Histologic Evaluation of a Human Immediately Loaded Titanium Implant with a Porous Anodized Surface

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ABSTRACT

Background: Several researchers have demonstrated, in the past decade, in clinical and histologic studies, that immediate loading can be successfully used in implant dentistry. Many factors are thought to be of importance in obtaining mineralized tissues at the interface. One of these factors is the implant surface characteristics. Recently, an implant with a new porous anodized surface has been introduced in the market.

Purpose: The goal of this study was to histologically evaluate a clinically retrieved immediately loaded implant with a porous anodized surface.

Materials and Methods: After a 6-month loading period, an immediately loaded implant with a porous anodized surface that had been inserted in the posterior maxilla was retrieved.

Results: Histology showed that mineralized tissue was present at the interface and the bone–implant contact percentage was about 60%. No gaps or fibrous tissue or inflammatory infiltrate were present at the interface.

Conclusions: Results show that immediate loading of dental implants has no untoward effects on the formation of mineralized tissues at the interface. Immediate loading is a possible alternative in implant dentistry.

KEY WORDS: dental implants, histology, immediate loading, oxide coating, porous surface

An unloaded healing period was thought to be necessary to ensure bone development at the interface of dental implants.[1,2] A functional rest of 3 to 4 months in the mandible and 6 months in the maxilla appeared necessary to obtain mineralized tissues at the implant–bone interface.[1,2] Micromovements of the implants, if the implants were loaded immediately after insertion, were believed to disturb the early phase of bone healing and remodeling, producing a fibrous repair and no osseointegration of the implants.[3–5] In more recent years, several clinical and histologic reports, in man and experimental animals, have shown that implants can be immediately loaded with success.[6–31] Randow and co-workers found that Brånemark implants can be successfully used in the interforaminal mandibular area even when immediately loaded; moreover, they reported that bone resorption is similar to that observed around two-stage implants.[10] No failures were reported by Ericsson and colleagues in early loaded implants, and all implants were working successfully after 5 years.[31] Brånemark and colleagues recently reported on a method for implant therapy of the edentulous mandible in 50 patients followed 6 months to 3 years.[30] There was an overall survival rate of 98% and a prosthetic survival rate of 98%. Jaffin and co-workers reported an overall survival rate of 95%,[27] whereas in the series reported by Ganeles and colleagues, the clinical success rate at the time of final abutment placement was 99.4%.[25] In a series reported by Gatti and co-workers, the success rate was 96%.[29] It has been reported that with immediately loaded implants, patients resumed function quickly, and masticatory function was uniformly judged to be superior to pretreatment time.[25] Another factor that must be borne in

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mind when dealing with the topic of immediately loaded implants is their surface characteristics. Direct extrapolation from animal experiments to a clinical application in humans is not always applicable because different loading patterns exist,[28] and moreover, it cannot be assumed a priori that immediately loaded implants will have identical bone healing and bone–implant interfaces.[32]

The goal of the present study was an evaluation of the peri-implant tissues in man, in an immediately loaded implant with a new surface treatment, inserted in the posterior maxilla and retrieved after a 6-month loading period.

MATERIALS AND METHODS

The patient was a 60-year-old male with a completely edentulous maxilla. The patient was a heavy smoker (about 60 cigarettes/d). Eleven implants (TiUnite™, Nobel Biocare, Gothenburg, Sweden) were inserted. A full-arch immediately placed maxillary provisional prosthesis was placed, and all the implants were loaded on the same day surgery was performed (Figure 1). The postoperative period was uneventful. The most distal implant, located in the left tuberosity, was retrieved with a trephine, for psychological causes, after a 6-month loading period. Before retrieval, the implant appeared to have clinically osseointegrated, mobility was absent, and a periapical radiograph showed that there was minimal bone resorption around the most coronal portion of the implant (Figure 2). The last provisional temporary crown was separated from the provisional bridge and the underlying implant was retrieved (Figure 3). Records showed that the implant was a 3.3 × 10 mm Mk III Brånemark System implant with the TiUnite surface. The last drill used had been 1.8 mm and the insertion torque had been 20 Ncm.

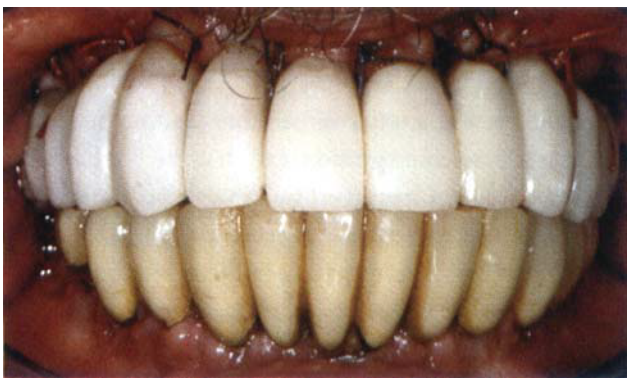

Figure 1. Full-arch immediately placed maxillary provisional prosthesis after the insertion.

