Advanced Immediate Functional Loading: Requirements for Long-Term Success in Modern Implant Dentistry

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Abstract: There are benefits to be derived from the use of advanced surgical protocols in conjunction with immediate functional loading using various dental implant designs and implant–abutment connections. Clinical protocols with simultaneous bone grafting, immediate implant placement, and/or sinus augmentations when a shortened treatment period is needed are included in this report, with the aim of providing understanding of the main protocol characteristics and prerequisites for long-term success in implant dentistry. This article presents three clinical cases that illustrate possibilities for advanced immediate loading using different implant designs. It demonstrates treatment of severe bone defects and the facilitation of placing implants in regenerated bone that can be immediately loaded.

The immediate loading (IL) concept in the intraforaminal part of the mandible whereby four primary stable implants are inserted and connected using a bar immediately after placement and loaded with an overdenture has been extensively documented.[1,2] The general rule of this treatment concept is to control micromotions at the bone–implant interface when implants are loaded. Implant length, appropriate thread design, surface roughness, and an excellent osteotomy procedure are main factors to maximize primary (mechanical) implant stability. Additional strategies, such as reduction of loading forces and recommendations for soft/liquid diet at the initial stages of healing, have been suggested in order to achieve stability at the bone–implant interface and implant integration.[3-7] Moreover, some authors increased the number of implants so as to distribute loading forces[4] using rigid immobilization with fixed restorations.[4,5,8-13] Transitional (ie, secondary) implants have also been used for immediate loading and temporary rehabilitation and were splinted later with submerged, healed (ie, primary) implants.[5,14,15]

Recent studies, however, have suggested the use of different types of restorations in the mandible using prefabricated abutments, splinted together utilizing a removable bridge and immediate loading.[7,16,17]

Primary Implant Stability

Primary (initial) stability (PS) is related to the level of primary bone–implant contacts at the interface during implant placement. Primary stability is an important determinant of implant survival,[18,19] especially when implants are loaded immediately after surgery.[20] PS is the absence of mobility in the bone bed upon insertion of the implant and depends on the quantity and quality of bone, surgical technique, and implant design.[19] There are varying scientific opinions regarding factors that influence PS. For example, some studies demonstrate that length, geometry, and surface area of the implant and bone-to-implant contacts at the histologic level influence PS,[21] while others state that implant PS is determined by the bone density, implant design, and surgical technique.[22]

Implant design and its association with PS has been evaluated by many scientific groups. A study showed results of implants on beagle dogs with no statistically significant differences in bone formation between cylindrical and tapered implant designs when placed using the non-submerged technique.[22] Implants with different geometries and similar diameters have shown no differences in strain levels on surrounding bone.[23] Improved stability with tapered implant designs versus cylindrical implants was also reported in different studies.[24-26]

Initial stability seems to be dependent on the bone quality and the surgical technique.[27,28] A positive correlation between implant

PS and bone density at the osteotomy site was demonstrated in a systematic review.[29] However, the use of narrow-diameter drills in poor bone quality may improve the primary implant stability.[30]

The clinical assessment of implant stability has been evaluated by objective methods, such as the Periotest® device (Medizintechnik Gulden, www.med-gulden.com) with Periotest values (PTV) and the Osstell® device (Osstell, www.ostell.com), which provides a resonance frequency analysis (RFA) with implant stability quotient (ISQ) values. Using RFA, O'Sullivan et al[24] demonstrated in a human cadaver study higher PS for tapered designed implants (compared to non-tapered) independent of bone quality. Similarly, Glauser et al[31] found significantly higher RFA values and insertion torques for tapered implants than cylindrical. Recent studies using tapered designed implants placed in vitro achieved greater PS than those with a parallel design. Both experienced and inexperienced clinicians consistently achieved PS; however, experienced clinicians achieved higher ISQ values with tapered implants in poor-quality bone.[28]

Based on the critical analysis of the literature and the author's own clinical experience, the immobilization of implants and the strength of the implant–abutment connection seem to be significant factors in achieving clinical success using the immediate loading concept.[32] This is of special benefit when implants have to be placed in sites with weak bone quality and slight bone volume (eg, soft bone, augmented sites, immediate implant placement, etc) and have to be loaded immediately after their insertion.

