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Immediately Loaded Maxillary and Mandibular Dental Implants with Fixed CAD/CAM Prostheses Using a Flapless Surgical Approach: A Clinical Report

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Abstract

Immediate implant loading is a viable treatment method for selected cases. One of the greatest advantages of this method is the virtual surgery, which precedes the actual clinical treatment and eliminates any need for last minute decisions. The actual surgery time is decreased, since all steps are predetermined. Additionally, no flaps have to be elevated, resulting in preservation of periimplant soft tissues, vascularization of the underlying bone, fewer postoperative complications, and minimal patient discomfort. This article presents a clinical approach made possible due to the evolution of modern scanning techniques and appropriate software.

Branemark's original protocol required 4 to 6 months for implant osseointergration before placement of the definitive prosthesis.[1-3] Although this approach gave very predictable results, it had certain drawbacks. The main disadvantages of this approach were prolonged treatment time, two surgical procedures, placement of a removable prosthesis that required modifications during the course of treatment, and a greater number of appointments.[4] Additionally, the original ad modum Branemark protocol required placement of five to six implants between the mental foramina and a fabrication of a bilateral cantilever of 15 to 20-mm long to provide posterior support and good mastication ability.[5,6]

Newly acquired data from clinical studies modified these original protocols, both in the number of implants required for a fixed prosthesis and the time required for implant loading.[7] It has been reported that immediate implant loading has high survival rates.[8-11] Advances in implant topography have contributed to the success of immediate loading. Research has shown that roughened implant surfaces give more predictable results than machined surfaces.[12-15] The reported success rates for implants with roughened surfaces are 93% to 99.2% for the maxilla, and 93.2% to 100% for the mandible, for 1 to 5 years of follow-up.[16-19] Although micromovement of implants during the healing period has been a concern for osseointegration, a limited amount (150 μm) does not seem to interfere with this process.[20] Micromotion can be limited by the use of a rigid prosthesis that splints implants together and by the use of expandable abutments.

Patient report

A 50-year-old woman presented with maxillary and mandibular complete dentures. She had been edentulous since she was 40 years old (Figs 1–3). The patient complained of the lack of stability and the esthetics of the present prostheses. She also stated that she never got psychologically accustomed to the removable prostheses and that she was interested in a fixed prosthetic rehabilitation. With the advent of the "Teeth in an Hour" concept, the patient was presented with the option of placing 7 to 8 implants in the maxilla and the mandible and immediately loading them.

The patient's medical and dental history and a panoramic radiographic survey were obtained. A comprehensive clinical

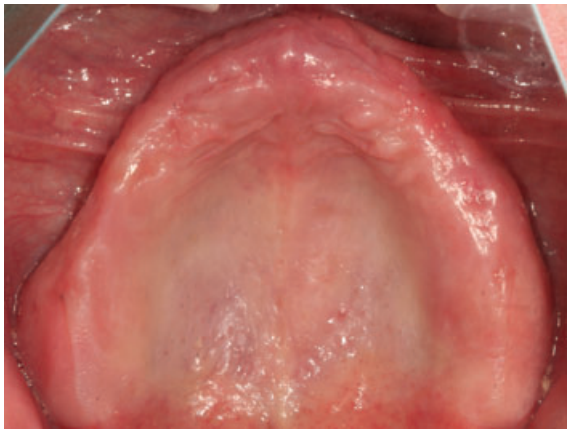

Figure 1 Occlusal view of patient's edentulous maxilla.

Figure 2 Occlusal view of patient's edentulous mandible.

exam was performed by both the prosthodontist and the periodontist. The patient was classified as an ACP PDI (American College of Prosthodontists Prosthodontic Diagnostic Index) for Complete Edentulism Class II.

A new set of maxillary and mandibular complete dentures was fabricated after an esthetic and phonetic evaluation and establishment of the appropriate occlusal vertical dimension (OVD). The patient was instructed to wear her dentures for 4 weeks, for evaluation purposes.

Figure 3 Interim maxillary and mandibular complete dentures with gutta percha points placed on the buccal flanges.

