Prosthodontics

Newsletter

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A Courtesy of:

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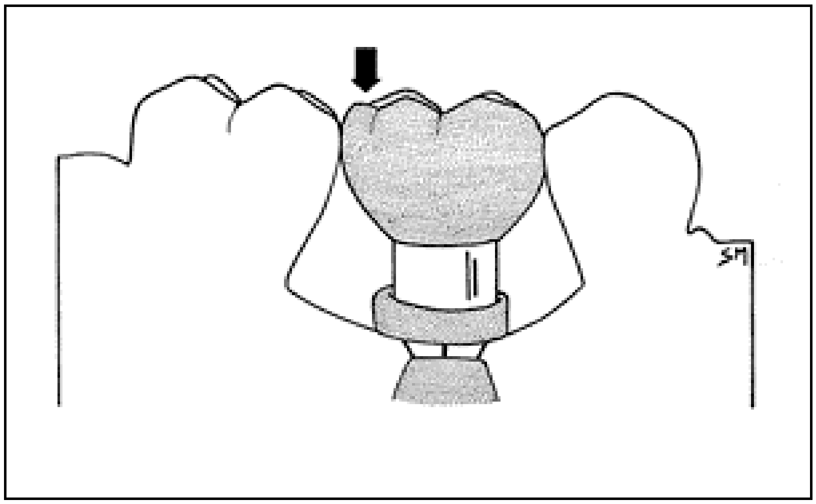

Strain gauges are commonly used to evaluate the effect of occlusal loading (arrow) of an artificial crown on the supporting implant. (See *Abutment Strain with Single Implant-Supported Crowns*, inside.)

Biomechanics of Occlusion and Implant Prosthodontics

A number of recent studies have attempted to measure and analyze the effects of occlusal loading on implant-supported restorations. The forces of occlusion, if not well controlled, can produce mechanical problems, such as screw loosening, screw fracture and implant fracture. Biologic complications may also occur with occlusal overload. This issue of *Prosthodontics Newsletter* reviews several reports on occlusal biomechanics for implant prosthodontics.

Occlusal Forces and Maxillary Implant-Supported, Complete-Arch Prostheses

There are a number of in vitro and in vivo studies on the effects of occlusal forces on implants. In vivo studies are more difficult to conduct and standardize, but results are more clinically relevant.

Success rates for complete-arch, implant-supported maxillary prostheses may be less favorable than those observed for mandibular implant-supported prostheses. In addition, maxillary removable overdentures have been reported to experience a relatively high failure rate. Forces directed to implants as a result of occlusal function are not well understood and are difficult to measure.

A study by Mericske-Stern et al from the University of Berne, Switzerland, measured occlusal forces on implants for maxillary complete-arch, implant-supported prostheses of 2 different designs. The 2 prostheses, made for the same patient, were interchangeable and supported by 5 uniformly distributed ITI implants (Strauman AG, Waldenburg, Switzerland).

One restoration was a metal-reinforced, bar-retained, U-shaped overdenture with acrylic resin artificial teeth. The other was a cast-gold, screw-retained, complete-arch fixed prosthesis. Piezo-electric force transducers were fitted to the implants (Figure 1).

Forces were measured in 3 dimensions for (1) clenching, (2) occluding on a bite plate positioned on the posterior teeth and (3) chewing on apples and bread. When the bar-retained overdenture was tested initially, a 1-piece bar that was rigidly attached to all 5 implants was used for support. The bar was then sectioned to form 2 separate bars and the experiment was repeated.

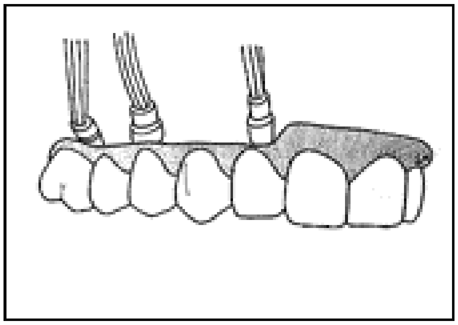

Figure 1. *Piezo-electric force transducers were fitted to implants supporting maxillary overdenture.*

Results indicated similar force patterns for the fixed and removable prostheses and for the 1-piece and 2-piece supporting-bar designs. Forces were significantly higher on posterior implants compared with anterior implants.

Comment

The implants for this patient were uniformly distributed and optimally placed for a fixed implant-supported prosthesis. This favorable positioning resulted in an overdenture with an occlusal table that was entirely supported by implants. Neither the bar nor the occlusal table for the overdenture produced a cantilevering effect, and forces were comparable to those generated with the fixed prosthesis.

