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Prosthodontics Newsletter™

Focusing on Dental Implants

Treatment of the Severely Atrophic Edentulous Mandible

The severely atrophic edentulous mandible presents significant rehabilitative challenges. Typically, the condition is preceded by the patient's maladaptation to a conventional complete denture, generally related to poor prosthesis retention and stability caused by a compromised denture foundation. Unfortunately, the same compromised soft and hard tissue foundation complicates dental implant therapy as well. This issue of Prosthodontics Newsletter *looks at modern considerations for implant rehabilitation of the severely atrophic edentulous mandible, helping the practitioner to remain current in recent trends for treatment planning and patient management.*

Stress Levels with Tilted Implants

Restoring the edentulous mandible in patients with excessive posterior alveolar bone loss or with a mandibular canal in a superior position while avoiding extensive surgical procedures can pose a challenge. Clinical studies of tilted distal implants and/or frameworks with posterior cantilevers have shown some short-term success. But little analysis exists concerning the stresses from these implant configurations and frameworks on the bone and implants.

Yu et al from Shandong University, China, applied finite element analysis to fill this gap. Their study used 3-dimensional models of an edentulous mandible with 2 different implant configurations:

- 2 mesial axial implants (canine regions) and 2 distal 30°-angled tilted implants (first molar regions) without posterior framework cantilevers
- 4 axial parallel implants (canine and second premolar regions) with posterior framework cantilevers

Both configurations were paired with complete-arch fixed mandibular prostheses made from different framework materials: pure titanium, cobalt–chromium alloy, type IV gold alloy, zirconia, polyetheretherketone (PEEK), and carbon fiber-reinforced polyetheretherketone (CFR-PEEK). Each combination received a load of 300 N applied at a 75° angle to the occlusal plate from the lingual side of the premolar and first molar buccal cusps.

For all design combinations, stresses were concentrated primarily on the cortical bone rather than the cancellous bone. The configuration with 2 tilted implants showed lower stress values on the bone than did the con-

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figuration with all straight implants. Rigid framework materials reduced cortical bone stress more than polymeric materials; CFR-PEEK reduced cortical bone stress more than PEEK. The tilted implant configuration showed reduced implant stress values around the distal implants compared with the straight implant configuration, although stress values increased in the anterior region of the framework. Rigid framework materials increased stress values for the implants and surrounding bone.

Comment

Substituting 2 tilted implants for 2 straight implants created a more favorable stress distribution around posterior implants. Employing a zirconia or cobalt–chromium alloy complete-arch fixed mandibular prosthesis rather than one made of polymeric materials created a more favorable stress distribution in implants and supported bone.

Yu W, Li X, Ma X, Xu X. Biomechanical analysis of inclined and cantilever design with different implant framework materials in mandibular complete-arch implant restorations. J Prosthet Dent *2022;127:783.e1-e10.*

Implant Lengths In Atrophic Mandibles

Treatment failure may occur from stresses on an implant, which lacks the periodontal ligaments that protect natural teeth against excessive loads. Longer implants reduce the stresses on the trabecular bone and can be beneficial for osseointegration; they provide the most predictable outcomes. But not all edentulous patients have sufficient bone height to accommodate long implants, and for these patients, short implants may be the best solution. Benevides et al from the Federal University of Pernambuco, Brazil, used 3-dimensional finite element analysis to assess the effect of different implant lengths on mandibular fixed, full-arch, implant-supported prostheses.

Table 1. Stress values (MPa) for molar and incisal loading.

Implant length	Bone	Implant	Abutment	Metallic framework	Prosthetic screw
Molar loading					
4 mm	60.25	120.40	114.54	355.19	61.66
6 mm	56.72	111.09	252.98	184.08	149.49
8 mm	45.00	90.16	228.05	173.17	132.14
10 mm	43.18	82.52	217.90	171.25	118.24
Incisal loading					
4 mm	32.31	41.73	54.92	199.87	45.57
6 mm	27.72	46.99	145.39	67.74	80.54
8 mm	23.29	46.80	137.27	64.13	81.23
10 mm	21.52	39.20	131.71	62.08	82.50

The researchers created 4 finite element models that mimicked a metal framework with distal cantilever extensions for restoring an atrophic mandible; each model was created to fit implants of 4.1-mm diameter and lengths of 4 mm, 6 mm, 8 mm and 10 mm.