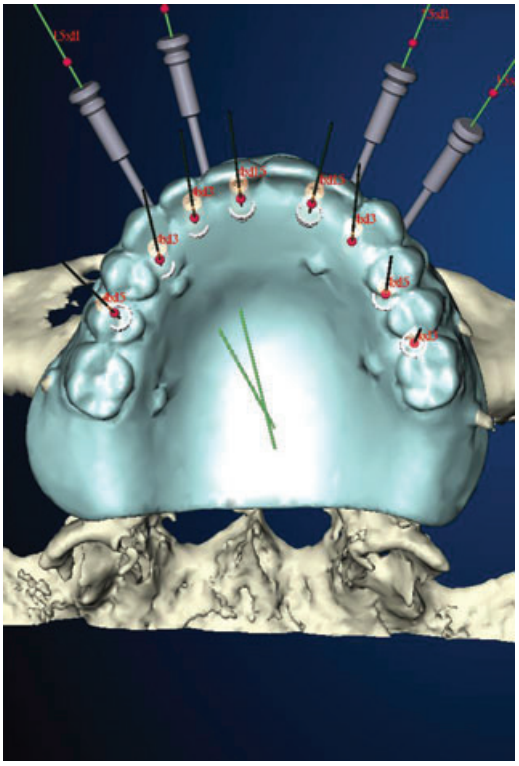

Figure 4 Virtual placement of the stabilizing pins and the diameters and lengths of the implants to be placed in the maxilla.

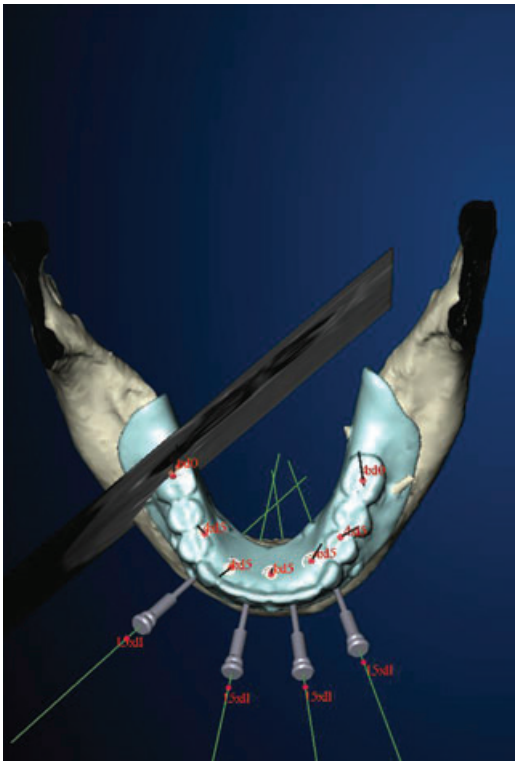

Figure 5 Virtual placement of the stabilizing pins and the diameters and lengths of the implants to be placed in the mandible.

Figure 6 Mandibular surgical template occluding with the duplicate complete denture by means of an interocclusal index.

Figure 7 Occlusal view of the definitive fixed mandibular complete denture.

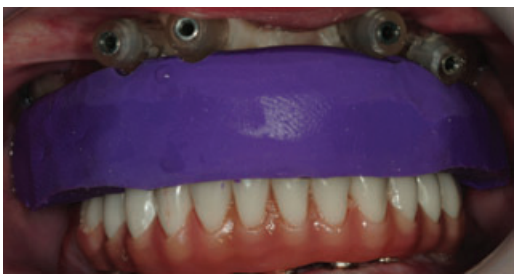

Figure 8 Maxillary surgical template occluding with the definitive fixed mandibular complete denture by means of an interocclusal index.

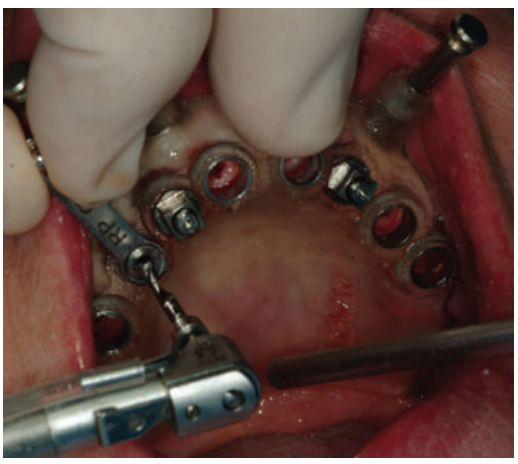

Figure 9 Maxillary surgical guide with metal sleeves employed for accurate implant placement.

