Computerized Occlusal Implant Management With the T-Scan II System: A Case Report

Dr. Stevens is a founding member of the Dr. Dick Barnes Group and lectures internationally on the subjects of smile enhancement, principles of occlusion, full-mouth restoration, and diagnosis and treatment of TMD.

Abstract

Many clinicians believe that occlusal forces placed on implants can have a deleterious effect on their long-term success. In addition to microbiological factors, excessive occlusal loading of dental implants has been implicated in the failure of both materials and implant osseointegration.[1,2] However, controversy exists as to the role of occlusion in the loss of bone following placement of an implant prosthesis.[3]

This article will review the literature regarding the relationship between microbiological factors and occlusal stress in regard to crestal peri-implant bone loss and will discuss current concepts in the establishment of occlusion when dental implants are restored. A case report will be presented in which control of occlusal forces reversed crestal bone loss associated with a restored implant.

LITERATURE REVIEW

Kronstrom, et al[4] found that antibody avidity to Bacteroides forsythus and antibody titer to Staphylococcus aureus were the two most important factors associated with early implant failures. Esposito, et al[5] suggested that excessive surgical trauma together with impaired healing ability, premature loading, and infection are likely to be the most common causes of early implant loss, but progressive chronic marginal infection (peri-implantitis) and overload in conjunction with the host characteristics may be the major etiological agents causing late failures. Callan, et al[6] found a direct relationship between subgingival placement of the implant/transmucosal abutment interface and loss of crestal supporting bone. Heydenrijk, et al[7] concluded that accumulating evidence indicates that bacteria cause the disease (peri-implantitis), while the individual's genetic makeup and environmental influences determine the severity of the disease. Others[8-10] have concluded that implant failure is likely multifactorial or often has multiple causative agents.

It is also recognized that excessive loading, or incorrectly vectored forces, as well as the time from implant placement to loading, can place deleterious stresses on an implant or implant restoration, resulting in failure. Misch[11] reported that improper occlusion can increase local forces, which frequently results in complications for the prosthesis, the implant, and the bone supporting the implant (eg, loosening of the implant, reduction in crestal bone height). He stated that creating an occlusal environment with proper force loading on an implant-supported prosthesis in terms of timing and direction results in a desirable physiologic outcome.

Any association between crestal bone loss and excessive occlusal forces does not exclude the importance of other factors such as bacterial infection and microgaps between the implant and the abutment. A number of investigators[4-7] feel that bacterial infection is necessary for implant failure, although occlusion is recognized as a factor. Saadoun, et al[12] described excessive occlusal forces on implants as a co-factor with microbial infection that can lead to bone loss and implant failure.

Clinical studies have indicated that occlusal forces can be transmitted to the bone-implant interface, and the amount of strain at the interface is directly related to the stress applied through the implant prosthesis. Quirynen, et al[13] evaluated 93 patients with various implant-retained restorations. They concluded that the amount of crestal bone loss was directly associated with occlusal loading.

A clinical report by Leung, et al[14] reported bone loss associated with an implant prosthesis in hyperocclusion. When the prosthesis was removed, the bony defect resolved, and when the prosthesis was replaced in proper occlusion, bone height remained stable. This report suggested the association between excessive occlusal forces and bone loss, and that bone loss may be reversible when the occlusion is adjusted.

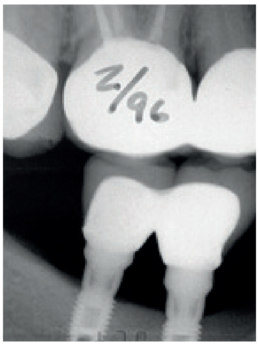

Figure 1. A 1996 bite-wing radiograph of implant prostheses replacing teeth Nos. 29 and 30. The bone level has been stable for 6 years.

Figure 2. A 1998 radiograph demonstrating crestal bone loss about the distal implant to the second thread.

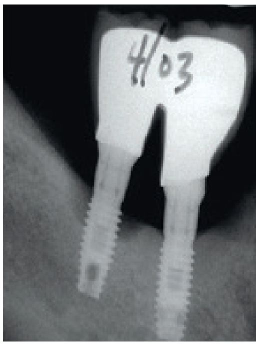

Figure 3. A 2003 radiograph demonstrating crestal bone loss about the distal implant to the fourth thread.

Figure 4. The T-Scan II system with the mylar sensor to record both force and time of contact.

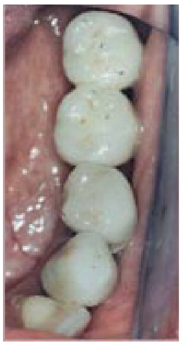

Figure 5. Articulation marks are observed, but the clinician cannot determine either the force of contact or the time the contacts were generated.

