Bicortical stabilization was achieved, if possible, and minimal, if any, countersinking was performed. Enhanced initial stability techniques for implant site preparation were considered unnecessary due to the generally dense cortical bone encountered in this region.[41] The bone quality and jaw shape was noted according to Lekholm and Zarb's rating system,[42] which rates bone quality on a scale from 1-4, and jaw shape from A-E. Insertion torque was measured with the aid of the drilling unit (Osseoset 100; Nobel Biocare AB) and with a manual torque wrench (Nobel Biocare AB). An insertion torque of at least 45 Ncm and RFA (Osstell; Integration Diagnostics,

Savedalen, Sweden) ISQ of at least 60 was required before considering connection of the abutment. The RFA transducer was connected to the implant head in a labiolingual direction and was hand tightened. A reference radiograph, using a custom film holder, was made. The film holder was a modified version of that described by Galasso,[43] except that abutment level impression copings were replaced with 2 open tray implant level impression copings (29072; Nobel Biocare AB) laser welded in parallel. It was not possible to rigidly fix a film holder to the ball abutments used in this study. The film holder, therefore, needed to be attached at the implant level. To prevent rotation, two 30-mm guide pins (29096; Nobel Biocare AB) were placed to protrude through a shortened anterior film holder (Rinn XCP; Dentsply, Elgin, Ill) and drilled with 2 holes to correspond with the guide pins. This provided antirotation to the device. One impression coping was attached to the implant. The nonengaging coping was shortened by 5 mm so as not to interfere with adjacent soft tissue, as shown in Figures 3 and 4. The film was then held in place in the conventional manner or fastened with elastic bands if the floor of the mouth was particularly shallow. This method, in comparison to another published method,[13] allowed not only a parallel film but also a reproducible film with respect to rotation of the beam axis (Fig. 5).

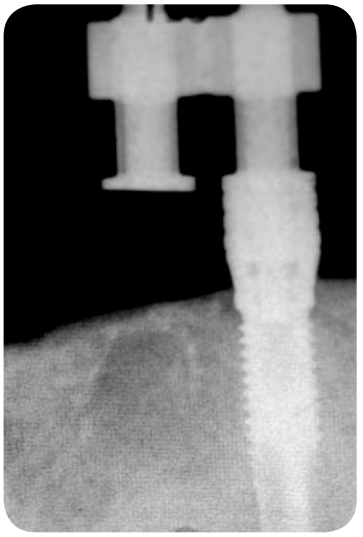
The ball attachment was connected, ensuring 2 mm of abutment collar height above the mucosa, and tightened to 32 Ncm with a torque wrench. The wound was then sutured (Fig. 6).

The first 15 patients had the retentive element secured to the denture with acrylic resin (GC Unifast; GC Corp Tokyo, Japan) immediately. The subsequent 10 patients had the denture relieved around the ball attachment and relined with tissue conditioner (Viscogel; Dentsply De Trey, Konstanz, Germany) to improve the healing response. For these 10 pa-



