Immediate Loading of Osseotite Implants: A Case Report and Histologic Analysis After 4 Months of Occlusal Loading

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A growing number of clinical reports show that early and immediate loading of endosseous implants may lead to predictable osseointegration; however, these studies provide mostly short- to mid-term results based only on clinical mobility and radiographic observation. Other methods are needed to detect the possible presence of a thin fibrous interposition of tissue that could increase in the course of time and lead to clinical mobility. A histologic evaluation was performed on two immediately loaded Osseotite implants retrieved after 4 months of function from one patient. He had received a total of 12 implants in the mandible, of which six were immediately loaded and six were left to heal in a submerged way. Clinical and histologic osseointegration was consistently achieved for both of the retrieved immediately loaded implants. Osteogenesis and bone remodeling on the Osseotite surface were not impeded by immediate loading as shown by histomorphometric evaluation, which revealed high levels of bone-to-implant contact ranging from 78% to 85%. This immediate loading protocol involving bilateral splinting of six Osseotite implants in the mandible proved to be successful after 4 months of loading. Further long-term clinical and histologic studies are needed before introducing this immediate loading protocol as a routine procedure in implant therapy. (Int J Periodontics Restorative Dent 2001;21:451–459.)

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The original Brånemark protocol recommended long stress-free healing periods to achieve the osseointegration of dental implants. However, a growing number of experimental and clinical studies are now showing that early and immediate loading may lead to predictable osseointegration. A review of the experimental and clinical literature discussing early loading (<3 months of healing) protocols in implant dentistry came to the conclusion that early loading per se is not responsible for the lack of osseointegration; the latter is rather due to the presence of excessive micromotion during the healing phase. The authors showed that implant design, surface state, loading mode, and prosthetic rehabilitation type dictate the bone response to implants loaded before the traditional 3 months of healing.

For fixed rehabilitations, immediate loading with various implant systems has been studied, and high success rates have been reported. Yet, in all these studies, the number of enrolled patients did not exceed 10 individuals per study.
Although clinical results seem to be promising in regard to immediate loading with a fixed cross-arch prosthesis, further long-term follow-ups and larger numbers of patients are required. Moreover, the above-mentioned clinical studies provide mostly short- to mid-term results based only on clinical mobility and radiographic observation. These methods are not suitable to detect the possible presence of a thin fibrous interposition of tissue that can increase over the course of time and lead to clinical mobility.9,19

While several animal experiments dealing with early and immediate loading protocols have been published,5–11 extrapolation from the animal model to the clinical application is not fully reliable because of the distinct loading schemes and exerted stresses. Retrievals of immediately loaded implants displaying clinical stability have been scarce20–24 and have involved a limited number of implants. As surface state7 and loading mode9 play a determinant role in healing under loading, demonstration of osseointegration by means of histologic evidence is warranted for each implant type differing in design and/or surface.

The aim of the present article is to report on two Osseotite implants (3i), retrieved from one patient, that had been immediately loaded after placement and were in function for 4 months in the mandible.

Method and materials

Case report

A healthy 61-year-old nonsmoking man was examined for a failing fixed partial denture (FPD) retained on five teeth and two implants. His teeth were in a state of advanced periodontal disease, one implant displayed noticeable bone loss because of untreated periimplantitis, and the second one was lingually angled. It was decided to extract all of the remaining teeth and remove the preexisting dental implants. As the patient wore an overdenture in the maxilla, he could not cope psychologically with another denture or with any other kind of partially removable appliance and therefore requested an immediate fixed restoration. An immediate loading protocol according to Schnitman et al,12 involving simultaneous placement of submerged and immediately loaded implants in the edentulous mandible, was discussed with the patient. In this protocol, the immediately loaded implants are intended to sustain a provisional FPD, while the submerged implants are left to heal in the traditional way. The rationale is that, should every immediately loaded implant fail during the provisional period, a sufficient number of submerged implants would still support the final fixed rehabilitation.