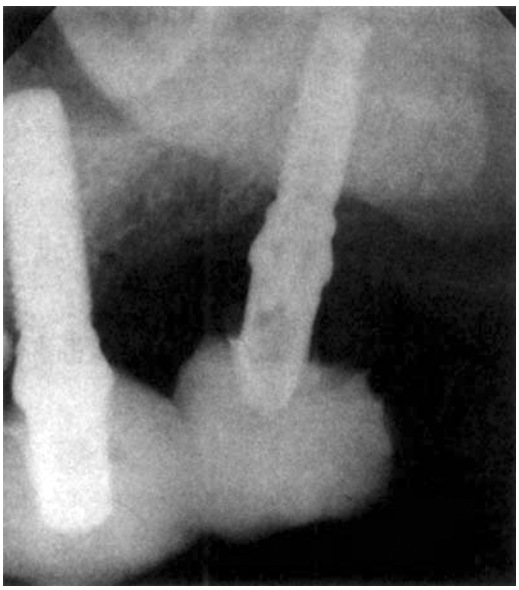

Figure 2. Periapical radiograph after a 6-month loading time: the implant is radiographically surrounded by mineralized tissues, and there is a minimal bone resorption.

Processing of Specimens

The implant and the surrounding tissues were stored immediately in 10% buffered formalin and processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy).[33] The specimen was dehydrated in an ascending series of alcohol rinses and embedded in a glycol methacrylate resin (Technovit® 7200 VLC, Kulzer & Co. GmbH, Wehrheim, Germany). After polymerization, the specimen was sectioned longi-

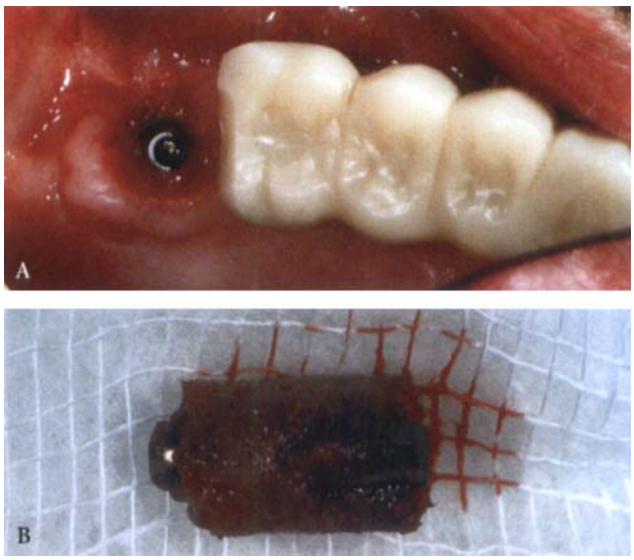

Figure 3. Six months later, *A*, the last provisional bridge element (temporary crown) has been separated from the provisional bridge and the underlying implant has been retrieved; *B*, the retrieved implant.

tudinally along the major axis of the implant with a high-precision diamond disk at about 150 μm and ground down to about 30 μm. Three slides were obtained. The slides were stained with acid fuchsin and toluidine blue. A double staining with von Kossa stain and acid fuchsin was done to evaluate the degree of bone mineralization, and one slide per implant, after polishing, was immersed in $AgNO_3$ for 30 minutes and exposed to sunlight; the slides were then washed under tap water, dried, and immersed in basic fuchsin for 5 minutes and then washed and mounted.

Histomorphometry

Histomorphometry of bone–implant contact percentage was done under a Laborlux-S light microscope (Leitz, Wetzlar, Germany), using an Intel Pentium III 300 MMX, a video-acquired schedules Matrox, a video-camera, and KS 300 Software (Zeiss, Hallbergmoos, Germany). The images acquired were analyzed using the KS 300 software system.

RESULTS

At low-power magnification, in most areas of the bone–implant interface, bone appeared to be separated from the metal surface of the implant by a 2-micron gap (Figure 4). At higher magnification, the bone was trabecular with wide marrow spaces. In the areas where the bone was in close contact with the implant surface, bone tended to grow down to the bottom of the threads. The bone–implant contact percentage was 60% (± 3.8%). Bone remodeling areas were present around the implant. No gaps or fibrous tissue were present at the interface (Figure 5). Inflammatory cells were absent. No foreign body reaction or resorption areas were found at the bone–implant interface. No epithelial downgrowth was present.

Figure 4. Bone is separated from the metal surface of the implant by a 2-micron gap, as a result of preparation artifact. (Acid fuchsin-toluidine blue; original magnification, ×4).