**3** Lateral view of modified radiographic film holder.

**4** Alignment and positioning of implant level impression copings and film holder.

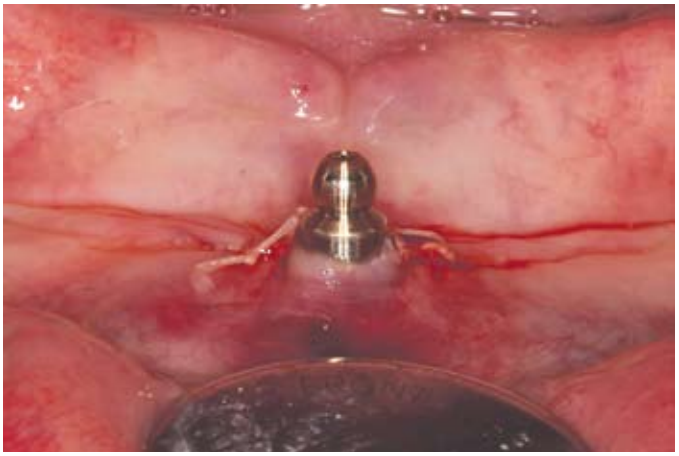


**5** Representative periapical radiograph.

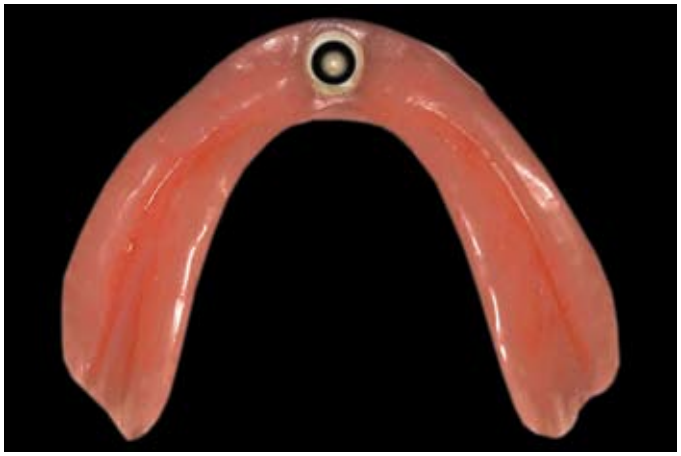
tients, a denture reline impression (Extrude; Kerr, Orange, Calif) was made 6 weeks after implant placement to incorporate the retentive element, a plastic cap with an O-ring (DCB 113-0; Nobel Biocare AB), and reline the entire intaglio surface of the denture with high strength heat-polymerized acrylic resin (Implacryl; Vertex-Dental BV, Zeist, The Netherlands) as illustrated in Figure 7. The denture was reinserted and subjected to conventional relining evaluation and occlusal adjustment.

All patients were limited to a soft diet for 6 weeks and instructed to leave the denture out at night. A single operator (GL) performed all surgical and prosthetic procedures. Radiographic (cephalometric and panoramic) visualization of implant placement is shown in Figures 8 and 9. The subjects were instructed in a plaque control protocol at the time of implant placement and this was reinforced at subsequent reviews. Professional maintenance in accordance with patient needs was performed by a dental hygienist.

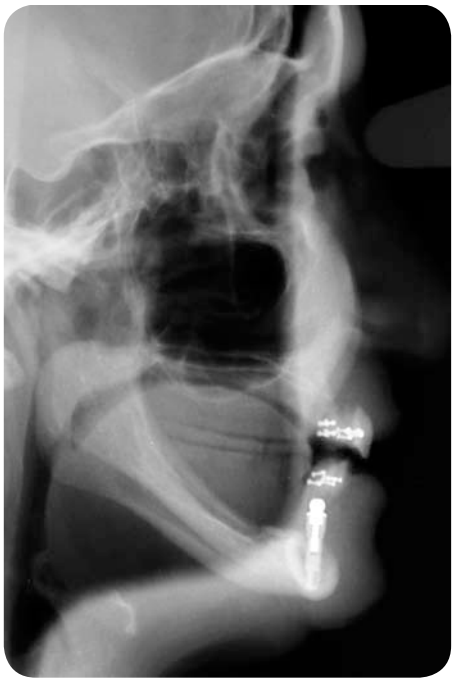
The implants were assessed individually to fulfil the requirements for Grade 1 quality of success advocated by Roos et al[44] as follows. Absence of mobility was assessed at 3 and 12 months by removal and reattachment of the abutment together with retorquing of the abutment screw to 32 Ncm without simultaneous counteracting of the force. Mobility or sensation/pain was regarded as a sign of lost osseointegration. Resonance frequency analysis was performed when the abutment was removed at 3 and 12 months. Periapical radiographs were made at insertion, 3 months, and 12 months, postoperatively. The distance from the collar of the implant to the most coronal point where the bone was in contact with the implant was measured with the aid of a graduated 7 magnification loupe (Fotar, Inc, Midland Park, NJ). Both authors completed the radiographic measurements independently, and the results were averaged. Soft tissue



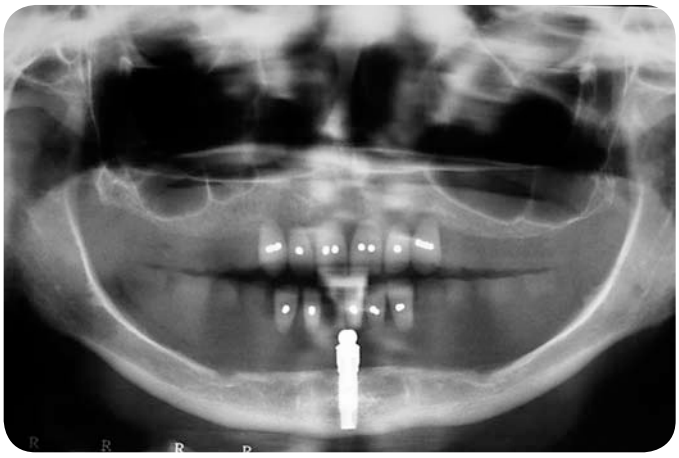
**6** Postoperative view of implant placement.