It was proposed to the patient that he receive two additional immediately loaded implants to retain his provisional FPD, with the aim of obtaining biopsies of the immediately loaded implants. These would be retrieved after 4 months of function, at uncovering the submerged implants. The patient volunteered for the protocol and signed an informed consent form. It was therefore decided to place 12 Osseotite implants, six implants to support the immediately loaded provisional FPD and six submerged implants to retain the final complete-arch rehabilitation of the mandible. The two implants destined to be retrieved were chosen to allow for adequate prosthetic support by the remaining implants.

Oral hygiene instructions were given, and before surgery the patient was scheduled for procedures to control his inflammatory disease. Subgingival scaling and root planing were performed. Augmentin (SmithKline Beecham) and Flagyl (Pharmacia & Upjohn) were administered 7 days before implant placement and were continued for 6 days. Teeth were gently removed and the sockets degranulated. The implants were explanted with a premolar forceps, trephining was avoided to preserve bone quantity, and the implant bed was thoroughly cleaned to remove any remaining soft tissue. Self-tapping Osseotite implants were placed according to the manufacturer’s instructions (Fig 1a). All implants displayed a high degree of primary stability, requiring a ≥ 32 Ncm torque as tested with a torque-control instrument. At a freshly explanted implant site, congruence at the implant neck was not obtained, and the resulting circular
crestal bone defect of about 1 mm
was filled with bone chips collected
with a bone trap during surgery.
Normal bone density was recorded
at all implant sites. The immediately
loaded implants received 4-mm-
high standard abutments. The soft
tissues were sutured over the six
submerged implants and around
the six protruding abutments. Four
hours following implant placement,
a screw-retained, resin metal-
reinforced provisional FPD was
seated on the six abutments (Fig 1b).
No special diet was suggested
for the patient, who was recalled
after 1 week, 3 weeks, and there-
after on a monthly basis. After 4
months of occlusal function, the
provisional FPD was unscrewed, a
gingival flap was opened, and the
previously submerged implants re-
ceived standard abutments. Clin-
ical mobility was assessed, revealing
that all of the immediately loaded
and submerged implants had
achieved clinical osseointegration.
Implants that were immediately
loaded in the positions of the
mandibular left second premolar
and right lateral incisor were re-
trieved with a 5-mm-diameter
trephine (3i). Care was taken to
avoid altering the lingual and
vestibular cortex at the implant sites.
During drilling, the trephine was
tilted away from the cortical tables; this reduced the amount of available bone in some areas of the retrieved biopsies. The flap was sutured, and standard prosthetic procedures were carried out up to final restoration (Figs 1c and 1d). Radiographs were taken after implant placement (Fig 2a), at retrieval, and 24 months later (Figs 2b and 3).

**Histology preparation**

The specimens were first rinsed in a saline solution and immediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in a 0.15-M cacodylate buffer at 4°C and a pH of 7.4. Subsequently, they were ground down with the Precise 1 automated system (Assing)\textsuperscript{25} and dehydrated in an ascending series of alcohol rinses, after which they were embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Heraeus Kulzer). After polymerization, the specimens were sectioned along the long axis with a high-precision diamond disk at about 150 µm and ground to about 30 µm. Great attention was paid to cut the slide sections parallel to the long axis of the implant in an attempt to obtain three slices per specimen. The slices were stained with Paragon (Paragon C & C) and observed in normal transmitted light. Histomorphometry was performed under a Laborlux-S light microscope (Leitz), using an Intel Pentium II 300 MMX computer, a video camera, and KS 100 Software (Zeiss). The acquired images were analyzed using the software system described.

**Results**

All of the immediately loaded implants achieved clinical osseointegration. Subsequently, they were added into the final fixed prosthesis. The patient was followed after implant retrieval, and a radiograph taken 24 months later (Fig 2b) confirmed that the trephined sites had healed without complications.

The implant at the mandibular right lateral incisor was retrieved with vestibular as well as buccal bone, and one histologic section was obtained. Figure 4a gives an overview of the preparation; osseointegration was achieved with close bone apposition as observed under the optical microscope (Fig 4b), and bone-to-implant contact was 80%.
The implant-bone interface consisted of a combination of new and old bone. Bone was in contact with the entire implant surface, including the inner diameter of the screw threads, ie, the bottom part between the threads (Fig 4). Occasionally, bone was not present at the tip of some threads. On the vestibular side, the crest was situated above the first thread level; on the lingual, it was slightly above the second thread (Fig 4a). Epithelium downgrowth was not found at the infracrestal areas contacting the implant surface.