It can be concluded that favorable force distribution is likely for a fixed or a removable implant-supported prosthesis when support is obtained from an optimal number and distribution of implants. However, these results are not applicable to all clinical situations.

Commonly, the bar-retained overdenture is a design of "last resort" when the positioning, distribution or number of implants does not permit optimal support for a fixed prosthesis. Resultant forces under less advantageous conditions, which were not evaluated in this study, may be quite different. Distal cantilevers that are common with less favorable implant support may generate bending forces on posterior implants and lifting (tensile) forces on anterior implants.

Mericske-Stern R, Venetz E, Fahrländer F, Bürgin W. In vivo force measurements on maxillary implants supporting a fixed prosthesis or an overdenture: a pilot study. J Prosthet Dent *2000;84:535-547.*

Abutment Strain with Single Implant-Supported Crowns

Multiple, splinted root-form implants have been used successfully to support complete-arch mandibular prostheses. Favorable results experienced with initial applications of implant-supported prosthodontics have encouraged new and innovative approaches.

These root-form implants have now been used to support single molar replacements. Nevertheless, this implant design was not intended originally to support freestanding single molars. Several alternative approaches have been suggested for single-molar implant support, including the use of a wide-diameter implant or the placement of 2 regular-diameter implants (Figure 2).

An in vitro experiment by Seong et al from the University of Minnesota used strain gauges to evaluate effects of occlusal loading of single molar crowns with 3 types of implant support. Three acrylic resin experimental models were made, each with an implant-supported mandibular first molar crown. One crown was supported by a regular-diameter (3.75 mm) implant, the second crown was supported by a wide-diameter (5 mm) implant and the third crown was supported by 2 regular-diameter implants.

The crowns were statically loaded with 35 and 70 N, and forces were measured with a strain gauge (see cover illustration). Forces were also varied by location on the occlusal surface and by angulation. The single 3.75 mm diameter implant experienced the largest strains compared with the other 2 designs. A 15°, off-axis loading induced much larger strains compared with axial loading, and altering the location of occlusal contact also had a significant effect on recorded strains.

Comment

Many factors can influence the success rate of implant-supported, single molar crowns. Locating the occlusal contacts over the center of the implant can avoid bending moments, and the use of wider-diameter implants can also improve the biomechanics.

The use of 2 implants to support a single mandibular molar crown is a logical approach—producing 2-rooted support similar to that of a natural molar. However, it is often difficult to find sufficient space to place 2 implants, and the roots of the adjacent teeth can be damaged during implant placement. Development of adequate embrasure form is also difficult when 2 implants are used to support a single molar.

The tactile sensation from the adjacent teeth is also an important consideration. A single implant-supported molar crown located between 2 natural teeth can depend on the sensation from the periodontal ligaments of the adjacent natural teeth for sensory input during mastication. Multiple implant-supported crowns in series, without contiguous natural teeth, do not benefit from this effect, and splinting of the crowns appears rational under these conditions.