**7** Denture with retentive element.



**8** Sagittal radiographic view of implant placement.



**9** Frontal panoramic radiograph view of implant placement.

was inspected visually with regard to color and morphology with the abutment removed. Complications, including severe soft tissue infections, persistent pain, and paraesthesia discomfort were noted. In this way, each individual implant was tested and could be defined as either failing or surviving.

Self-administered questionnaires that followed the Visual Analogue Scale (VAS) method were completed by patients preoperatively and at each scheduled recall to assess oral comfort and function.[7,45] Each VAS questionnaire consisted of a 100-mm line anchored at the beginning and end by opposing responses/statements such as "not at all satisfied" to "totally satisfied". The participants marked a vertical line on the horizontal VAS line to indicate their feelings. Scores were determined by measuring the distance (in mm) from the left starting point of the line to the intersection of the response line. There were 10 questions, in 5 categories: general satisfaction, social life, mastication of hard food, comfort, and fit. Data were entered into a spreadsheet (Microsoft Excel version 10; Microsoft, Redmond, Wash), and all statistical analyses were performed using statistical software (SPSS Version 12; SPSS, Chicago, Ill). One-way repeated-measures analysis of variance (ANOVA) was used to determine differences between means ($\alpha$=.05).

## RESULTS

Refabrication of dentures was required for 1 patient as the dentures did not meet the inclusion criteria. This was undertaken prior to the surgical procedure. Remaking of the dentures did not solve the patient's fundamental complaint, which was poor retention related to severe residual ridge resorption. In total, 28 implants were placed in 28 patients. Twenty-five implants had sufficient stability to be immediately loaded and are the basis for this study. The remaining 3 implants did not fulfil the requirements for sufficient implant stability; that is, they did not have an insertion torque greater than 45 Ncm or a resonance frequency of 60 ISQ or greater. These implants had a cover screw placed and the soft tissue closed. The implants were uncovered, a ball attachment was placed, and the prosthesis was relined 3 months later. These implants successfully integrated and were all in function at a 12-month follow-up; however, they have not been included in the statistical analysis as they were not immediately loaded.

Immediate rigid connection of the retentive element resulted in tissue impingement during the postoperative healing period. This resulted in greater postoperative discomfort and difficulties with self-administered placement of the denture. In 2 patients tissue hypertrophy occurred, with 1 patient requiring removal of the excess tissue. This patient had received an abutment with a collar height of 3 mm. The subsequent use of tissue conditioner material eliminated dead space around the abutment collar but allowed some tissue expansion in the immediate postoperative period. Therefore, the periimplant tissue healed more rapidly with a subjectively improved comfort level.

The 25 immediately loaded implants were all tested individually, yielding a survival rate, according to Roos et al,[44] of 100%. The distribution of implant and abutment length is illustrated in Table I. Bone quality and jaw shape encountered is listed in Table II. At the 12-month review all patients were available for recall examination with no dropouts. The VAS questionnaires were completed by all patients at pretreatment, 3 months, and 12 months after implant placement, and all showed a significant improvement in all 5 categories (Fig. 10). Using 1-way repeated measures ANOVA, the *P* value for the general satisfaction category was $P<.001$, social life, $P=.07$, mastication of hard food, $P=.002$, comfort, $P=.01$, and fit, $P=.001$. Direct questioning indicated that common pretreatment problems, such as recurrent denture ulceration, had been eliminated, and nonmasticatory functions such as yawning, laughing, and singing could be accomplished without complications.