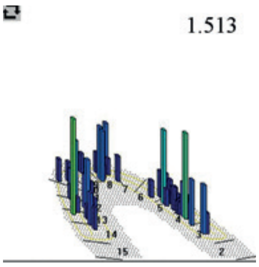

Figure 6. Playback of the force loading indicates simultaneous loading of the implant prosthesis and natural teeth. The software displays the force patterns on the maxillary arch.

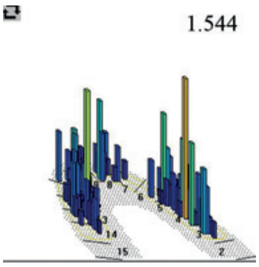

Figure 7. Just 0.031 seconds later the implant prosthesis is subjected to most of the force.

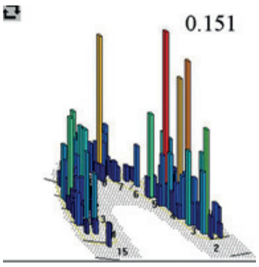

Figure 8. Playback after occlusal adjustment demonstrates the natural teeth are loaded first.

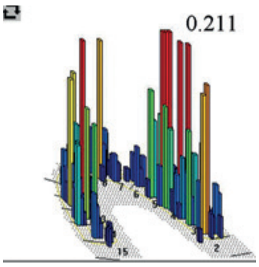

Figure 9. The implant system is loaded 0.060 seconds later.

Figure 10. A 2005 radiograph. Note the regeneration of the crestal bone to a level above the second thread.

OCCLUSAL MANAGEMENT

Traditionally, clinicians have used both articulating paper and patient feedback to adjust the occlusion. These methods, although widely used, have limitations. The marks that articulating paper make on the teeth are not indicative of either the force of contact or the length of time the teeth are in contact. The marks indicate the location of contact, provided that proper transfer of the ink occurs. Larger marks have often been incorrectly interpreted as due to heavy force. But it is important to emphasize that considering the size of the contact, a large mark may in fact represent dispersion of the force as compared to a smaller contact area.

Patient feedback is also a subjective and sometimes an unreliable means of determining occlusal balance. Because implants do not have a periodontal ligament and therefore do not have proprioceptors and mechanoreceptors, perception of occlusal force and contact timing is diminished. A study by Hammerle, et al[15] in 1995 indicated that a patient's perception of occlusal contacts on an implant-supported prosthesis is 8 times less reliable than on natural teeth.

A further complication to proper occlusal adjustment on implant prostheses occurs when there is a mixed implant/natural tooth occlusal scheme. Because of the lack of a periodontal ligament, an implant has little or no depressibility in the alveolar bone, whereas a healthy tooth experiences far more vertical depression than an implant. Parfitt[16] performed a study of healthy, nonmobile teeth. He found nonmobile posterior teeth depress approximately 28 µm in a vertical direction and can move 56 to 75 µm laterally. In contrast, Sekinie[17] found that well-integrated endosteal implants had a 5-µm vertical depression and could move 12 to 66 µm laterally. Since the implant-retained prosthesis moves less than natural teeth, simultaneous occlusal loading of natural teeth and an implant prosthesis within the same quadrant may result in the implant prosthesis bearing more of the occlusal load than the more depressible natural teeth. Moreover, based on the data of Hammerle, et al[15] the patient may not be able to recognize the increased force placed on the implant prosthesis. Excessive occlusal loading of an implant prosthesis that goes unrecognized by both patient and dentist can impact the long-term success of the prosthesis, including the degree of osseointegration and the stability of crestal bone height.

To eliminate excessive occlusal force loading on an implant prosthesis, Kerstein[18,19] and Kirveskari[20] have proposed a quantifiable time (and force) delay so that the natural teeth occlude in advance of the implant prosthesis. The natural teeth would then undergo depression into the periodontal ligament, at which time occlusal loading on the prosthesis would occur. The natural teeth and the implant prosthesis would then absorb the occlusal loading. However, this time delay must be short enough so that the implant prosthesis actually occludes.

Achieving a quantifiable time delay requires a measurement device such as the T-Scan II Computerized Occlusal Analysis System (Tekscan). As described in the literature,[21-26] the T-Scan II sensor is nominally 85 μm thick and contains approximately 2,500 sensing cells (sensels) of special ink that varies in conductivity with pressure. The T-Scan II program scans the sensels and digitizes their outputs at a rate of approximately 100 frames/second. This allows measurement of not only the relative force at each contact point within the arch, but also the onset and duration of each contact with a 10-millisecond resolution. Consequently, recordings made with this computerized occlusal analysis system provide the restorative dentist with a precise means of determining relative force, onset, and duration of each contact on an implant prosthesis and on all the surrounding natural teeth. The data is stored on a computer hard drive for subsequent analysis as a sequence of images, referred to as a movie.