In clinical conditions with bone dehiscences (or fenestrations), where bone grafting is needed, implants with good PS may be used but they cannot be loaded immediately if the implants are not clinically stable when abutments are connected in situ. The high friction of the implant–abutment interface requires less torque for providing a sealing at the connection and, therefore, allows a large variety of clinical options with immediate loading. Immediate functional loading cases in conjunction with simultaneous sinus lift procedures or implant placement in fresh extraction sockets, implant placement with simultaneous bone grafting, immediate loading of implants without direct splinting,[17] or implants connected with teeth using a secondary splinting[7,33] are some clinical protocols requiring advanced surgical and prosthetic skills but also use of implant designs with excellent PS.

QUOTE

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Conical Connections

Morse-tapered (conical) connections seem to be mechanically more stable under loading conditions[34] even when implants are splinted together[35] and are associated with less crestal bone loss compared to other internal or external butt-joint connections. Biological considerations, such as trauma during surgery (ie, bone planing to create space for the restoration), are associated with crestal bone loss and these are not related to the use of a specific implant design with or without platform-switching.[35] In general, it is well known that external hexagons present a microgap associated with bacterial accumulation and inflammatory reactions in the surrounding tissues.[36] Even earlier studies showed leakage between different implant–abutment connections in vitro[37]; recent studies have presented a better sealing at Morse-tapered connections[38,39] and these systems have been introduced by different manufacturers today. It should be emphasized that, in general, not every conical connection is a Morse-tapered connection, and the exact angle of the surfaces (abutment–implant interface) should be determined in order to provide excellent sealing and improved abutment stability.

Implants with Morse-tapered connections and concepts of one-abutment at one time[40,41] with (or without) subcrestal implant placement[41] have been evaluated by different

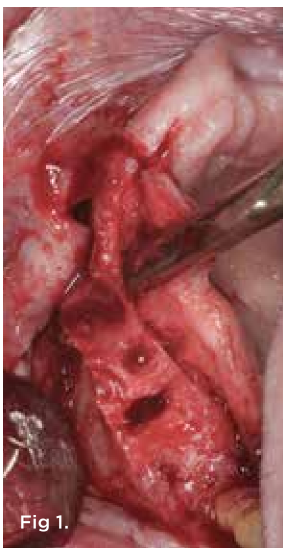


Fig 1.

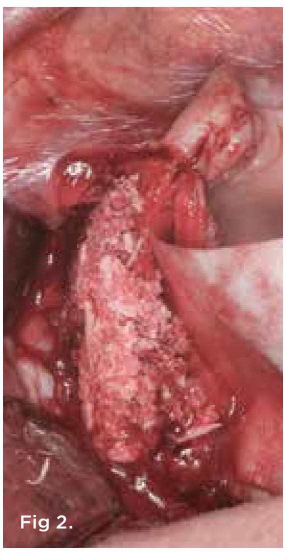


Fig 2.


Fig 3.


Fig 4.

Fig 1. Advanced resorbed maxilla before bone grafting. **Fig 2.** After ramus autogenous block was harvested and milled for guided bone regeneration, particulated bone (composite graft: autogenous and allograft) was used for ridge augmentation and was well condensed before coverage with a membrane. **Fig 3.** Five months after augmentation, implants were placed and connected with multibase abutments for fixation of a provisional screw-retained restoration and immediate loading. **Fig 4.** Provisional restoration in place immediately after implant placement.

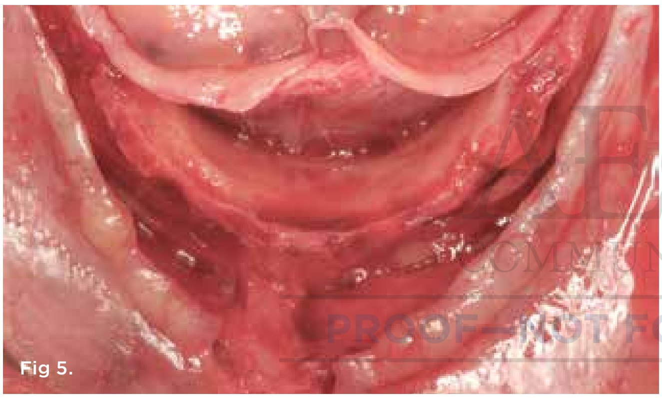
researchers to control crestal bone loss. Other authors do not see advantages of such treatment concepts with platform-switching based on dog studies. Specifically, flap surgery and subcrestal implant placement, implant technology comparing platform shift/switch with standard abutments, surgical approach, and abutment selection seem to have a limited impact on crestal remodeling, associated bone loss, and mucosal profile.[42] Also, when immediate implants were placed subcrestally in dogs, the biological width dimension was in a most coronal position, but it did not have any effect on minimizing the marginal bone loss.[43] In a recent clinical study using two different implant designs with platform-switching but with different implant–abutment connections (butt-joint and Morse-tapered) in the same patients, a bacterial composition similar to periodontitis and peri-implantitis was found when implant designs had the butt-joint connection even when chlorhexidine for decontamination at the implant–abutment interface was used.[44]