A static occlusal force of 100 N was applied on the left molar region of each model to simulate mastication at the moment of clenching. Stress values for molar and incisor loading were recorded at the bone, implant, abutment, metallic framework and prosthetic screw.

Higher bone stress rates occurred in the molar peri-implant region. The model with 10-mm implants had the lowest bone stress values; stress values increased as implants shortened. Similar outcomes occurred for the implant and metallic framework, with the latter showing a particularly large gap between the 4-mm and 6-mm implant models. Conversely, the model with 4-mm implants recorded lower stresses at the abutment and prosthetic screw level. Stress values for incisor loading followed a similar pattern, but were much lower than for molar loading (Table 1).

Comment

As the implant length increased, superior biomechanical performance was observed, although little difference was seen among the 6-mm, 8-mm and 10-mm implants. No models reached a large enough compressing stress level on the bone to indicate possible bone resorption or component failure. The use of 4-mm implants for fixed full-arch implant-supported prostheses may be a viable alternative for patients with severely atrophic mandibles.

Benevides F, Cimões R, Vajgel A, et al. Stress evaluation of different implant lengths on atrophic edentulous mandibles with fixed full-arch implant-supported prosthesis: a finite element analysis. Comput Methods Biomech Biomed Engin *2021;24:358-374.*

Patient Satisfaction by Restoration Type

Studies have reported the superiority of implant-supported or implant-retained prostheses to conventional complete dentures for the rehabilitation of edentulous arches. Overdentures are more cost-effective than fixed restorations; however, fixed restorations permit greater occlusal loading force and a reduced need for prosthetic maintenance. While extensive literature exists assessing clinical parameters of these restoration options, comparatively little evidence has been published concerning patient satisfaction. Borges et al from the University of Campinas, Brazil, conducted a systematic review and meta-analysis to compare patient-reported outcome measures and clinical outcomes for implant-supported overdentures and fixed prostheses in the edentulous mandible.

A literature search identified 10 human studies comparing implant-supported overdentures and fixed prostheses in patients with an edentulous mandible for oral health-related quality of life (OHRQoL), patient satisfaction, implant survival rate, probing depth and marginal bone loss; 5 of the studies were randomized clinical trials, while the remaining 5 were nonrandomized clinical trials. Follow-up periods ranged from 4 months to 10 years.

OHRQoL was evaluated using the Oral Health Impact Profile (OHIP)-49 questionnaire and its shorter version, the OHIP-14. Patients reported significantly greater OHRQoL with fixed prostheses for the domains of functional limitation, physical disability and physical pain; there were no significant differences between overdentures and fixed prostheses for handicap, psychological disability and social disability. Overall scores showed significantly lower OHRQoL for overdentures than for fixed prostheses. Using a visual analog scale to measure satisfaction, patients receiving fixed prostheses reported greater satisfaction for comfort, ease of mastication, retention and stability, while patients receiving overdentures reported greater satisfaction for ease of cleaning; scores for ease of speaking and esthetics were similar for both groups.

Comment

Patients showed a preference for restoration with fixed prostheses, while clinical findings revealed no differences between overdentures and fixed prostheses. However, the certainty of evidence for all OHRQoL assessments ranged from very low to moderate, while the certainty of evidence for satisfaction assessments ranged from very low to low, which limits the level of confidence in the findings.

Borges GA, Barbin T, Dini C, et al. Patient-reported outcome measures and clinical assessment of implant-supported overdentures and fixed prostheses in mandibular edentulous patients: a systematic review and meta-analysis. J Prosthet Dent *2022;127:565-577.*

Bicortical vs Monocortical Implants

One option to rehabilitate the atrophic mandible involves anchoring implants in the anterior region of the basal cortical bone, where the bone is thickest. This method, called bicorticalization, promotes greater implant stability in mandibles with poor-quality bone while avoiding the need for grafting. Yet, bicortical implants have been associated with higher rates of implant fractures than those in monocortical implants; moreover, little evidence exists on the impact of these implants on bone biomechanics. To fill this knowledge gap, Garutti et al from the Federal University of Mato Grosso, Brazil, conducted a finite element analysis to determine the biomechanics of severely atrophied edentulous mandibles with full prostheses supported by monocortical or bicortical implants.

