A Literature Review

Short Dental Implants

A Literature Review and Rationale for Use

When treatment planning for dental implants, the height of available bone is often used to determine the implant length, if adequate width and mesio-distal space are present. The height of available bone is measured from the crest of the edentulous ridge to the opposing landmark. The posterior regions of the jaws usually have the least height of existing bone, since the maxillary sinus expands after tooth loss and the mandibular canal is 10 mm or more above the inferior border of the mandibular body. A radiographic study of 431 partially edentulous patients revealed that the posterior placement of implants at least 6 mm in length was possible in only 38% of maxillae and 50% of mandibles. The posterior regions of the mouth have a higher bite force than the anterior regions (Figure 1). As a consequence, in the posterior regions of the mouth with the highest bite forces, the existing available bone for implants is often less compared to anterior edentulous sites.

RATIONALE FOR SHORT IMPLANT LENGTH

Stresses distributed to the apical third of an implant are of much less magnitude than those in the crestal third. Most endosteal dental implants are fabricated from alloyed or pure titanium with a modulus of elasticity (stiffness) approximately 5 times greater than dense cortical bone. A basic mechanical principle states that when 2 materials of different moduli are placed together with no intervening material and one is loaded, a stress concentration can be observed where the 2 materials first come into contact. These stress contours form a v-shaped or u-shaped pattern, with greater magnitude near the point of first contact, which corresponds to the crest of the bone. For an implant in bone of adequate density with a direct bone contact, the greatest magnitude of stress is concentrated in the crestal 5 mm of the bone-implant interface. The phenomenon of higher crestal stresses next to an implant is confirmed in photoelastic and 2-D or 3-D finite element analysis (FEA) studies when an implant is placed within a bone simulant and loaded (Figure 2). Therefore, although implant length does affect the overall surface area of an implant support system and is therefore theoretically desirable, stresses around implants during function and parafunction are typically concentrated at the crest of the ridge, unlike what occurs for a natural tooth and its periodontal membrane.

There are many advantages to using short dental implants to support an implant prosthesis. Bone grafting to compensate for the expansion of the sinus and/or loss of available bone height at the crest is unnecessary prior to implant placement. This saves the patient time and money and eliminates the pain related to the procedures. Shorter implants are easier to insert. Osteotomy preparation is simplified. The potential for overheating the bone is less, since the bone preparation is in a short site and the irrigation has direct access. Angulation to the load may be improved, since the basal bone beyond the original alveolar ridge for longer implants is not always in the long axis of the missing tooth (Table 1).

A question that is very relevant to implant treatment planning is this: at what length does an implant begin to have an increase in complications? The purpose of this article is to review the literature related to implant length and implant survival. In addition, the biomechanical issues related to implants of 10 mm or less will be addressed, including guidelines to reduce risks of failure.

LITERATURE REVIEW

A Medline search of 13 studies related to implant failure and implant length was published by Goodacre, et al in 2003,10-22 In these reports, 2,754 implants were 10 mm or less in length, and 3,015 implants were greater than 10 mm in length.
found an 8-mm-long, 5-mm-diameter implant failed 35% of the time in the maxilla and 33% of the time in the mandible. On the other hand, the 10-mm and 12-mm implants that were 5 mm in diameter reported no mandibular failure and a 10% failure in the maxilla.

Winkler, et al\textsuperscript{22} published a multicenter report in 2000. These data were collected from more than 30 hospitals and 2 university sites during a 3-year period and represented 6 different implant body types. The 7-mm-long implants had a 25.6% failure rate, while 16-mm implants demonstrated only a 2.8% rate of failure. Implants of 8 mm had a 13% failure rate, while 10-mm implants failed at a rate of 10.9% and 13-mm implants failed at a rate of 5.7% within the 3-year period reported. Therefore, failure rate was directly related to implant length: it increased 2 to 5 times with shorter implants.

