Clinical and Histologic Features of a Nonaxial Load on the Osseointegration of a Posterior Mandibular Implant: Report of a Case

Adriano Piattelli, MD, DDS*/Antonio Scarano, DDS**/Michele Paolantonio, MD, DDS***

The authors report on the clinical and histologic features of a single implant replacing a mandibular molar, which fractured after a 1-year loading period. Because of anatomic factors, the implant had been placed in an angulated position. The histologic examination showed a very high percentage of bone-implant contact. The bone located at the interface with the implant was mature, compact, and had few marrow spaces. No resorption areas were present, and no connective tissue was seen at the interface. Most likely, the lateral nonaxial forces exerted on the implant created very high bending moments. These forces produced a fracture of the implant, although no loss of osseointegration was observed at the interface.
(INT J ORAL MAXILLOFAC IMPLANTS 1998;13:273–275)

Key words: axial loading, bending moments, commercially pure titanium, implant failure, implant fracture, overloading

Dental implant failure appears to occur primarily within two time frames:[1–6] a few weeks or months after implant placement (early failures), and after a much longer period (some years) of load (late failures).

In the first instance, the main cause of the failure could be related to local tissue damage involving excessive bone necrosis, inadequate implant immobilization,[4–5] bacterial contamination, and premature loading.[4–6] Late failures appear to be mainly the result of peri-implant infections and/or excessive occlusal stresses.[6,7]

The aim of the present report was to document the clinical and histologic analysis of a single implant replacing a mandibular molar which had fractured after a 1-year loading period.

*Professor of Oral Pathology and Medicine, Dental School, University of Chieti, Chieti, Italy; Honorary Senior Lecturer, Eastman Dental Institute and Hospital for Oral Health Care Sciences, London, United Kingdom.
**Research Fellow, Dental School, University of Chieti, Chieti, Italy.
***Researcher, Dental School, University of Chieti, Chieti, Italy.

Reprint requests: *Prof Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy. E-mail: apiattelli@unich.it*

Case Report

A 20-year-old woman underwent the placement of a 3.3-mm full-screw Bonefit implant (ITI Straumann, Waldenburg, Switzerland) in the left mandibular molar region. The surgeon had placed the implant in an angulated position because of anatomic factors (a very thin ridge was present), and the use of two implants was rejected by the patient for economic reasons. Presence of the thin ridge was also the reason for the use of a 3.3-mm implant. The left first and second molars had been extracted some years previously as the result of caries. Four months after implant placement, a crown with a mesial cantilever was placed on the implant. On the 12-month follow-up radiograph, it was possible to see only slight peri-implant "cup" resorption (Fig 1). No bleeding on probing or implant mobility were present; the peri-implant tissues were healthy and the probing depth was less than 3 mm.

After an additional month, the prosthesis showed abnormal mobility, and a periapical radiograph showed the presence of an implant fracture. The crown was removed with a forceps, and the portion of the implant remaining in bone (Fig 2) with the surrounding tissues was retrieved with a bur under generous saline irrigation, washed in saline solution, and immediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in 0.15 mol/L cacodylate buffer at 4°C and pH 7.4, to be processed for histology. To

COPYRIGHT © 2000 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Fig 1 Periapical radiograph 1 year after loading. A full-screw implant had been placed in an angulated position. Note the "cup" resorption of the coronal peri-implant bone.

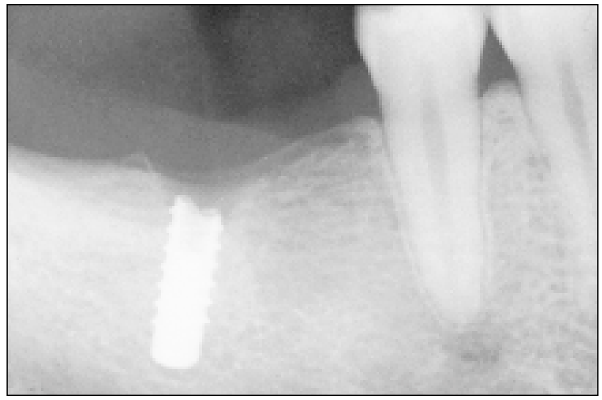

Fig 2 The fractured implant.