Two models of an atrophic mandible, with a height of ≤10 mm between the base of the mandible and the apex of the alveolar process, received four 4.1-mm diameter implants placed between the mental foramina:

➤ **monocortical model:** 8-mm long implants were placed so that only the cervical portion of the implant was in contact with the cortical bone

➤ **bicortical model:** 10-mm long implants were placed so that the cervical and apical portions of the implant were in contact with the cortical bone

A load of 150 N on each posterior tooth and 600 N on the complete model was applied, and the maximum stress at each component was compared with the component's yield strength.

The highest compressive stresses in the monocortical model occurred in the cervical region of the distal implants. The highest compressive stresses in the bicortical model, which occurred in the inferior cortical region of the distal implants, measured nearly twice the rate of the highest stresses in the

Table 2. Minimum values of principal stress on cortical and medullary bone in the severely atrophic edentulous mandible.

	Principal compression (MPa)	
	Cortical bone	Medullary bone
Monocortical implants	–32.56	–3.70
Bicortical implants	–63.79	–1.91

monocortical model (Table 2). While tensile stress occurred in the superior and basal cortical bone of the mandible with the bicortical model, it occurred only in the superior cortical bone with the monocortical model, and then at a lower intensity.

Comment

Biomechanical behavior of monocortical implants showed superior distribution of axial loading forces on bone structure in fully osseointegrated implants. Although excessive stress concentrated in the cortical bone promotes bone resorption near the implant platform, neither model demonstrated stress levels likely to promote loss of bone.

Garutti FCMB, Lehmann RB, Gialain IO, de Lima FFB. Analysis of the atrophic mandible rehabilitated with fixed total prosthesis on mono or bicortical implants. Braz Dent J *2024;35:e24-5621.*

Short, Tilted and Vertical Implants

To compensate for a lack of bone in the posterior atrophic mandible, several solutions to this problem, including the use of tilted implants and distal cantilevers, have been suggested. Yet these have potential drawbacks, such as the extreme lateral direction of occlusal forces on tilted implants and an increase in higher stresses around implants and peri-implant bone created by the distal cantilever. Doğanay and Kılıç from Bezmialem Vakıf University, Türkiye, conducted a finite element analysis of several models to determine the transmission of stresses on implants and surrounding bone.

The researchers created 4 three-dimensional models of the atrophic mandible. Each was restored with the same framework and superstructure mounted on 4.1-mm diameter implants in the following configurations:

- **model 1:** 2 straight 10-mm long implants placed in the lateral incisor regions and 2 tilted 10-mm long implants angled at 30° inserted into the second premolar regions; this model also had 11-mm long cantilevers
- **model 2:** same as model 1 with the addition of 2 short (4-mm long) implants in the first molar regions, eliminating the cantilevers
- **model 3:** same as model 2, except all implants were straight
- **model 4:** same as model 3, except all 6 implants were 10-mm long; this model served as the control

For each model, a static 45° oblique load of 200 N in the buccal–lingual direction was exerted on the buccal cusp of the most distal part of the prosthesis.

The most intense stresses were recorded for the tilted implants in model 1. Stress values for the tilted implants decreased with the addition of the short implants in model 2. The lowest stress levels (outside the control) were recorded for model 3. Vertical and short implants demonstrated lower compressive stress values than did the tilted implants.

Comment

While finite element analyses provide valuable information about the biomechanical properties of dental implants and restorations as well as the surrounding bone, they can only approximate material behavior in a virtual environment. Nevertheless, the study results suggest that posteriorly placed short implants may reduce stress in restorations of the atrophic mandible.

Doğanay Ö, Kılıç E. Comparative finite element analysis of short implants with different treatment approaches in the atrophic mandible. Int J Oral Maxillofac Implants *2020;35:e69-e76.*

In the Next Issue

What's new with implant-assisted removable partial overdentures

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

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.