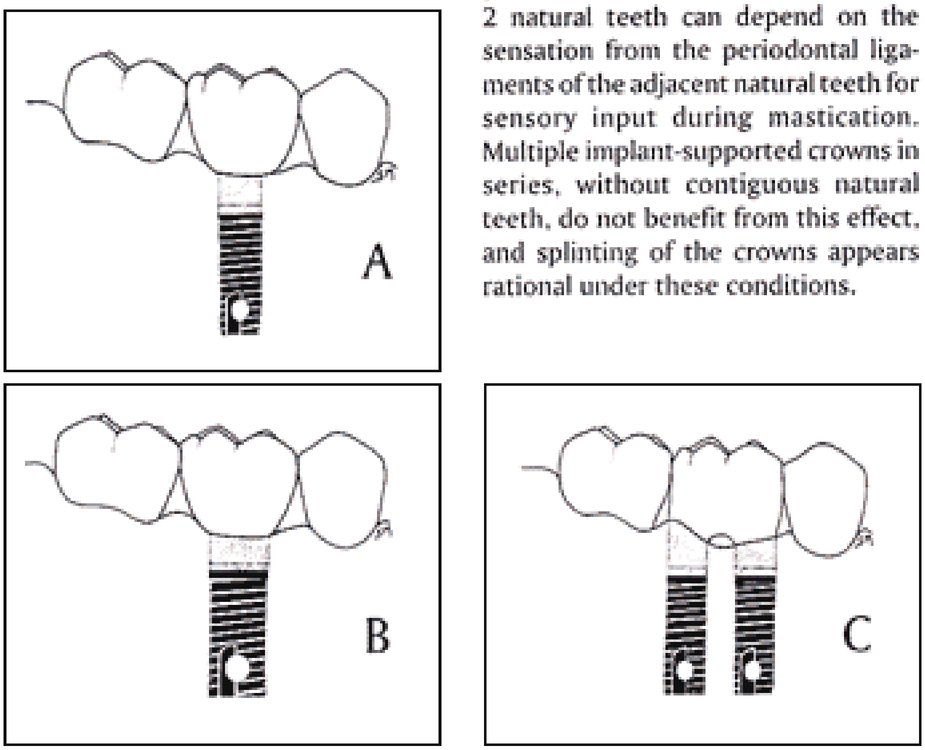

Figure 2. *Methods of support can be conventional-diameter implant (A), wide-diameter implant (B) or 2 conventional-diameter implants (C).*

Seong W-J, Korioth TWP, Hodges JS. Experimentally induced abutment strains in three types of single-molar implant restorations. J Prosthet Dent *2000;84:318-326.*

Angulation of Osseointegrated Dental Implants

Implants can tolerate axial loading much better than off-axis loading. Consequently, the overall angulation of the implant in relation to the occlusal plane will play an important role in occlusal force distribution. Presurgical planning with the use of surgical guide templates has been recommended to improve the accuracy of implant placement consistent with optimal force distribution.

Nevertheless, the ability of templates to enhance implant positioning was conjecture. A recent clinical evaluation by Naitoh et al from Aichi-Gakuin University, Japan, studied the effects of using a surgical guide template on the final outcome of implant placement.

Twenty-one implants were placed with the use of a surgical template and were evaluated in 6 patients. Most implants were inserted in the molar regions where surgical access is more restricted.

Results indicated that the mean difference between the actual location and the proposed location of the entry points for the implants was 0.3 mm, and the mean difference between actual angulation and proposed angulation was 5°.

Comment

In this study, mean differences in angulation were very slight, and the greatest differences in angulation were noted in the third molar regions.

Next:

- Clinical performance of porcelain laminate veneers
- Glass ceramic inlays
- Color stability of compomers

Our next report features a discussion of these claims and the studies that support them, as well as other articles exploring topics of vital interest to you as a practitioner.

This observation was most likely the result of problems with orienting the dental handpiece during the surgery because of restricted interarch clearance and unrelated to problems with the template. Forces are highest in the third molar area, so accurate angulation in that region is more critical.

Results of this study suggest that carefully planned and fabricated surgical guide templates can ensure precise implant placement, especially in areas mesial to the third molar region. Optimal angulation of implants will facilitate the prosthetic phase of treatment and allow effective control of the biomechanics.

Naitoh M, Ariji E, Okumura S, et al. Can implants be correctly angulated based on surgical templates used for osseointegrated dental implants? Clin Oral Impl Res *2000;11:409-414.*

Effects of Occlusal Overload On Osseointegration

Many dentists have assumed that trauma from occlusion can cause bone resorption around implants. To test this hypothesis, Miyata et al from Meikai University, Japan, placed implant-supported restorations with various amounts of excessive occlusal height in 4 monkeys.

Each monkey received 2 adjacent implants that were restored with crowns. One monkey served as control and received crowns in functional occlusion. The other 3 monkeys each received a restoration that was supraoccluded by 100 μm, 180 μm or 250 μm. The peri-implant tissues were maintained with plaque-control measures to control inflammation.

After 4 weeks, the animals were examined clinically and radiographically and then sacrificed for histologic evaluation. Results indicated substantial bone loss for the restorations that were supraoccluded by 180 μm and 250 μm. Bone loss was approximately half the length of the implant for the restoration with 180 μm supraocclusion and bone resorption extended to the apex of the implant for the monkey restored with 250 μm supraocclusion.

Comment

This study found dramatic bone loss after only 4 weeks for supraoccluded restorations, despite an inflammation-free environment. The crowns restored with only 100 μm occlusal excess did not produce resorption during the 4 weeks. However, long-term effects of this very slight supraocclusal relationship are unknown.

A previous report by the same authors indicated that experimental inflammation combined with 100 μm supraocclusion could also produce bone resorption in monkeys. These animal studies indicate the importance of ensuring a precise, accurate occlusal relationship combined with control of local inflammation for implant prosthodontics.

Miyata T, Kobayashi Y, Araki H, et al. The influence of controlled occlusal overload on peri-implant tissue, part 3: a histologic study in monkeys. Int J Oral Maxillofac Implants *2000;15:425-431.*

Do you or your staff have any questions or comments about Prosthodontics Newsletter? Please write or call our office. We would be happy to hear from you.