CASE REPORT

In 1990 a healthy, 45-year-old female patient was treated with 2 implant fixtures to restore an edentulous segment from teeth Nos. 29 to 30. Tooth No. 31 was also missing, but this tooth was not replaced. From the date of the final restoration, the patient was seen regularly for a 3-month prophylaxis recare program.

At regular intervals, radiographs were obtained to monitor horizontal bone stability. Figure 1 shows the implant fixtures in February 1996, 6 years after placement. Note the stability of the horizontal bone height.

In May 1998 a radiograph demonstrated the exposure of at least 2 threads on the distal implant (Figure 2). No further bone loss was noted until a radiograph obtained in April 2003 demonstrated significant change. At that time 4 threads on the distal implant were exposed (Figure 3).

Because of the patient's full compliance with the 3-month recare program, her excellent oral hygiene, and the height of bone at the time of implant placement, the loss of horizontal bone level was thought to be related to the occlusion. Since neither patient perception nor articulation paper was considered as a reliable indicator of the occlusal load or the time the tooth and implants were in contact, the T-Scan II computerized occlusal management system was utilized (Figure 4).

The patient was first asked to close on the occlusal sensor to record the data. Then the patient was asked to close on articulating paper so that comparison of the recorded data could be made to the articulation marks (Figure 5). Contact marking was evident on the prosthesis, but much of the contact marking was smudged and unclear. Further, the clinician has no means of determining the duration of contact. This can be determined by the T-Scan II system.

With the T-Scan II recording, relative force at any point in time is displayed in columns. Figure 6 demonstrates that at 1.513 seconds after the total force exceeded a threshold of 5% of maximum, there was force on both the implant prosthesis and the natural teeth anterior to the prosthesis. However, just 0.031 seconds later (3 frames later in the movie), the implant is subjected to most of the occlusal force (Figure 7).

Occlusal adjustments were made on the implant prosthesis to delay its contact, and new T-Scan II recordings were made to quantify the effect of those adjustments. In the final recording, the teeth anterior to the prosthesis are loaded at 0.151 seconds (Figure 8). Then 0.060 seconds later (6 frames) the implant prosthesis is loaded (Figure 9). The final amount of relative force on the implant was reduced in the process.

The patient continued to be seen for regular prophylaxis visits. A new radiograph was obtained in May 2005 (Figure 10). The film suggests regeneration of the crestal bone to a level above the second thread.

DISCUSSION

There are many possible causes of crestal bone loss around implants. Chapman[27] suggests that the development of an appropriate occlusion plays a vital role in the success of both the implant and the prosthesis attached to it. According to Misch, et al,[28] methods to decrease stress on an implant prosthesis are appropriate and warranted, and the restorative dentist is the one most able to address this condition.

Occlusal management with the T-Scan II system is a potentially important aid in force and contact time management of occlusal stress on implant prostheses. Use of traditional clinical methods of checking the occlusion are qualitative. Excessive force due to incomplete equilibration may compromise an implant; lack of occlusion, perhaps due to excessive equilibration, may result in the implant prosthesis being no more than a nonfunctioning space maintainer. When occlusal forces are well managed, the implant prosthesis can become a long-term functioning component in the patient's occlusal scheme.

Conclusion Development of an appropriate occlusion following implant placement and restoration, with elimination of excessive forces on the implant, is one of the important factors in the long-term success of implant-borne prostheses. In order to develop an appropriate occlusion, occlusal contacts should be measured in terms of both force of contact and duration of contact time during which the force is exerted. Articulating paper does not provide any indication of contact force or time of contact. A device such as the T-Scan II system, which measures force and time, is a valuable tool for establishing the appropriate occlusion.

