Mandibular implant-retained overdentures: A literature review

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The implant-retained overdenture for the mandible has been shown to be a highly successful prosthetic treatment similar to the fixed implant denture. However, controversy persists as to its design and indications. Few literature reviews have been published on the topic. This article critically analyzes the existing mandibular implant overdenture literature relative to bone preservation, effect on antagonist jaw, number of implants required, anchorage systems, maintenance, and patient satisfaction. A MEDLINE search was completed (from 1987 to 2001), along with a manual search, to locate relevant English-language articles on mandibular implant overdentures. Twelve treatment concepts are elucidated from a distillation of the literature review. (J Prosthet Dent 2001;86:468-73.)

Despite its broad acceptance, the mandibular implant-retained overdenture has been investigated only with longitudinal studies since 1987. van Steenberghe et al[1] were among the first authors to propose placement of only 2 implants in the edentulous mandible. Their 98% success rate, with up to 52 months of observation, was encouraging. However, 5-year prospective studies on implant overdentures supported by endosseous implants are limited.

Mericske-Stern et al[2] reported 97% implant survival with 2 implants (splinted or solitary), irrespective of keratinized tissue or duration of edentulism. Jemt et al[3] reported 100% cumulative success rate for overdentures supported by 2 implants; the mean marginal bone loss was 0.5 mm during a 5-year period. Naert et al[4] compared the clinical outcome of different overdenture anchorage systems and found 100% implant success after 5 years for all groups. In spite of these reports, controversy persists regarding the treatment concept and indications.[5,6]

This article reviews the literature on mandibular implant overdentures to clarify factors critical in treatment planning. Emphasis is placed on bone preservation, effect on antagonist jaw, number of implants required, anchorage design, immediate loading, maintenance, and patient satisfaction. A MEDLINE search was completed (from 1987 to 2001), along with a manual search, to locate relevant English-language articles on mandibular implant overdentures.

Treatment considerations for implant overdentures on the maxilla appear to be different than for those on the mandible.[7] Atrophy of edentulous jaws may limit implant placement on the maxilla, whereas in the mandible, the reduction of residual ridge often leaves a significant depth and width of basal bone anteriorly to accommodate implants.[8] The maxilla consists of a looser arrangement of trabecular bone that is less capable of stabilizing and supporting implants.[9] Anatomic limitations and bony morphology may compromise implant number, length, and inclination. A greater burden of maintenance care[10] and higher failure rates[11] have been reported for the implant overdenture on the maxilla in contrast to the mandible.

BONE PRESERVATION

In longitudinal studies, Atwood et al[12] and Tallgren[13] showed an average annual alveolar ridge height reduction of approximately 0.4 mm in the edentulous anterior mandible resulting from physiologic changes. The anterior mandibular bone under an implant overdenture may resorb as little as 0.5 mm over a 5-year period, and long-term resorption may remain at 0.1 mm annually.[3,14,15] Similar findings for a fixed implant complete denture have been documented.[16] Recently, von Wowern and Gotfredsen[17] observed load-related positive bone remodeling in the anterior mandible caused by increased function with implants. This effect appeared to be independent of the attachment system.

However, the resilient overdenture design may in fact cause posterior mandibular resorption. Jacobs et al[18] found a 2- to 3-fold annual posterior mandibular resorption in overdenture wearers as opposed to complete denture wearers if patients were edentulous for less than 10 years. Conversely, in their retrospective study, Davis et al[19] found that the fixed implant complete denture may not only preserve bone but also regenerate posterior bone. Therefore, for younger patients or those with an extremely narrow posterior mandibular height, an overdenture design on 2 implants may be contraindicated.

EFFECT ON ANTAGONIST JAW

Several authors have reported a combination syndrome effect with various designs of mandibular

Presented before The Academy of Prosthodontics annual meeting, Santa Fe, N.M., May 2001.