Only the vestibular part of the retrieved left second premolar implant was readable, and three histologic sections were obtained. Figure 5a gives an overview of one of the histologic preparations. Osseointegration was achieved in all slices, and the mean bone-to-implant contact was 81.5% (78% to 85%). Similar to the previous implant, old and new bone was seen at the interface (Fig 5b). The new bone was undergoing remodeling, the implant surface was contacted by bone, and no lacking bone patterns were found at the tip of the threads. Again, epithelium downgrowth was not found at the interface. Figure 5a shows that the implant was placed in bone of normal quality.

Discussion

A 3- to 6-month healing period has long been considered a prerequisite for the achievement of osseointegration. However, the relevance of this concept has been recently questioned in both the animal and the clinical literature. The human histology data of the present study confirm that loading per se does not impede osseointegration. Rather, osseointegration of immediately loaded Osseotite implants has now been documented for the first time. These histologic data also strongly support the assumption that the other immediately loaded implants incorporated in this prosthesis osseointegrated as well.

At present, only a limited number of clinical immediate loading studies have been published, providing short- to mid-term data. They are based on clinical mobility and radiographic analysis and are therefore not able to provide reliable information on the status of the implant-bone interface. Subsequent human histologic investigations are needed to demonstrate the actual implant osseointegration for each variety of immediate loading protocol and implant system. Four reasons might explain why early loading has been discouraged: (1) it may lead to fibrous integration; (2) the necrotic bone at the implant bed border is not capable of load bearing and must first be replaced by new bone; (3) rapid remodeling of the dead bone layer compromises the strength of the osseous tissue supporting the bone-implant interface; and (4) the integrity of the periosteal margin may be threatened by undermining remodeling of adjacent bone during the late healing period. The present implants were loaded 4 hours after placement and were in occlusal function for 4 months in the mandible. At the interface, a

Figs 3a to 3c Periapical radiographs of the final case show no radiolucency around the implants.
**Fig 4a** (left) General overview of section from mandibular right lateral incisor implant shows that the recipient site was of good bone quality. Bone is reaching the internal core of the screw, between the threads. The vestibular side is on the left (Paragon stain; original magnification × 1.5).

**Fig 4b** (right) Direct bone apposition at implant surface shows osseointegration and the presence of old (light stain) and new bone (darker stain). The vestibular side is on the left (Paragon stain; original magnification × 25).

**Fig 5a** (left) Overview of section 1 of mandibular left second premolar implant shows that only the vestibular side, left, is readable. Bone quality at the recipient site was good; during surgery, it was identified as normal bone. On the vestibular side, bone reaches the internal core of the implant screw. The implant is well integrated and presents a high level of osseointegration (Paragon stain; original magnification × 1.5).

**Fig 5b** (right) Direct bone apposition at implant surface (section 2) shows osseointegration and the presence of old and new bone (darker stain). Bone remodeling occurs as well at a distance (Paragon stain; original magnification × 25).
combination of remodeled mature new bone and old bone was found, similar to loaded implants that heal in a traditional way. This proves that the bone-healing sequence was not disturbed by the stresses transmitted under this mechanical environment. Moreover, the histology data demonstrate that both the bone injured during drilling and the remodeled necrotic bone provided sufficient load-bearing capacity. In addition, the data show that the periosteal margins were not threatened by extensive remodeling.