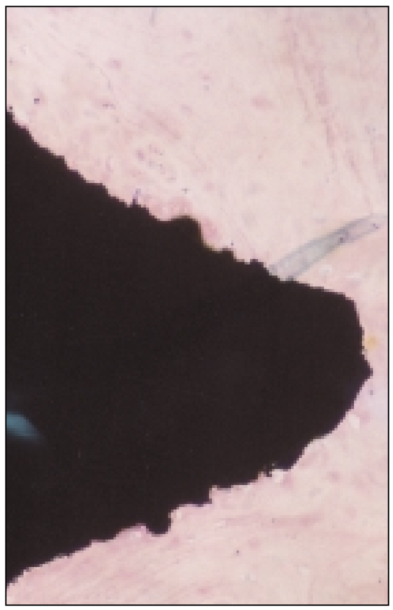

Fig 3 *(Left)* At low magnification, mature, compact bone with few marrow spaces is visible in a peri-implant location (basic fuchsin-toluidine blue, magnification × 13).

Fig 4 *(Right)* At higher magnification, no gaps or connective tissue are visible at the interface. The bone is in tight contact with the metal. Many osteocyte lacunae are located near the implant surface (basic fuchsin-toluidine blue, × 100).

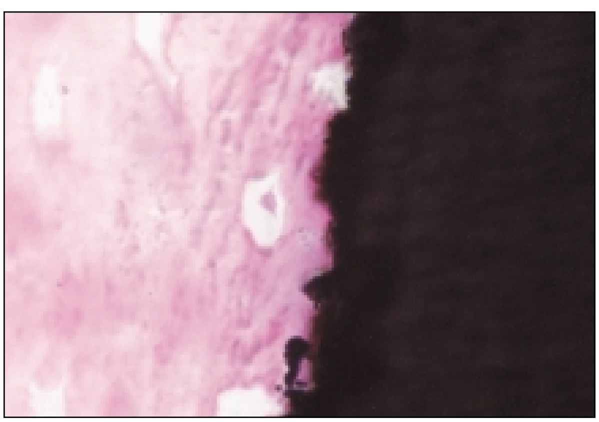

Fig 5 No gaps are visible at the interface. Some osteocyte lacunae are present on the metal surface (basic fuchsin-toluidine blue, × 1200).

obtain thin ground sections, the specimen was processed with the Precise 1 Automated System (Assing, Rome, Italy).[8] The specimen was dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Germany). After polymerization, the specimen was sectioned longitudinally with a high-precision diamond disc at about 150 µm and ground to about 30 µm. A total of four slides were obtained. The slides were stained with basic fuchsin, toluidine blue 0, and von Kossa, and observed under normal and polarized light in a Leitz Laborlux microscope (Leitz, Wetzlar, Germany). The histochemical analysis of acid and alkaline phosphatases was carried out according to a previously described protocol.[9] The morphometry was done with a Microvid System (Leitz) connected to an IBM personal computer.

COPYRIGHT © 2000 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Results

At low magnification, direct bone-implant contact was present around the implant without signs of inflammation or bone resorption (Fig 3). The histomorphometry showed that the percentage of bone-implant contact, evaluated on the three best threads, was 82.4% (± 3.1%). The peri-implant bone, under polarized light, was compact, mature, lamellar, and osteonic. Bone and titanium had a very close and tight contact (Fig 4). No gaps or connective tissue were present at the interface. Newly formed and preexisting bone were differentiated with the basic fuchsin staining, and von Kossa showed that the peri-implant bone was highly mineralized. Some osteocytes were present near the metal surface, and a few of them actually impinged on the plasma-sprayed surface (Fig 5).

Around some portions of the implant perimeter, bone fragments, produced during the implant retrieval, were present. Around the most apical portion of the implant, at higher magnification, it was possible to observe very thin bone lamellae, demonstrating that bone was in tight and close contact with the metal. The major part of the bone in this area had, however, been lost during implant retrieval. No cells positive to acid phosphatase and only a few cells positive to alkaline phosphatase were present.