A multicenter study of 6 different centers was reported by Weng, et al\textsuperscript{23} in 2002 and found 60% of all failed implants were 10 mm or less in length. The overall failure rate of all implants in the study was 9%. The 7-mm implant failed 36% of the time, the 8-mm implant had a 19% failure, while the 10-mm implant had a 9% failure. Therefore, the 10-mm implant survival was more similar to the longer length implants, while implants shorter than 10 mm demonstrated significantly greater risks of failure.\textsuperscript{12} Naert, et al\textsuperscript{27} also reported on clinical outcomes of dental implants in 2002. They found a cumulative survival rate of 19.4%. Implants shorter than 10 mm had a survival rate average of 81.5%. Therefore, these additional reports agree with the Goodacre, et al\textsuperscript{12} summary of articles that indicates failure rates are higher in implants of shorter length. However, many of these clinical findings are more alarming, since implants shorter than 10 mm had a risk of failure of 16% to 33% versus a failure rate of 4% to 9% for longer implants.

It should be noted that the failure rates in these reports are not surgical failures or failures to osseointegrate. The failures reported occurred after prosthesis delivery and prosthetic loading. In other words, the surgical success did not vary relative to implant length, but once the prosthesis was loaded, an increase in failure was observed, especially within the first 2 years.

On the other hand, a retrospective report by Misch, et al\textsuperscript{28} was compiled from 2 private offices using a square thread implant body design (BioHorizons) rather than a v-shaped thread as primarily reported in the previous literature. During a 3-year period, 126 patients received implants less than 10 mm long. The total number of implants in this report was 437 (408 implants, 9 mm long and 29 implants, 7 mm long), which supported 141 restorations. The majority of these restorations were in the posterior mandible or maxilla. The restorations in this report were loaded for at least 18 months. Of the 437 implants, there were 3 implant failures in the posterior mandible and 1 failure in the posterior maxilla (99% survival). All these failures were implants 9 mm long and 4 mm in diameter. No implants failed during the prosthetic fabrication. Hence, the overall implant survival from stage 1 surgery to prosthesis delivery was 99.0%. The implants and restorations were followed at least 18 months and as long as 3 years. No implants were lost during this time frame, and no restorations were refabricated (Figures 3 and 4).

This report used several guidelines for treatment in the use of short implants: a change in implant design, splinting implants together, no cantilevers in the prosthesis, and additional methods to decrease stress to the implant interface. Hence, from this clinical report, these modifications of treatment may decrease the risk of failure with shorter implant lengths (Table 2).

**DISCUSSION**

The loading failure of short implants may be due to a number of factors, including an increase in forces from an increased crown height. As the crestal height of the ridge is resorbed, the available bone height is reduced and the crown height is increased. When an osteoplasty is used to increase the width of crestal bone for implant insertion, the available bone height is reduced and the crown height is increased. As a result, the failure rate of implants 10 mm or less was 10%, compared to a 3% failure rate of implants longer than 10 mm.

In addition to the Goodacre, et al\textsuperscript{12} review, several other papers have reported clinical results with screw-type dental implants of reduced length. Minsk, et al\textsuperscript{29} reported the results of a training center in 1996, with 80 different operators using 6 different systems over a 6-year period. Implants 7 mm to 9 mm in length reported a 16% failure rate. The overall survival rate of all lengths was 91.3%. Hence, similar to the Goodacre, et al\textsuperscript{12} review, shorter implants had at least a 7% higher failure rate when they were less than 10 mm long. Ivanoff, et al\textsuperscript{24} in 1999
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Table 1. Advantages of Short Implants.

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<th>Author</th>
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Table 2. Short Implant Failure Rates.

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Table 3. Advantages of Short Implants.