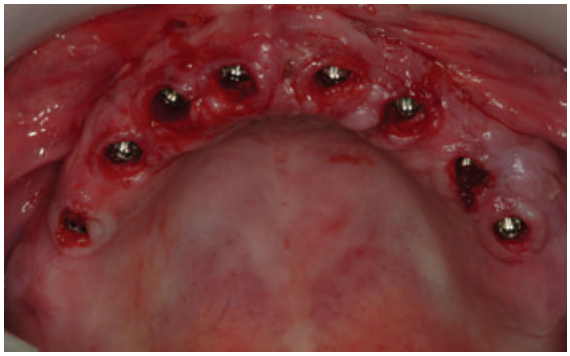

Figure 10 Accurate placement of eight implants in the maxilla made possible with meticulous pre-surgical planning.

Figure 11 Occlusal view of the definitive fixed maxillary complete denture.

Figure 12 Definitive fixed maxillary and mandibular complete dentures delivered on the day of implant placement.

After it was ascertained that the patient was satisfied with both the esthetics and the function of the prostheses, these dentures were used as guides for the fabrication of surgical templates. Afterward, dimples were prepared with a #4 round bur (Brasseler USA, Savannah, GA) at the buccal flanges of the complete dentures. These 1.5-mm diameter dimples were then filled with gutta percha points (Dentsply Maillefer, Tulsa, OK) (Fig 3). An interocclusal record of the patient's centric relation at the established OVD was subsequently taken using poly(vinyl siloxane) (Blumousse, Parkell, Edgewood, NY). After complete polymerization, the interocclusal record was carefully trimmed with a Bard-parker #25 knife (Bard Parker, Franklin Lakes, NJ) and placed intraorally for accuracy verification.

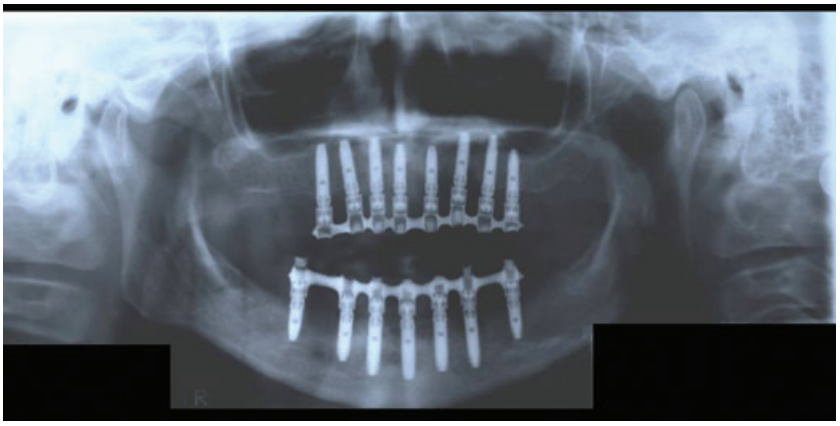

Figure 13 Posttreatment panoramic radiograph of the patient.

The patient was then referred for a high-resolution spiral computed tomography (CT) scan. Three scanning procedures were performed. The maxilla and the mandible were first scanned, with the patient wearing the prostheses with the radiopaque markers, to visualize the osseous architecture and the anatomical limitations (Figs 4 and 5). The maxillary and mandibular complete dentures with the radiopaque markers were then CT scanned. Different settings were used for the radiolucent radiographic guide to be displayed. The two DICOM files, or scans of the maxilla and the maxillary denture, were combined by superimposing the gutta percha markers. The same procedure was followed for the mandible. The CT data sets of the maxilla and the mandible were used for a 3D digital reconstruction (Procera software; Nobel Biocare AB, Goteborg, Sweden) of both the bone and the prostheses.

A simultaneous observation of the maxillary and the mandibular bone structures, as well as of the radiographic guides in three spatial planes, was thus achieved. The planning software allowed for the evaluation of the osseous tissue in relation to the planned prostheses, and consequently the angulation and the size of the implants to be used. The number, position, and implant trajectory were also determined in that stage. An ideal planning of the implant surgery could be performed through the use of the above mentioned software. Exact implant placement was therefore provided by the surgical template. Four horizontal pins were also planned to fix the surgical guides to the maxillary and mandibular bone at the time of the surgery. These stabilizing pins were planned to be placed between the implant positions, in order not to interfere with implant placement.