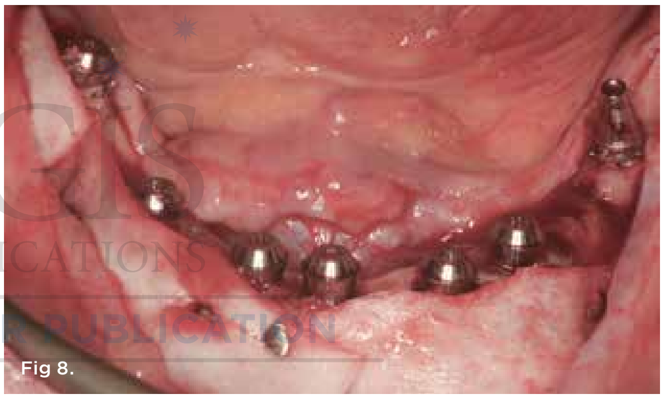
QUOTE

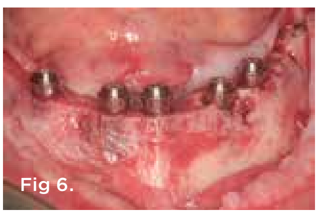
In a previous clinical study, telescopic abutments were used in the mandible for implant-supported restorations and immediate loading. Four implants were placed and connected with prefabricated telescopic abutments (4-degree angle). The implants were loaded immediately after insertion.[16,17] Prefabricated secondary copings were inserted in the prosthesis. Using this treatment concept in the mandible, a high survival rate was reported after 2 years of loading with a maximum of 129 months of loading period.[17] A similar clinical concept with immediate loading was used in the maxilla when implants, splinted together with periodontally healthy teeth, using a telescopic-retained prosthesis showed a high success rate for implants and residual teeth with a predictable clinical outcome improving the esthetic result and plaque control.[33]

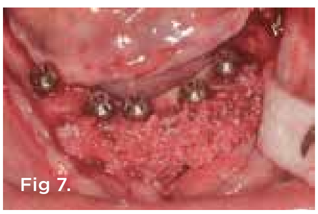
Clinical Cases

The present report demonstrates benefits of advanced surgical protocols in conjunction with









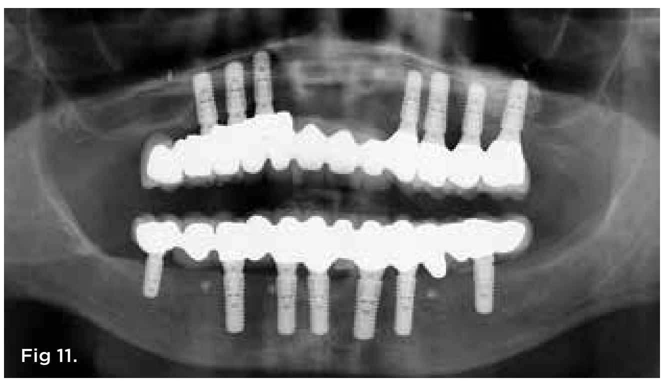


Fig 5. Extreme atrophic mandible after elevation of a mucoperiosteal flap. **Fig 6.** After implant placement in the thin alveolar ridge following planing of the bone to create space for the restoration, the implants are shown in situ after connection with multi-base abutments. **Fig 7.** Lateral ridge augmentation with particulated bone. **Fig 8.** Coverage of the bone-grafted area with two collagen membranes fixated with titanium tags. **Fig 9.** Provisional restoration in place immediately after implant placement. **Fig 10.** Esthetic result of the prosthesis 2 years after immediate loading. **Fig 11.** Panoramic radiograph 2 years after implant placement and loading, demonstrating maintenance of the crest of bone.

immediate functional loading using different implant designs and implant–abutment connections. Clinical protocols with simultaneous bone grafting, immediate implant placement, and/or sinus augmentations when the treatment period has to be reduced and that avert biological complications and implant failures are included in this report. The aim is to provide understanding of the main protocol characteristics and discuss prerequisites for long-term success. Further advanced protocols in conjunction with immediate functional loading have been published[7] and the role of loading forces around immediately loaded implants to improve wound healing and bone formation was reported in a recent comprehensive paper.[45]

The three clinical cases presented here illustrate possibilities of advanced immediate loading using different implant designs.