| Bone Density | The density of the bone is directly related to the strength of the bone. Softer bone types are 50% to 80% weaker than denser bone qualities. On average, implants loaded in soft bone have a 16% higher failure rate. Several reports in the posterior maxilla report 25% failure when short implants are used to support the prosthesis. The posterior regions of the jaws often have less dense bone than the anterior regions. Hence, biomechanical methods to decrease the stresses to short implants are further warranted. Methods to decrease stress include decreasing force to the implant prostheses or increasing implant surface area of prosthetic support. These modifications of treatment include the following: 30

| Decreasing Force: | (1) Decrease lateral forces to the posterior implant prostheses (incisal guidance). (2) Eliminate cantilevers in the restoration. (3) Increase the number of implants. (4) Increase the surface area design of implants: *thread number. *thread depth. *thread shape. |

| Implant Number | Most forces applied to the osteointegrated implant body are concentrated in the crestal 5 to 7 mm in good bone, regardless of implant design. Therefore, implant body length is not the most effective method to counter the effect of crown height. In the posterior regions. The aesthetics of the implants can be improved by individual crowns, especially in the posterior regions. The hygiene of the implants can be easier in terms of flossing with individual crowns, but only 10% to 20% of patients floss. The other 80% to 90% of the patients would receive no hygiene benefit. Yet all of these patients have an increased stress risk factor and may lose their implants as a result. Rarely is implant loss due to a lack of using dental floss in comparison to overload of the restoration. |

| Implant Size | Methods to increase the functional surface area, specifically in the crestal 5 to 7 mm, is warranted, especially in the posterior regions that have greater forces applied to the prosthesis. The logical method to increase functional surface area by implant design is by increasing the diameter of the implant. For every 1-mm increase in diameter, implants may increase the functional surface area by 50% to 200%, depending on their design (ie, cylinder versus square thread shaped implants). This is most important in the molar region, where the surface area of the natural tooth increases 200% (Figure 11). When larger diameter implants cannot be used, 2 implants for each molar are suggested. However, the report by Ivanoff, et al may indicate that implant diameter is not the only factor to increase success of a short implant, since a failure rate of 25% to 33% still was observed in the posterior regions with short implants. |

Implant Design

1. Thread Pitch. Functional surface area is that portion of an implant interface that is able to transmit compressive or tensile loads to the bone. It may be modified by varying 3 thread geometry parameters: thread pitch, thread shape, and thread depth.

2. Thread Depth. The thread depth refers to the distance between the major and minor diameter of the thread. The greater the thread depth, the greater the surface area. Not all implants have the same depth of thread. One implant design may have a thread depth of 0.25 mm, whereas other have a thread depth of 0.419 mm. The latter thread depth results in greater functional surface area.

3. Thread Shape. The thread shape is another characteristic of overall thread geometry. Three thread shapes are generally presented in dental implant designs include square, v-shape, and a reverse buttress (Figure 12). In conventional engineering applications, the v-thread design is called a "fixture" and is often used for the fixation of metal parts. This thread shape is the most commonly used for fixing the abutment screws to the implant body and is the most common thread shape. The reverse buttress thread shape is similar, but flat on the top, which is optimized for pullout loads. This thread design origin...
These complications may heighten the anterior region of the mouth. The thread provides more surface area for intrusive, compressive forces to the posterior teeth in mandibular excursions and eliminating can­tilevers on the prosthesis. The area of forces applied to the prosthesis may be increased by increasing the implant number, increasing the implant diameter, increasing the implant design surface area, and splitting the implants together. As a result of these biomechanical methods to decrease stress, Misch, et al reported a 96% implant survival with 7-mm and 9-mm implants in the posterior regions of the jaws.

It is interesting to note that the natural teeth follow a similar biomechanical approach to accommodate the higher bite forces in the posterior regions of the force of the molar teeth do not become longer than the anterior teeth. The diameter is increased, the design of the roots is different, and the roots are splinted together. The anterior teeth have incisal guidance and eliminate posterior lateral forces to the posterior teeth in all mandibular excursions. A similar biomechanical approach is logical for posterior implants, especially when shorter implants are used to support the prosthesis.

References
24. Dr. Misch is a clinical professor and director of oral implantology at Temple University School of Dentistry in the department of prosthodontics; director of the Misch International Implant Institute and is co-chair of the board of directors of the American Congress of Oral Implantologists. He is author of the books Contemporary Implant Dentistry (C.V. Mosby) and Dental Implant Prosthodontics (Elsevier-Mosby). He can be reached at info@mischeck.com or by visiting http://www.misch.com.
25. To comment on this article, visit the discussion board at dentistrytoday.com.

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