Discussion

Some investigators have reported several features common to implant fractures:[10] small diameter of the fractured implants; location in the posterior mandible; and failed prostheses usually supported by one or two implants. The features of the patient under consideration correspond to the data reported in the literature concerning implant diameter and location. Rangert et al[10] reported that implants located in posterior regions were at an increased risk of overload, and that in their study, single-tooth fractures occurred in the first molar area of the mandible. In this area, a bending moment relative to the implant is created by lateral forces,[11] and bending has been demonstrated to produce a poorer distribution of the stresses to implant and peri-implant bone than axial load.[7] In fact, the authors noted, nonaxial repeated loading cycles had not produced any influence on the peri-implant bone.

No resorption was radiographically visible, and the histology showed that mature, compact, lamellar bone was present around the entire implant perimeter; no fibrous connective tissue was present. These results are strikingly similar to those of Celletti et al[12] in an experimental animal study, who found direct bone contact with the use of preangled abutments, which are said to induce high bending forces on the implants and surrounding bone. A way of obviating the problems related to the use of a single implant to replace a single molar would be the use of two implants or of a wide implant.[11,13] Moreover, bending overload can be prevented by controlling the forces applied to the implants and by obtaining, in each situation, an axial implant loading.[7]

Acknowledgments

This work was partially supported by the National Research Council (CNR) and by the Ministry of University, Research, Science and Technology (MURST).

References

1. Adell R, Eriksson B, Lekholm U, Brånemark P, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
2. Albrektsson T, Dahl E, Enbom L, Engevall S, Engquist B, Eriksson AR, et al. A Swedish multicenter study of 8139 consecutively inserted Nobelpharma implants. J Periodontol 1988;59:287–296.
3. Lekholm U, Van Steenberghe D, Herrmann I, Bolender C, Folmer T, Gunne J, et al. Osseointegrated implants in the treatment of partially edentulous jaws: A prospective 5-year multicenter study. Int J Oral Maxillofac Implants 1994;9:627–635.
4. Tonetti MS, Schmid J. Pathogenesis of implant failures. Periodontology 2000 1994;4:127–138.
5. Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants:The Toronto study. Part I: Surgical results. J Prosthet Dent 1990;63:451–457.
6. Sanz M, Alandez J, Lazaro P, Calvo JL, Quirynen M, van Steenberghe D. Histopathologic characteristics of peri-implant soft tissues in Brånemark implants with 2 distinct clinical and radiological patterns. A histometric and ultrastructural study. Clin Oral Implants Res 1991;2:128–134.
7. Rangert B, Forsmalm G. Strength characteristics of cp titanium. Nobelpharma News 1993;7:4–5.
8. Piattelli A, Scarano A, Quaranta M. High-precision, semi-automated, cost-effective system for producing thin sections of oral tissues containing dental implants. Biomaterials 1997;18:577–579.
9. Piattelli A, Scarano A, Piattelli M. Detection of alkaline and acid phosphatases around titanium implants: A light microscopial and histochemical study in rabbits. Biomaterials 1995;16:1333–1338.
10. Rangert B, Krogh PHJ, Langer B, Van Roekel N. Bending overload and implant fracture: A retrospective clinical analysis. Int J Oral Maxillofac Implants 1995;10:326–334.
11. Balshi TJ, Hernandez RE, Pryszlak MC, Rangert B. A comparative study of one implant versus two replacing a single molar. Int J Oral Maxillofac Implants 1996;11:372–378.
12. Celletti R, Pameijer CH, Bracchetti G, Donath K, Persichetti G, Visani I. Histologic evaluation of osseointegrated implants restored in nonaxial functional occlusion with preangled abutments. Int J Periodont Rest Dent 1995;15:563–573.
13. Bahat O, Handelsman M. Use of wide implants and double implants in the posterior jaw: A clinical report. Int J Oral Maxillofac Implants 1996;11:379–386.

COPYRIGHT © 2000 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.