Case 1

The first case demonstrates bone grafting in the maxilla (Figure 1 through Figure 4) and mandible (Figure 5 through Figure 11) (including sinus augmentation with a lateral window on the left side) and, after 5 months of healing, implant placement (Bone Level®, Straumann, www.straumann.us) with multi-base abutments and a screw-retained provisional restoration for immediate functional loading. In the mandible, the implants were placed with a simultaneous buccal augmentation with cancellous allograft (Puros®, Zimmer Dental, www.zimmerdental.com) and immediate loading. The final screw-retained prostheses were delivered (at the Department of Prosthodontics, Eastman Institute for Oral Health, University of Rochester [NY] Medical Center) 9 months after loading. The final result 2 years after loading showed excellent crestal bone maintenance and a successful clinical outcome.

Case 2

The second clinical case demonstrates removal of clinically stable implants placed in a foreign country in positions difficult to restore prosthetically. Moreover, the implant system that had been used was not FDA approved, and, therefore, the prosthetic components were not available in the United States.

Advanced bone grafting was performed with a combination of autogenous bone and bone mineral (cancellous BioOss®, Geistlich, www.geistlich-na.com) covered by a collagen membrane (BioMend® Extend™, Zimmer Dental), immobilized with titanium tags (Salvin

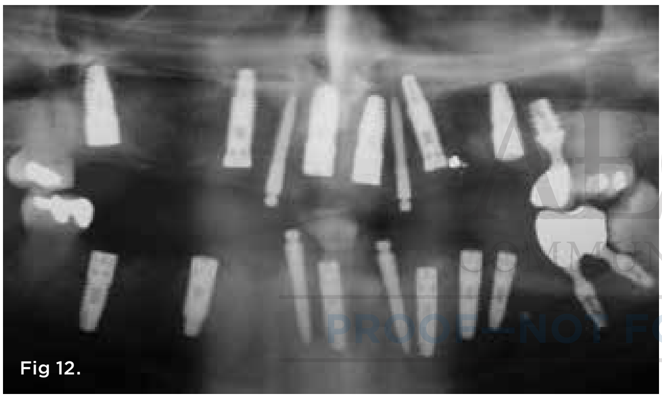


Fig 12.

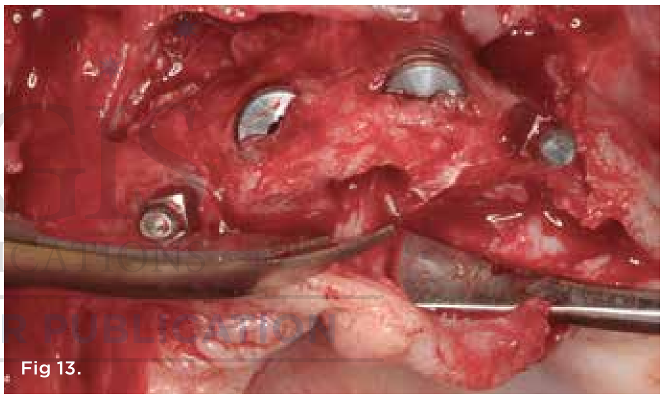


Fig 13.

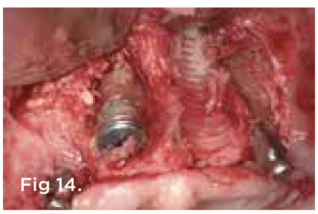


Fig 14.


Fig 15.


Fig 16.


Fig 17.


Fig 18.

Fig 12. Preoperative panoramic radiograph presenting the implants placed in prosthetically non-restorable positions. **Fig 13.** Anterior implants before removal, demonstrating the buccal position. The incisal canal has been prepared before removal of the incisive nerve and implant removal to reconstruct the anterior maxilla. **Fig 14.** The thread design of the implants without excellent bone incorporation was presented after implant placement. A layer of fibrous encapsulation was not found. The implants were osseointegrated with low mechanical stability. **Fig 15.** Implant placement with simultaneous bone grafting and membrane immobilization. **Fig 16.** Abutment connection with final torque for immediate functional loading. **Fig 17.** Provisional resin material within the vaccuform allowed chairside fabrication of the provisional restoration (cement-retained). **Fig 18.** Provisional restoration in place immediately after surgery (implant placement and simultaneous grafting for immediate functional loading).

