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Considerations for the Severely Atrophic Edentulous Maxilla

Successful restoration for severely atrophic maxillary edentulous patients is one of the most complex rehabilitations in dentistry. Obstacles often include the lack of residual bone volume, the need for advanced surgical maneuvers to improve bone volume, and the high cost of therapeutic solutions. Dentists need to know about the existence of these complex treatments to inform their patients about treatment options. This issue of Prosthodontics Newsletter focuses on critical considerations involved in implant rehabilitation of the severely atrophic maxilla, from surgical interventions to restorative considerations to patient satisfaction with outcomes.

Stresses Using Tilted and Short Implants

Small quantity and low quality of bone along with anatomic constraints may restrict the number, length, width and position of implants in the atrophic maxilla. While bone grafting and sinus elevation can improve implant placement location, increased risk of morbidity, high cost and lengthy treatment time may discourage their use. Two alternatives are the use of tilted or short implants. However, it remains unclear whether employing short implants in the posterior region or tilted implants in the anterior region results in a superior outcome.

Almeida et al from the Federal University of Rio Grande do Norte, Brazil,

used a 3-dimensional finite element analysis (3D-FEA) to compare the biomechanical behavior of 3 different implant arrangements to support a fixed prosthesis in an atrophic maxilla:

- 4 anterior vertical implants (M4S)
- 2 anterior mesial vertical and 2 anterior distal tilted implants (M4T)
- 4 anterior vertical implants and 2 short vertical posterior implants (M6S)

All 3 models were splinted with a rigid titanium bar. Axial and oblique (in the buccal-lingual direction) loads of 150 N were applied to the area corresponding to the first

molar region; principal and von Mises stresses were computed.

The M4T model recorded the highest maximum principal stress in the bone under both loading conditions, followed by the M6S and M4S models; the lowest minimum principal stress was recorded for the M6S model, fol-

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Stresses Using Tilted and Short Implants

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lowed by the M4S and M4T models. For von Mises stress in the implants, the maximum value was recorded in the M4T model, followed by the M6S and M4S models. In general, implants closer to the loading area showed higher stress values.

Comment

The presence of distal tilted implants increased the level of stress in the maxillary bone in comparison to all vertical implants. The presence of an additional 2 distal short implants did not reduce the overall stresses compared to the use of 4 anterior vertical implants; however, the configuration of 6 implants did show reduced stresses at the majority of the implants compared to the 4-implant configuration.

Almeida EO, Rocha EP, Freitas Júnior AC, et al. Tilted and short implants supporting fixed prosthesis [sic] in an atrophic maxilla: a 3D-FEA biomechanical evaluation. Clin Implant Dent Relat Res 2015;17 Suppl 1: e332-e342.

Zygomatic Implants at 5 Years

Zygomatic implants were originally proposed for patients with extensive maxillary defects resulting from tumor resections, trauma and congenital defects. Today, rehabilitation with zygomatic implants is indicated for patients who cannot undergo bone reconstruction surgery; only 1 surgical procedure is needed, and the implants can be immediately loaded.

Table 1. Postoperative Lund–Mackay scores (LMS).

	Patients
2 totally radiopaque maxillary sinuses (LMS 2 + 2)	2
1 totally radiopaque sinus and 1 radiolucent sinus (LMS 2 + 0)	4
1 totally radiopaque sinus and 1 partially radiopaque sinus (LMS 2 + 1)	3
2 partially radiopaque sinuses (LMS 1 + 1)	3
1 partially radiopaque sinus and 1 radiolucent sinus (LMS 1 + 0)	9
2 radiolucent sinuses (LMS 0 + 0)	20

D'Agostino et al from the University of Verona, Italy, undertook a longitudinal retrospective study to evaluate the survival rate of zygomatic implants, along with the relationship between implant position and radiological and clinical signs of sinonasal disease.

The 42 patients included in the study received zygomatic implants using 2 different protocols:

- placement of 4 zygomatic implants
- placement of 2 zygomatic implants and ≥2 conventional premaxillary implants

Some patients received immediate loading, but most underwent deferred prosthetic loading after 4 to 6 months. On average, implant survival was determined 5 years after prosthetic loading; failure was defined as the need for implant removal.