Implant design, surface state, splinting, and the loading mode influence bone-implant interface status, ie, either osseointegration or fibrous encapsulation. The present screw design has been associated with primary stability, which seems to be the paramount requirement to achieve osseointegration, whatever the loading conditions are. The Osseotite dual-etched textured surface represents an improvement over the machined surface. Clinically, this has been assessed by Testori et al; they did not observe any increased failure rate for short Osseotite implants (≤ 10 mm), in contrast to short-machined surface implants. In addition, Lazzara et al demonstrated that the Osseotite surface makes it possible to predictably reduce the healing period to 8 weeks, even for single teeth and short-span FPDs, from the 12 to 24 weeks recommended for machined surfaces. Furthermore, Davies showed in vitro that the Osseotite surface, in contrast to a machined surface, is able to ensure a substantial anchorage to the fibrin fibers of the clot. This suggests a higher clot stability in case of micromotion and subsequently a higher threshold of tolerance to deleterious micromotion. In the present patient, six implants arranged in a wide tripod were splinted 4 hours after implant placement. Implants were sufficient in number because Schnitman et al suggested that three implants arranged in a wide tripod might be enough to sustain a provisional FPD. The prosthesis was conceived to allow full occlusal loading, the most demanding loading mode, under a mechanically disadvantageous crown:implant ratio of 1.1:1.4; splinting was sufficient to decrease the amount of micromotion during mastication below the threshold of deleterious micromotion.

Sagara et al investigated the bone-healing response to three distinct loading modes, the submerged mode, the protruding mode (implant post protruding in the oral cavity, more than 3 mm above the bone level; soft diet; pressure exerted by tongue, cheeks, and lips), and the occlusal mode (crown on post, occlusion, and hard diet), that started 7 days after surgery. Early loading in the occlusal mode led to incomplete bone apposition, ie, bone did not grow down to the implant surface between the threads, but stayed at a distance from the implant surface. These authors attributed this to the effect of early occlusal loading during initial bone healing. In the present histology data, complete bone apposition was found despite loading 4 hours after surgery. The difference may be attributed to the surface features because they play a key role in bone response. Indeed, in the dog study, bone interacted with a smooth machined surface, whereas in the present study the patient’s bone responded to the Osseotite textured surface. The difference might be also due to the strain amplitude at the interface. In the present patient six implants were bilaterally splinted in a wide tripod, whereas in the above experimental study three implants were splinted in a unilateral FPD. It should be stressed that the unilateral FPD design allows for high moment in the vestibulolingual axis, while the bilateral FPD configuration reduces it. Furthermore, occlusion in this patient was obtained in this region via an overdenture with resin contacts, whereas in the dog it was obtained through a fixed metallic bar connected to natural teeth in the maxilla.

An intriguing feature was observed at both retrieved immediately loaded implants. The first implant-to-bone-contact occurred at a lower level with respect to the cortical crest, down to the upper flank of the third thread (Figs 4a and 5a). This region corresponds to the transition zone between the turned and the Osseotite textured surface. It could be that under immediate loading conditions, the bone that is undergoing healing requires the presence of the Osseotite microtextured surface rather than the turned surface to distribute adequately the
stresses at the bone-implant interface. Furthermore, the earliest stages of endosseous wound healing have been proposed to be critically dependent on platelet activation and fibrin retention by the implant surface. These phenomena seem to be favored by a microtextured surface, as described in recent papers by Davies and coworkers, and precede and accelerate osteogenic cell migration toward the implant surface through a fibrin meshwork. Therefore, the osteoconductive nature of a microtextured implant surface like Osseotite may increase the rate at which new bone forms on the implant, thereby reducing the interval necessary between implant placement and functional loading. Therefore, when shortened protocols are indicated, it might be advantageous to have a textured surface up to the implant collar to increase the healing potential of the most coronal part of the immediately loaded implants. Further studies should address this issue.

The development of predictable immediate loading protocols should be regarded as an effort to alleviate the psychologic burden of patients switching from partial to total edentulism or facing sudden tooth loss. In addition, immediate loading simplifies and eases implant therapy, shortens it, and renders it more cost effective. Simplification and reduction of treatment costs are achieved by reducing the numbers of surgeries and the number of sessions required to deliver the final fixed prosthesis.

Osseointegration was consistently achieved for both retrieved immediately loaded Osseotite implants. An immediate loading protocol involving bilateral splinting of six Osseotite implants proved to be safe in this patient after 4 months of loading. Bone remodeling was not impeded by these immediate loading conditions. A high level of bone apposition was measured (78% to 85%), including growth down to the bottom of the threads. The interface was composed of a combination of mature new bone and old bone, as with unloaded implants. Load-bearing capacity was ensured by the dynamic remodeling of the necrotic bone. Further clinical and histologic studies are needed before a protocol of five to six immediately loaded implants can be introduced on a regular basis in implant therapy.

References