Dental, www.salvin.com). After 4 months of healing, Ankylos® implants (DENTSPLY Implants, www.dentsplyimplants.com) were placed and loaded using standard abutments. The provisional prosthesis (cement-retained) was delivered the day of surgery and fabricated chairside using temporary cement and a vacuum-form machine. In a similar approach, implants were removed in the mandible, and vertical and horizontal bone augmentations with coronal flap advancement for tension-free closure were performed.

Five months later, implants were placed and connected with their respective abutments for immediate loading. These abutments were never removed and impressions were taken for the final prosthesis using prefabricated impression copings and implant analogues. Fixed prostheses were delivered and cemented with provisional cement material (Temp-Bond®, Kerr Dental, www.kerrdental.com) for follow-up evaluation of the implants. The final clinical and radiographic evaluation showed an excellent result, and the patient was very happy with the outcome. This case is depicted in Figure 12 through Figure 25.

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Case 3

The third case demonstrates a clinical situation after a tooth extraction (tooth No. 4) and, 2 weeks after healing (because the patient could not wait longer due to relocation), implant placement (Ø 4.1 mm/10 mm, Trabecular Metal™ [TM], Zimmer Dental) with a simultaneous osteotome technique (vertical augmentation from the socket) and abutment connection (friction fit) for immediate functional loading. The provisional crown was cemented, and a soft/liquid diet was recommended for a period of 2 to 3 months. The final prosthesis was fabricated outside the mouth to remove the initial abutment using an impression coping and an abutment analogue. A final metalo-ceramic crown was cemented 3 months after loading. The implant presented excellent clinical stability and maintenance of the peri-implant soft and hard tissues at the 1-year follow-up (Figure 26 through Figure 31).

This implant design (slightly tapered) with a tantalum pattern in the middle portion of the implant allows significant improvement of


Fig 19.


Fig 20.

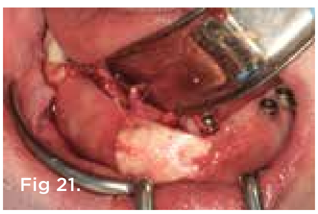
Fig 21.


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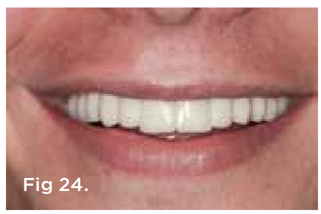
Fig 24.


Fig 25.

Fig 19 and Fig 20. Extreme atrophy of the mandible before (Fig 19) and during (Fig 20) vertical and horizontal augmentation using a composite grafting material with autogenous bone and bovine bone mineral. **Fig 21.** Coverage of the augmentation material with two collagen membranes to immobilize the grafting particles. **Fig 22.** Implants placed and prepared for immediate function. **Fig 23.** Chairside fabrication of the cement-retained provisional restorations in occlusion immediately after surgery. **Fig 24.** Final restorations in place (smile line). **Fig 25**. Panoramic radiograph 3 years after immediate loading presenting no crestal bone loss around all implants.

biological stability due to faster bone formation within the porous tantalum-based cylinder.[46] However, advanced surgical skills in such cases are required to improve the initial stability, especially when single-tooth implants are placed in fresh extraction sockets.

Conclusion

In conclusion, clinicians who are successfully using the immediate loading concept in their practice may improve the applications of this biological concept, when:

- implant systems with great initial implant stability are used
- micromotions at the bone–implant interface are avoided
- high primary contacts between implant surface and surrounded bone are attempted
- implant–abutment connection with high stability (using low torque for sealing) is used, and
- soft/liquid diet at the initial stages of healing is recommended

Current developments in implant dentistry with new surfaces and implant designs, platform geometries, and implant–abutment connections may improve crestal bone stability. This may better control biological complications, reduce the entire treatment period, and improve the final esthetic outcome.

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Fig 26.


Fig 27.


Fig 28.


Fig 29.


Fig 30.


Fig 31.

Fig 26. Extraction socket with granulation tissue 2 weeks after tooth extraction. **Fig 27.** Immediate implant with a tantalum core in the middle of the implant for improvement of the biological stability after osteotome technique (internal sinus lift). **Fig 28.** Radiograph immediately after surgery. **Fig 29 and Fig 30.** Abutment connection (friction fit connection) for immediate loading (Fig 29) and provisionalization in place (chairside fabrication) immediately after surgery (Fig 30). **Fig 31.** Follow-up after 1 year showing some bone loss due to the removal of the initial abutment for impression at the implant level and crown delivery.

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