Planning was verified by both the prosthodontist and the periodontist and was then sent to the computer-aided design computer-aided manufacturing (CAD/CAM) facility (Procera; Nobel Biocare AB) for the fabrication of both the surgical guide and of the duplicates of the scanned prostheses. The surgical guides were used for the fabrication of fixture level models. Externally hexed implant replicas (Nobel Biocare AB), silicone-based gingival simulation material (Gi-Mask; Coltene, Altstatten, Switzerland), and type 4 dental stone (Resin Rock; Whip Mix, Louisville, KY) were employed for the fabrication of the models. The fit of the duplicate dentures provided by the CAD/CAM manufacturing facility was verified on the working casts. A precise fit proved to exist. The working casts were then articulated on a semiadjustable arcon articulator (Denar Mark II; Waterpik, Fort Collins, CO) using a facebow transfer (Denar Slidematic Facebow, Waterpik) and the interocclusal record already obtained.

The definitive prostheses were fabricated on the stereolithographic casts prior to implant placement. A milled titanium prosthetic framework (Procera Nobel Biocare AB) in combination with acrylic denture teeth (IPN; Dentsply International, New York, NY) and heat-polymerized polymethyl–methacrylate resin (Lucitone 199; Dentsply International), were used. The provisional maxillary and mandibular prostheses were used as guides, since they were acceptable by the patient both functionally and esthetically.

The "Teeth in an Hour" concept (Nobel Biocare AB) was followed for the flapless surgical procedure, using local anesthesia and strict asepsis protocols.[21,22] A maxillary duplicate complete denture was placed into the mouth. Next, the mandibular surgical template was positioned in place, and the patient was asked to occlude with firm pressure on the maxillary duplicate complete denture using an interocclusal index (Fig 6). The 1.5-mm twist drill was employed to open the retentive holes for four transalveolar horizontal stabilizing pins used for the fixation of the surgical template. A precise positioning of the implants was achieved through the use of metal cylinders incorporated into the surgical template. These metallic sleeves could accommodate removable stainless steel drill guides with varying inner diameters. Punching of the soft tissue was performed. The standard 2-mm pilot drills (Nobel Biocare AB) were then used. The drilling sequence for the Speedy Groovy RP implants (Nobel Biocare AB) was followed. Initially two implants on either side of the mandibular arch were placed. The surgical template was further stabilized by the placement of expanding abutments on these two implants. The patient's bone quality was manually assessed during the surgery and was classified as normal (type 2–3).[23,24] Therefore, the manufacturer's recommendation for the drilling sequence for that type of bone was followed.

Once all seven implants were placed, the CAD/CAM manufactured mandibular prosthesis (Fig 7) was delivered and connected to the implants by using the expanding abutments. These

Ti abutments can expand with screw tightening and lock the fixed complete denture into place, through intimate contact between the outer surface of the abutments and the inner surface of the metal cylinders incorporated into the prosthesis. Thus, the expanding abutments can compensate for small 3D discrepancies between the planned and the actual implant position obtained, allowing for a passively fitting prosthesis. This discrepancy is usually in the range of a fraction of a millimeter and a few degrees.[25] A radiographic evaluation was then performed to confirm the precise adaptation of the abutments to the implants. The abutments were then tightened to 35 Ncm.

The maxillary duplicate complete denture was then placed into the mouth and was articulated against the fixed mandibular complete denture for verification purposes. Once the accurate position had been confirmed, the maxillary surgical template was positioned into place, and the patient was asked to occlude with the mandibular definitive prosthesis through an interocclusal index (Fig 8). The same protocol used for the mandibular implant placement was followed for the maxilla as well. Eight implants were placed (Figs 9 and 10), and the definitive fixed maxillary complete denture was delivered (Fig 11).

The access holes were filled with gutta percha points (Dentsply Maillefer) and were then sealed with autopolymerizing polymethyl–methacrylate acrylic resin (Repair Material; Dentsply International). The occlusion was evaluated and was adjusted to provide simultaneous centric contacts on both sides of the dental arch. Canine-guidance occlusion was established, as published data[26,27] suggests that posterior distribution of occlusal loads during excursive movements can generate high lateral stresses, which can be dangerous for the prosthetic elements, the implants, and the adjacent bone. The patient approved the esthetic appearance of the prostheses (Fig 12). The exposed abutment at the area of the maxillary right lateral incisor was not an issue, because of the patient's low lip line. A panoramic radiograph was then taken (Fig 13).