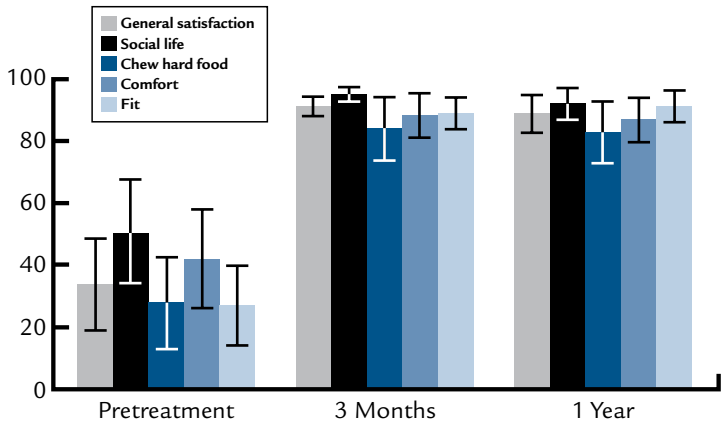
Radiographic follow-up was difficult in this study due to superimposition of the genial tubercles and the marginal bone and to the clinical problems associated with film placement that directly impinged on the lingual frenum. Twelve (48%) of the patients had quantitatively assessable radiographs. No periimplant radiolucency was noted. Bone level changes were measured on the left and right sides of the implant. The mean bone loss (mm) from baseline to 3 months

TABLE I. Distribution of mandible by shape and quality, defined according to Lekholm and Zarb[42]

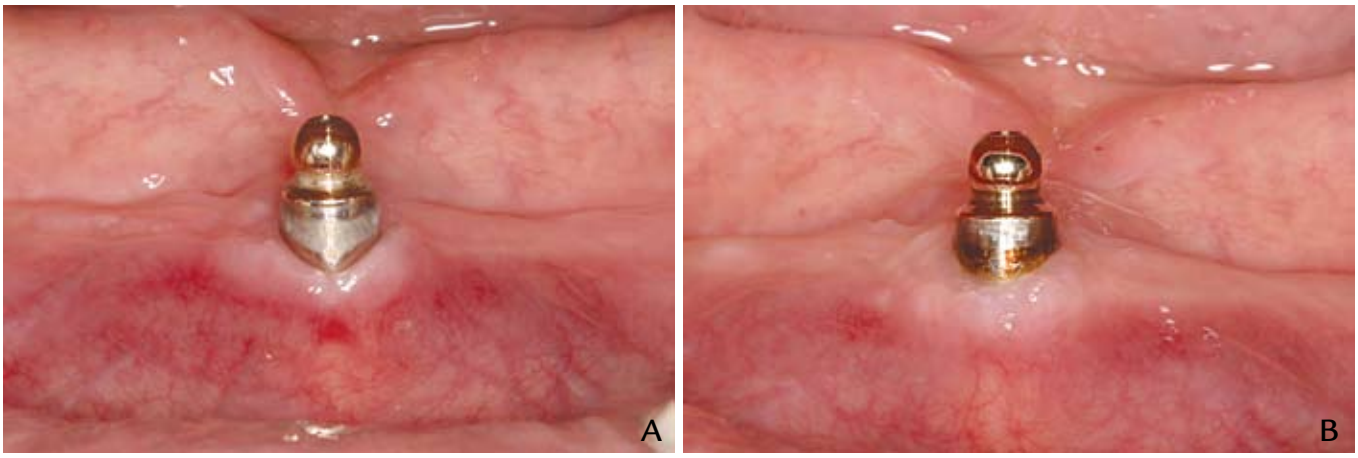
| | Jaw Shape | | | | |
|---|---|---|---|---|---|
| **Bone Quality** | **A** | **B** | **C** | **D** | **E** |
| 1 | 0 | 0 | 0 | 2 | 2 |
| 2 | 0 | 0 | 6 | 3 | 0 |
| 3 | 0 | 3 | 5 | 4 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 |

TABLE II. Distribution of implant length (mm) and height of ball abutment collar (mm)

| | Implant Length | | | | |
|---|---|---|---|---|---|
| **Abutment Height** | **10** | **11.5** | **13** | **15** | **18** |
| 3 | 0 | 0 | 1 | 0 | 0 |
| 4 | 1 | 7 | 5 | 4 | 3 |
| 5.5 | 0 | 2 | 2 | 0 | 0 |




**10** Patient-reported satisfaction and function from pretreatment to 1 year.




**11** A, Soft tissue appearance at 6 weeks. B, Soft tissue maturation at 1 year.

was 0.32 ± 0.49 (left) and 0.47 ± 0.48 (right). The 12-month mean bone loss (SD) was 0.63 (0.53) and 0.70 (0.48) for the left and right, respectively. The bone loss from insertion to 3 months and 12 months was clinically measurable but not statistically significant ($P$=.247, F=1.429, $df$=2).