Patients were evaluated for signs or symptoms of sinusitis, with the level of severity based on the Lund–Mackay score from 0 (complete radiolucency of a maxillary sinus) to 2 (complete opacity of a maxillary sinuses). The authors classified implants as clinical successes if they remained intact in situ without pain, rotation, bleeding/pus or soft tissue inflammation. Implants in which inflammation did not resolve through oral hygiene and application of a local disinfectant were classified as unsuccessful.

Over the course of the study, 3 zygomatic implants failed, resulting in a cumulative implant survival rate of 97.4%. One patient reported a fracture of the cheekbone, while 9 patients reported sinonasal complications. Only 2 patients presented with bilateral radiopacity of both maxillary sinuses at the postoperative radiological evaluation; an additional 7 showed a radiopacity on 1 maxillary sinus. The majority showed bilateral radiolucent maxillary (Lund–Mackay score = 0; Table 1). In addition to the failed implants, 6 implants required systemic antibiotic administration; thus, 107 out of the 116 zygomatic implants met the success criteria.

Comment

Placement of zygomatic implants is a predictable procedure associated with less morbidity, shorter treatment time and less discomfort for patients with extreme maxillary atrophy. While the complication rate was not negligible, it must be recognized that zygomatic implant treatment is an alternative to complex upper-jaw reconstruction and should not be compared to conventional implant treatment.

D'Agostino A, Lombardo G, Favero V, et al. Complications related to zygomatic implants placement: a retrospective evaluation with 5 years follow-up. J Craniomaxillofac Surg 2021;49:620-627.

Implant-Supported Maxillary Overdentures

The current gold standard to treat the edentulous maxilla is an overdenture supported by 4 implants. However, providing overdentures supported by 4 maxillary implants can be a costly and invasive procedure if the patient requires reconstructive surgery to place the implants. One possible solution is to use fewer implants.

Onclin et al from University Medical Center Groningen, the Netherlands, designed a randomized controlled trial to compare marginal bone level changes, implant and overdenture survival, masticatory performance and patient-related outcomes at 1 year between patients receiving overdentures supported by 2 or 4 implants. They enrolled 40 nonsmoking edentulous patients who were having functional problems with their maxillary conventional denture. All patients had been edentulous for ≥1 year and had sufficient bone volume for the placement of 4 maxillary implants. Two groups were randomly created: Patients in the control group received 4 implants, and patients in the experimental group received 2 implants.

All patients received bar-attached overdentures.

Two patients in each group did not complete the trial. The primary outcome measure was changes from baseline in the marginal bone levels at 1 year after overdenture placement, as measured by intraoral radiographs. Median marginal bone level change was -0.16 mm in the 4-implant group and -0.03 mm in the 2-implant group; the difference was not statistically significant.

One patient in the 4-implant group lost all 4 implants; 4 patients in the 2-implant group lost a total of 6 implants, a significant difference in the survival rate (Table 2). As a result, 1 overdenture in the 4-implant group and 4 overdentures in the 2-implant group were lost because the remaining number of implants was insufficient to support the overdenture. Median probing depth at 1 year was 0 in both groups; median plaque, calculus, gingiva and bleeding scores were also 0 in both groups. Both groups showed significant improvement from baseline in masticatory performance and in patient-related outcomes as measured by 3 different standardized questionnaires.

Comment

Patients obtained similar results from maxillary 2- and 4-implant retained

overdentures over the course of this study. However, the 4-implant overdentures performed better in terms of implant and overdenture survival. The 4-implant retained overdenture remains the gold standard for restoring the edentulous maxilla.

Onclin P, Speksnijder CM, Vissink A, et al. Two or four implants for maxillary overdentures in edentulous patients: 1-year results of a randomized controlled trial. Clin Implant Dent Relat Res 2023;25:1138-1148.

Alveolar Atrophy And Implant Survival

Immediately loaded implant-supported fixed complete dentures have been a popular treatment modality for edentulous patients, with predictable success rates. The impact of bone atrophy on success, however, has not been established. A clinical decision support system has been published (Caramês, *Rev Port Estomatol Med Dent Cir Maxilofac* 2019;60:175-188) that proposed a classification system for full-arch rehabilitation options based on levels of jaw atrophy. To determine a possible association between the cumulative implant survival rate and jaw atrophy using the proposed classification system as a guide, Caramês et al from the University of Lisbon, Portugal, conducted a retrospective study of 882 patients (1200 jaws) who received implant-supported fixed complete dentures over a 16-year period.