The patient was then prescribed medication for postoperative pain and was instructed to use a 0.12% chlorexidine rinse (Peridex, Zila Pharmaceuticals, Phoenix, AZ) twice a day for 2 weeks. Oral hygiene instructions were given, and use of dental floss (Superfloss, Oral B Laboratories, Iowa City, IA) and of an oral irrigator (Waterpik Ultra Dental Water Jet, WP-100W, WaterPik Technologies Inc, Newport Beach, CA) as adjunctive aids was suggested. The patient was placed on a soft diet for 8 weeks, and was recalled at 24 hours, 1 week, 3 months, and subsequently every 6 months. No postinsertion adjustment was required. The total procedure took 3.5 hours.

Discussion

Immediate implant loading has been proven to be a viable treatment method for selected cases. Initial documentation of this clinical procedure was published in the late 1970s.[28] The presented clinical approach has been presented by Nobel and was made possible with the evolution of modern scanning techniques and appropriate software.

One of the greatest advantages of this method is the virtual surgery preceding the actual clinical treatment, thus reducing any need for last minute decisions. The actual surgery time is decreased because all steps are predetermined. Additionally, no flaps have to be elevated, a fact which results in reduced intraoperative bleeding, preservation of periimplant soft tissues, vascularization of the underlying bone, fewer postoperative complications, and minimal patient discomfort.

Disadvantages of the flapless implant surgery include the required presence of adequate amount of bone volume, favorable bone architecture for dehisences and fenestrations to be avoided, difficulty in seating the abutment and tissue entrapment beneath the abutment, and presence of keratinized tissue. If there is a lack of keratinized tissue, then a grafting should be performed prior to the flapless implant surgery procedure.[29–31] The presence of 3 mm (apicocoronally) of keratinized soft tissue is a prerequisite, since it provides the epithelial and connective tissue elements needed for soft tissue integration and the development of circumferential biologic width without sacrificing the underlying periimplant supporting bone.[32] Additional criteria for flapless implant surgery include:

(a) adequate soft tissue thickness of 2.5 to 3 mm, which contributes to the maintenance a stable periimplant soft tissue environment. This prerequisite along with tissue keratinization helps to resist recession, protects periimplant crestal bone levels, and provides adequate esthetic masking of underlying metal components,
(b) adequate ridge width relative to the planned implant diameter, and
(c) adequate bone height relative to the planned implant length.[29,30,32]

It should be mentioned that immediate loading could be provided when implants achieve a primary stability of at least 30 Ncm.[33,34] It has been reported that implant length is important in achieving primary stability.[35] In the technique outlined in this article, primary stability is further enhanced by the exact preparation of the osteotomy site, due to the precise surgical template[36] and by cross-arch stabilization through the definitive prosthesis.[33,37]

Usually minor occlusal adjustments are necessary after delivery of the prosthesis. Although the technology used is precise, certain factors may slightly alter the planned occlusion. These include fitting of the scanned dentures, resiliency of the mucosa, the patient's occlusal forces during the scanning procedure, and positioning of the surgical guide before being anchored.

The described method also has the advantage of delivering the definitive prosthesis immediately after the placement of the implants, enhancing esthetics, and function. It should be mentioned, however, that occlusal forces generated during the first 6 to 8 weeks should be minimal in order not to impede with the implants' osseointegration. The patient's awareness and full compliance with the oral hygiene instructions and a soft diet are therefore essential for a successful outcome.

An alternative approach to the presented concept involves the fabrication and placement of custom provisional prostheses instead of the definitive ones; however, since the literature supports the notion that placement of definitive prostheses for immediate loading is a very reliable option,[38] the latter method was used in this case. Regular recalls are essential to determine periimplant tissue health, as well as changes in occlusion and deterioration of the prosthetic materials, which both can determine repair or replacement of the prostheses.

Other methods involving a duplication of maxillary and mandibular dentures by incorporating a solution of barium sulfate have been reported.[39,40] These duplicate dentures can be used as radiologic templates during CT scans that allow the visualization of the prosthetic plan prior to treatment. Appropriate software may then be used for the fabrication of stereolithographic surgical guides permitting accurate implant placement.[41-43] Long-term success rates of immediately loaded implants have been reported to be comparable to those of conventional loading;[34,38] however, it should be mentioned that a careful selection of patients is needed to have successful, predictable results.

Conclusion

The surgical and prosthetic approach presented in this article caused minimal trauma to the patient, dramatically reduced the treatment time, decreased the patient's discomfort, had an immediate acceptance by the patient, and immediately enhanced the patient's esthetic appearance and function.

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