Three denture base fractures occurred at the site of the abutment attachment. These occurred within 3 months of attaching the retentive cap with autopolymerizing acrylic resin at the time of surgery. No denture base fractures were recorded after the protocol was changed to a laboratory fabricated heat-polymerized acrylic resin reline. At the 1-year follow-up, no ball attachment retentive caps had failed and no rubber O-rings required replacement. No discernable wear of the ball attachment was detected, and abutment screw loosening did not occur.

Resonance frequency analysis was performed for all implants at insertion and at each recall visit by removal of the ball attachment and collar followed by attachment of an implant level transducer facing labiolingually. The results showed a generally high mean initial value (ISQ = 74.1 ± 5.3), and maintenance of this high value up to the 1-year review (ISQ=73.1 ± 4.9). Many implants showed a small increase in ISQ value after 3 months, although this was not statistically significant ($P$=.630, F=0.580, $df$=2) There was no statistical difference between baseline, 3-month, and 12-month values ($P$=.630).

Plaque control was considered acceptable for most patients and considered relatively simple by the patients themselves. Soft tissue health was acceptable in all patients with no evidence of mucosal enlargement at recall appointments, as shown in Figure 11, at the 6-week and 12-month observation times. Calculus formation that impeded seating of the retentive cap was encountered on 2 occasions and was further prevented by more diligent oral hygiene.

## DISCUSSION

The purpose of this prospective study was to ascertain whether simplifying mandibular overdenture treatment using single-stage surgery and immediate prosthetic loading of a single implant would achieve acceptable implant success rates and compare favorably with the functional improvement expected using conventional techniques. Presurgical evaluation of the patient for this single-implant procedure is simplified due to use of lead foil, the patient's existing denture, and the relatively inexpensive lateral cephalometric and panoramic radiographs. These important diagnostic aids, together with adequate visualization of the lingual surface of the bony ridge after flap elevation, cannot be overstated in light of reports of life-threatening hemorrhage from the floor of the mouth during routine implant placement in this region.[37,38]

Careful, conventional placement of the implant was achieved with the use of a dense bone protocol recommended by the manufacturer, including screw tapping to the entire implant length, as compared to bone compression techniques with high insertion torques.[41] The initial insertion torque once seated was over 45 Ncm, however, and the resonance frequency analysis recordings were always above ISQ 60. Three patients that did not achieve this value were treated with a 2-stage approach, in which the implant was exposed and the ball abutment was placed and loaded 3 months after implant placement. As expected, these 3 patients had a successful treatment outcome at the 12-month stage of follow-up and, although satisfied with the outcome, would have preferred not to have had a second-stage surgical procedure, as compared to the single-stage surgery patients. The lack of initial stability may be related to bone type and surgical protocol. Of the 3 patients, 1 was a former smoker, 1 a nonsmoker, and 1 smoked less than 5 cigarettes per day. The ISQ readings that remained at high values despite being above 67-70 are of interest, as this is reported to be the value that most

functioning implants attain.[36] This may be attributed to the higher bone density in the symphyseal region of the mandible and improved stability related to the oxidized (TiUnite) surface of the implant.

Implant overdentures, in general, have less controlled loading when compared to fixed prostheses.[46] It can be postulated, therefore, that forces, both axial and lateral, generated by an overdenture on a single implant, have the potential to be greater than those produced by a multiple implant-retained overdenture. In a study by Tawse-Smith et al[28] comparing 2 different types of implant systems with delayed and early loading protocols for support of mandibular overdentures, a higher failure rate was experienced with unsplinted machined implants that underwent early loading. The oxidized surface in comparison studies has been shown to maintain primary stability compared to the machined surface, which has shown a drop in implant stability during the early healing phase.[26,27] Furthermore, the healing time required to achieve secondary stability is also shortened.[24,25] Clinical studies have shown a superiority in performance of the oxidized surface in immediate function.[29,31] A human histologic study on retrieved delayed and immediately loaded implants showed higher bone-to-implant contact with immediately loaded oxidized implants.[30] The results of this study are in agreement with the results found in the previously mentioned studies when oxidized implants are placed in immediate function.