DISCUSSION

Only rarely, human retrieved immediately loaded implants have been reported in the literature.[16,21–24,28] Immediate loading shortens the total rehabilitation time, with increasing patient satisfaction, and it avoids the delays in the final rehabilitation and the difficulty of wearing a conventional denture during the healing phase.[29] Brånemark implants placed in the interforaminal mandibular area, where good implant primary stability can be obtained, have been demonstrated to be successful even when early or immediately loaded.[31] Reports indicate that once immediately loaded implants have clinically osseointegrated, they appear to take on the long-term predictability of conventionally healed and loaded implants.[25] Because the surface characteristics of each implant are important in determining the pattern of healing under loading, the histologic evidence of osseointegration is needed for each implant type with a different surface.[28] This documentation is only feasible by histologic analysis of loaded implants from humans.[23] The surface characteristics of an implant are certainly extremely important for the osseointegration, especially in demanding situations, such as when implants are loaded immediately after insertion. Several surface treatments (particle blasting, plasma-spray coatings, acid etching) have been proposed to improve implant surface characteristics and to increase the quantity and quality of bone at the interface, with increased interlocking. Recently, a new implant surface, TiUnite, has been introduced.[34] The surface topography of this implant is smooth; sharp features are not observed; and open pores are homogeneously distributed over the surface. These implants have removal torque values significantly superior to those of machined surfaces.[35,36] The histologic data from the present study confirm that loading per se did not impede osseointegration and that the bone healing sequence was not disturbed by the stresses transmitted at the interface under these mechanical conditions. The splinting of the implant probably decreased the amount of micromotion during the early healing phase, giving the implant a higher tolerance to deleterious micromotion. Probably, rigid splinting and minimal lateral forces are critical factors for success.[25]

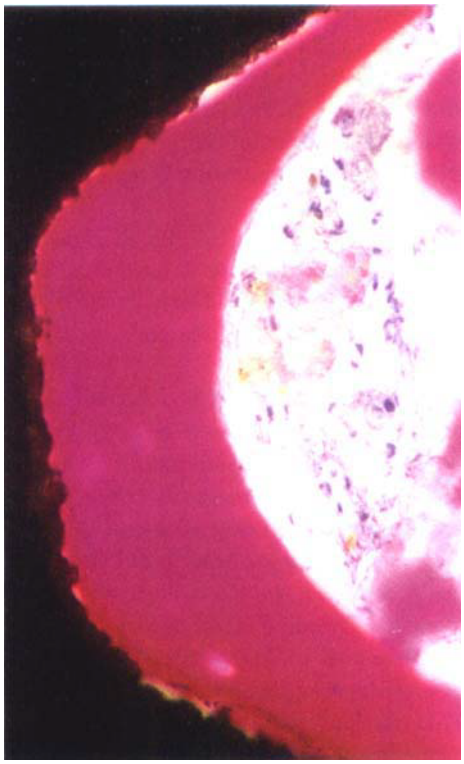

Figure 5. The bone is in close contact with the implant surface, and no fibrous tissue is present. (Acid fuchsin-toluidine blue; original magnification, × 50).

The 2-micron gap noted at the interface around a large part of the implant perimeter between bone and implant is certainly attributable to an artifact produced during the retrieval of the implant, because the shape of the peri-implant bone corresponds exactly to the shape of the implant. In the areas where there was a close bone-to-implant contact it was possible to observe a perfect congruence between the surface and the bone; this shows that direct bone ingrowth occurred after implant placement.[23] Thus, interdigitation occurred and increased the attachment of the growing bone to the metal surface.[23] In the case presented, a bone–implant contact percentage was about 60%. Higher bone–implant contact percentages in man have been reported by other authors: 78 to 85% by Testori and co-workers,[28] and a mean of 76.4% by Ledermann and colleagues.[23] However, these implants had been inserted in the anterior (premolar) area of the mandible, whereas in the present case, the implant was placed in a posterior (third molar) area in a jaw with low bone quantity and quality (D3 type bone, according to Lekholm and Zarb[37]). From a basic science perspective, there is no acceptable definition of osseointegration or of the precise proportion of direct bone-to-implant contact.[38] It is not known with certainty how much bone contact is needed for an implant to be regarded as truly osseointegrated. Albrektsson and colleagues reported, in a histologic investigation of 33 implants, that clinically observed osseointegration of loaded implants corresponded to 60% or more of bone-to-implant contact.[38] Thus, it would appear that the percentage noted in the present study in this low-quality bone area, even if lower than that reported by other investigators, is sufficient from a clinical and histologic perspective. In addition, it must be pointed out that, before retrieval, the implant appeared clinically and radiologically to be osseointegrated, because the implant was not mobile and there were no radiolucencies in the peri-implant bone.

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