Patients included in the study received immediately restored implant-supported fixed complete dentures in the maxilla, mandible or both. Ancillary procedures were performed following

Table 2. Implant and overdenture survival at 1 year.

	2-implant group	4-implant group
Implants	36	72
Implants lost	6	4
Implant survival (%)	83.3	94.4 ^a
Overdentures	18	18
Overdentures lost	3	1
Overdenture survival (%)	77.8	94.4

^aSignificantly different from the 2-implant group.



the parameters of the clinical decision support system. After the first 12 weeks following surgery, patients underwent comprehensive medical reevaluation every 4 months; prostheses were removed annually for inspection. On average, patients were followed for 3.8 years.

Of the 6047 implants placed, 111 failed during the study period; 2- and 5-year cumulative survival rates were 98.2% and 97.9%, respectively. Patient age was a factor for those patients with level 5 atrophy, who were significantly older than patients in the other groups. A greater percentage of implants was lost in the maxilla than in the mandible, with the percentage increasing in both jaws as the amount of bone resorption increased. The amount of alveolar atrophy was a significant factor for denture survival only in the maxilla; the risk ratio for implant loss was 0.59× lower for mandibular implants than for maxillary implants. A regression model identified the risk factors for implant loss as age, level of alveolar atrophy, cigarette smoking, and the number and length of implants.

Comment

This study found that implant survival in the maxilla decreases as the level of alveolar atrophy increases. Conversely, the level of alveolar atrophy did not affect mandibular implant survival. Using the clinical decision support system assisted the clinician in achieving acceptable implant survival rates for all levels of alveolar atrophy.

Caramês JMM, Marques DNdS, Caramês GB, et al. Implant survival in immediately loaded full-arch rehabilitations following an anatomical classification system—a retrospective study in 1200 edentulous jaws. J Clin Med 2021;10:doi:10.3390/jcm10215167.

Evidence for Zygomatic Implants

The atrophic maxilla constitutes a major challenge for implant rehabilitation. While several techniques are available, no method is without disadvantages. The extensive bone grafting required for maxillary reconstruction requires a lengthy period of time and is accompanied by greater morbidity rates.

One rehabilitation alternative is the zygomatic implant, in which the implant is anchored in the zygomatic bone, thereby obviating the need for grafting and sinus lift procedures. Zygomatic implants, usually placed bilaterally, allow for immediate prosthetic loading and feature a reported survival rate of >96%. However, the procedure requires a skilled, experienced surgeon to avoid the risks of maxillary sinusitis, oroantral fistula, infraorbital paresthesia, peri-implant disease and orbital perforation.

Evidence for the procedure's success comes primarily from systematic reviews. Sales et al from the Federal University of Pernambuco, Brazil, undertook a study to determine the quality of the systematic reviews.

An extensive search of multiple online databases and a supplementary hand search of referenced publications yielded 7 systematic reviews that assessed the effectiveness of zygomatic implants in nonsmoking human patients without extensive dental caries, active periodontal disease, endodontic infections, diabetes or other systemic diseases. The reviews were evaluated for methodological quality using a 16-question quality assessment.

One systematic review was assessed to be of low methodological quality; the remaining 6 reviews received a rating of critically low methodological quality. Overall reported survival rates were quite high, yet the review could not determine a success rate, due to the failure to evaluate peri-implant bone loss or bleeding index, which could adversely affect long-term outcomes. The majority of the studies did not include a control group, further calling their reliability into question.

Comment

Zygomatic implants show promise as an option for atrophic maxilla rehabilitation. Studies that include outcomes indicative of the potential for long-term implant failure are needed for practitioners to plan and properly place zygomatic implants.

Sales PHdH, Gomes MVSW, de Oliveira-Neto OB, et al. Quality assessment of systematic reviews regarding the effectiveness of zygomatic implants: an overview of systematic reviews. Med Oral Patol Oral Cir Bucal 2020;25:e541-e548.

In the Next Issue

Considerations for the severely atrophic edentulous mandible

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.

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