Soft tissue impingement with immediate attachment of the retentive cap hampered gingival healing, resulting in discomfort. While no wound dehiscence occurred, hypertrophy was a problem for 2 patients, 1 requiring excision of the excess tissue at the 8-week period. Only this patient had a 3-mm abutment collar. The insufficient collar height above the level of the mucosa allowed the tissue to creep over the shoulder of the abutment and the tissue was therefore traumatized by denture insertion and movement. Where the collar height was at least 2 mm above the tissue level, this problem was not encountered. Payne et al[13] encountered similar problems in a comparable study using 2 implants. Their protocol dictated a 2-week healing period prior to definitive relining. The rationale in the present study of delaying relining and connection of the attachment cap for 6 weeks was to allow more complete maturation of the periimplant mucosa. Given the increased function reported by the patients during the healing phase, this was not regarded as an undue hardship. The use of a viscoelastic relining material not only inhibited tissue proliferation by eliminating dead space but also was more comfortable for the healing soft tissue and this finding is in agreement with another report.[13] Both patients with tissue hypertrophy had a normal soft tissue profile after tissue conditioning and maintained the tissue health after a heat-polymerized acrylic resin reline procedure. No patients developed late mucosal enlargement as has been reported in other studies such as that by Engquist et al,[3] which had an incidence of 25%, and that by Wright et al,[11] which reported 35%. The findings in the present study are in agreement with those of Cordioli et al,[19] who also reported no mucosal enlargement. The overall oral hygiene compliance for the group was considered acceptable. However, on 2 occasions patients had calculus formation around the ball attachment that prevented seating of the attachment. The lack of dead space with this attachment mechanism and relining procedure is thought to contribute to the favorable tissue response.

The change in protocol to 6 weeks of tissue conditioner instead of rigid fixation could be construed as a change from immediate loading to progressive or early loading.[13,21] Sixty percent of the patients in this study had immediate loading. No changes in measurable parameters were noted between the immediate and progressive loading groups, other than a subjectively more comfortable postoperative period.

Prosthetic problems were relatively few compared to other studies,[14,15] with all attachments functioning well at the 1-year recall and relines unnecessary. Other studies used metal retentive caps, whereas this study used plastic caps and rubber O-rings. The inherent resilience with this attachment may allow more movement and, therefore, less strain and potential for wear. The retentive cap is, however, substantially larger, resulting in a reduced amount of denture base around the attachment, particularly in the frequently narrow labio-lingual dimension encountered in the anterior mandible. If the implant was not placed in the ideal position from a prosthodontic perspective, then an unfavorable contour of the denture base would result. This is less of a problem with smaller retentive caps. The 3 fractures of the denture base at the attachment site were due to a small labio-lingual dimension around the implant site and occurred subsequent to fixation of the attachment with autopolymerizing acrylic resin. No fractures occurred following the heat-polymerized, acrylic resin, laboratory-fabricated reline protocol. Denture tooth wear was within normal limits for this patient group, with the exception of 1 patient who demonstrated severe wear within a year of denture fabrication, necessitating tooth replacement. The fit, stability, and comfort of the denture bases were still acceptable, however, and implant parameters (RFA, bone levels, and soft tissue health) were favorable.

The resorbed mandible is a difficult region to radiograph due to impingement of the film into the floor of the mouth. This has been reported in several studies.[4,10,43] The current study, in which all implants were placed in the symphyseal midline, had a greater incidence of superimposition of the genial tubercles. Fifty-two