References

1. Kohavi D. Complications in the tissue integrated prostheses components: clinical and mechanical evaluation. *J Oral Rehabil.* 1993;20:413-422.
2. Isidor F. Histological evaluation of peri-implant bone at implants subjected to occlusal overload or plaque accumulation. *Clin Oral Implants Res.* 1997;8:1-9.
3. Oh TJ, Yoon J, Misch CE, et al. The causes of early implant bone loss: myth or science? *J Periodontol.* 2002;73:322-333.
4. Kronstrom M, Svenson B, Hellman M, et al. Early implant failures in patients treated with Branemark System titanium dental implants: a retrospective study. *Int J Oral Maxillofac Implants.* 2001;16:201-207.
5. Esposito M, Hirsch JM, Lekholm U, et al. Biological factors contributing to failures of osseointegrated oral implants. (II). Etiopathogenesis. *Eur J Oral Sci.* 1998;106:721-764.
6. Callan DP, O'Mahony A, Cobb CM. Loss of crestal bone around dental implants: a retrospective study. *Implant Dent.* 1998;7:258-266.
7. Heydenrijk K, Meijer HJ, van der Reijden WA, et al. Microbiota around root-form endosseous implants: a review of the literature. *Int J Oral Maxillofac Implants.* 2002;17:829-838.
8. Rosenberg ES, Torosian JP, Slots J. Microbial differences in 2 clinically distinct types of failures of osseointegrated implants. *Clin Oral Implants Res.* 1991;2:135-144.
9. van Steenberghe D, Naert I, Jacobs R, et al. Influence of inflammatory reactions vs. occlusal loading on peri-implant marginal bone level. *Adv Dent Res.* 1999;13:130-135.
10. Jansson H, Hamberg K, De Bruyn H, et al. Clinical consequences of IL-1 genotype on early implant failures in patients under periodontal maintenance. *Clin Implant Dent Relat Res.* 2005;7:51-59.
11. Misch CE. *Contemporary Implant Dentistry.* St Louis, Mo: Mosby; 1993.
12. Saadoun A, Le Gall M, Kricheck M. Microbial infections and occlusal overload: causes of failure in osseointegrated implants. *Pract Periodontics Aesthet Dent.* 1993;5:11-20.
13. Quirynen M, Naert I, van Steenberghe D. Fixture design and overload influence marginal bone loss and fixture success in the Branemark system. *Clin Oral Implants Res.* 1992;3:104-111.
14. Leung KC, Chow TW, Wat PY, et al. Peri-implant bone loss: management of a patient. *Int J Oral Maxillofac Implants.* 2001;16:273-277.
15. Hammerle CH, Wagner D, Bragger U, et al. Threshold of tactile sensitivity perceived with dental endosseous implants and natural teeth. *Clin Oral Implants Res.* 1995;6:83-90.
16. Parfitt GS. Measurement of the physiologic mobility of individual teeth in an axial direction. *J Dent Res.* 1960;39:68.
17. Sekine H, Komiyama Y, Hotta H, et al. Mobility characteristics and tactile sensitivity of osseointegrated fixture-supporting systems. In: van Steenberghe D, ed: *Tissue Integration in Oral Maxillofacial Reconstruction.* Amsterdam: Excerpta Medica; 1986:306-332.

18. Kerstein RB. Nonsimultaneous tooth contact in combined implant and natural tooth occlusal schemes. *Pract Proced Aesthet Dent.* 2001;13:751-755.

19. Kerstein RB. Computerized occlusal management of a fixed/detachable implant prosthesis. *Pract Periodontics Aesthet Dent.* 1999;11:1093-1102.

20. Kirveskari P. Assessment of occlusal stability by measuring contact time and centric slide. *J Oral Rehabil.* 1999;26:763-766.

21. Lyons MF, Sharkey SW, Lamey PJ. An evaluation of the T-Scan computerised occlusal analysis system. *Int J Prosthodont.* 1992;5:166-172.

22. Mizui M, Nabeshima F, Tosa J, et al. Quantitative analysis of occlusal balance in intercuspal position using the T-Scan system. *Int J Prosthodont.* 1994;7:62-71.

23. Dario LJ. How occlusal forces change in implant patients: a clinical research report. *J Am Dent Assoc.* 1995;126:1130-1133.

24. Gonzalez Sequeros O, Garrido Garcia VC, Garcia Cartagena A. Study of occlusal contact variability within individuals in a position of maximum intercuspation using the T-SCAN system. *J Oral Rehabil.* 1997;24:287-290.

25. Garcia Cartagena A, Gonzalez Sequeros O, Garrido Garcia VC. Analysis of two methods for occlusal contact registration with the T-Scan system. *J Oral Rehabil.* 1997;24:426-432.

26. Garrido Garcia VC, Garcia Cartagena A, Gonzalez Sequeros O. Evaluation of occlusal contacts in maximum intercuspation using the T-Scan system. *J Oral Rehabil.* 1997;24:899-903.

27. Chapman RJ. Principles of occlusion for implant prostheses: guidelines for position, timing, and force of occlusal contacts. *Quintessence Int.* 1989;20:473-480.

28. Misch CE, Suzuki JB, Misch-Dietsh FM, et al. A positive correlation between occlusal trauma and peri-implant bone loss: literature support. *Implant Dent.* 2005;14:108-116.