percent of the implants could not be read accurately for this reason. All implants demonstrated a lack of periimplant radiolucency. Qualitatively, many patients showed no discernable bone loss, and others were consistent with remodelling of bone to the first thread. The success criteria used in this study[44] specified not more than 1 mm of marginal bone resorption during the first year of loading. As this could not be measured quantitatively for all implants, the term success could not be applied. Each implant was tested individually for mobility, adverse symptoms, and periimplant pathosis, however, so they can be categorized as surviving using this criteria. The measurable (48% of patients) bone remodelling findings compared favorably with those reported by Petersson et al[2] in a split mouth study of 7 patients comparing 1- and 2-stage surgery. It was postulated that the lack of a second-stage surgical procedure would limit coronal bone loss, especially in the initial phases of prosthetic loading. The authors did demonstrate a similar bone remodelling comparing 2-stage, delayed 1-stage, and early loading after 18 months of follow-up with little change to the 5-year follow-up point. The current report is a 1-year follow-up, so it is conceivable that further remodelling could occur. The long-term observation of the patients in this study is, therefore, important.

Data show that edentulous patients in the United States tend to come from households with below-average income.[47] For this reason, the cost of treatment becomes a more significant determinant of treatment acceptance, compared to other groups. Any reduction in cost to the patient group becomes more critical. Studies measuring the cost of implant overdenture therapy have been done with a microcosting technique, which examines the direct cost to the patient and, also, indirect costs, such as time and transportation.[18] Measured in this way, the difference in cost between 1 and 2 implants would be primarily half the component costs, as the time differential from both the surgical and prosthodontic viewpoint would be minimal. The nature of this treatment modality is such that there are no expensive laboratory costs involved, so that the implant components represent a significant overhead. Therefore, from the authors' perspective, providing a 2-implant overdenture with ball attachments would cost approximately 1.7 times more compared to a single-implant overdenture. From a psychological view, the surgical trauma is less and this is appealing to the prospective patient. The small reporting of prosthetic problems at the 1-year point is interesting from a maintenance cost standpoint. If this type of overdenture design and attachment component has a lower maintenance requirement, then this has favorable implications with respect to cost-effectiveness.

The McGill consensus statement suggests that the 2-implant overdenture should become the first choice of treatment for the edentulous mandible.[16] Fitzpatrick,[17] in a 2006 review of the standard of care for the edentulous mandible, stated that the McGill consensus should be viewed as a milestone, as well as a desirable stepping stone, in the pursuit of a universally acceptable standard of care for all edentulous patients. However, the standard of care in the edentulous mandible is the intervention judged by the well-informed patient, in consultation with an appropriately trained and experienced dental health care provider, to best meet the needs and circumstances of the patient.[17] The present report on the immediately functioning single-implant overdenture showed excellent survival rates and dramatically improved patient-reported satisfaction levels in patients with pretreatment denture problems. With respect to the 100% survival reported, the possibility should be considered that the authors are skilled clinicians experienced with this technique, so the single-implant procedure cannot be generalized to the entire practicing community. However, the procedures involved are not arduous or complex, provided the protocol is followed. It is difficult to postulate whether 2 implants are twice as effective as 1 or even whether there is any discernable difference from a patient perspective. A limitation of this study is the lack of a comparison group with the more conventional 2-implant overdenture. Therefore, a randomized clinical trial comparing single-implant overdentures and 2-implant overdentures with particular regard to patient satisfaction is indicated. Given the clear improvements and reduced costs with this modality, serious consideration for longer term and more extensive clinical trials is warranted. In the long term, with favorable results, the McGill consensus statement may be challenged.

This preliminary 1-year report on this procedure indicates that it is a positive treatment modality, which should make it advantageous for more completely edentulous patients with limited resources to benefit from an implant-retained prosthesis. It may well be considered to be the entry level treatment option for rehabilitation of the edentulous mandible in selected patients, especially the underprivileged geriatric groups.

## CONCLUSIONS

Within the limitations of this study and the preliminary nature of this 1-year report, it may be concluded that the immediately loaded, single implant-retained mandibular overdenture, using an oxidized surface implant, is a viable treatment proposition for selected patients. The relatively simple treatment protocol and reduced component and laboratory involvement should mean that a greater number of edentulous patients could benefit from an implant-retained prosthesis.

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Acknowledgments
The authors thank Dr Bo Rangert, Chief Clinical Scientist, for his support in the supply of implants and associated prosthetic components from Nobel Biocare AB, Goteborg, Sweden. Thanks also to Dr Estee Kruger for the statistical analysis and the staff at The Branemark Center, Perth, and the Oral Health Centre of Western Australia for their encouragement and cooperation.

0022-3913/$32.00