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implant overdentures opposing maxillary complete dentures.[20-23] This condition can lead to a transfer of significant occlusal forces onto the anterior maxilla with maxillary alveolar bone resorption and soft tissue inflammation. Haraldson et al[24] also noted that increased occlusal forces could generate more midline fractures of the opposing denture. Furthermore, investigators have found subjective loss of fit and need for a maxillary denture reline in 25% to 33% of treatment groups over 5 years.[25,26] However, this phenomenon remains controversial. In a randomized, 6-year prospective study evaluating a transmandibular prosthesis, single-bar overdenture, and complete denture, Narhi et al[27] found continuous maxillary ridge width reduction independent of prosthesis type. The occlusal concept was considered important to preserve maxillary bone. Thiel et al[28] and other authors[29-31] have recommended no anterior contact in the centric relation position and minimal anterior contact during excursive mandibular movements. Regular recalls to evaluate the overdenture for extension base fit, maximal extension, and appropriate plane of occlusion have also been emphasized to decrease the need for relines of the maxillary denture.[28]

NUMBER OF IMPLANTS

Meijer et al[32] conducted a finite element analysis of 2 versus 4 implants placed in the interforaminal region of the mandible. In neither of the models was a reduction of the principle stresses clearly demonstrated if the load was uniformly distributed. Furthermore, in a prospective 12-month study, Batenburg et al[33] evaluated 60 mandibular overdenture patients divided into 2 groups: 1 treated with 2 implants and the other with 4 implants. They found no significant differences in the peri-implant health. These studies were consistent with Mericske-Stern's[34] retrospective work on 67 patients divided into 3 groups: 29 with 2 implants connected with a bar, 27 with 2 solitary ball anchors, and 11 with 3 or 4 implants splinted with a bar. She concluded that retention, stability, and occlusal equilibration of the dentures improved only slightly with an increasing number of implants.

In an in vivo study, Fontijn-Tekamp et al[35] compared a transmandibular design of 4 implants and 2 anteriorly placed endosseous implants. They found that masticatory forces did not differ between the mainly implant-borne and mucosa-implant–borne treatments; these results were similar to the findings of Geertman et al.[36] However, these patients all wore opposing complete dentures, which may have been a limiting factor.[37]

In the light of these studies, the use of more than 2 implants to support a mandibular overdenture has been recommended only in the following scenarios[5,38]: a dentate maxilla, implants <8 mm in length and <3.5 mm in width, sensitive mucosa, high muscle attachments, sharp mylohyoid projections, large V-shaped ridges, or patients with high retention needs.

ANCHORAGE DESIGN

Published reports on the stress on mandibular overdentures retained by 2 implants, either interconnected or independent, are contradictory. In vitro and in vivo studies by Menicucci et al[39,40] compared the stresses on the bone surrounding 2 implants with either a bar-clip or ball attachments for overdentures. They found greater stresses on the peri-implant bone with a bar-clip attachment. This was consistent with a photoelastic analysis by Kenney et al.[41] However, other authors, in an in vivo study on force transmission onto implants supporting overdentures, found that rigid bars contributed to load sharing.[42]

In longitudinal prospective studies, Gotfredsen and Holm,[43] Naert et al,[15] and Bergendal and Engquist[44] found no differences in implant survival rate, health of peri-implant tissue, or marginal bone loss in the 2 different anchorage systems on 2 implants retaining an overdenture. In another study, Chao et al[45] concluded that the direction of occlusal forces has more influence than the connection of implants and that the difference in stress concentration between models with and without a bar is small. Furthermore, in an in vivo study on 2 implants, Mericske-Stern[46] observed that the anchorage system may have a more minor influence and that other parameters, such as superstructure fit and occlusion, may also determine loading of implants.

A number of authors[47-50] have hypothesized that it is appropriate to use 2 implants with an interconnector parallel to the hinge axis and a resilient overdenture on an ovoid or round bar. Their aim was to enhance free rotation during dorsal loading with twist-free load transmission to the implants. However, a review of mandibular overdenture treatment concepts proposes that these concepts were based on empirical data, and the use of a rigid versus moveable retention mechanism remains controversial.[6,51]

It has been shown that solitary ball attachments are less costly, less technique sensitive,[52] and easier to clean[53] than bars. Moreover, the potential for mucosal hyperplasia reportedly is more easily reduced with solitary ball attachments.[54] Bars, however, have been shown to be more retentive.[55]

In a photoelastic analysis, Sadowsky and Caputo[56] investigated the stress transfer of different anchorage designs on 4 implants in the parasymphyseal region supporting an overdenture. They tested a cantilever bar, a noncantilevered bar, and solitary attachments. The results showed that, with intimate extension base contact, there was little difference in stress transfer. Retention, jaw morphology and anatomy, and patient

compliance for recall were recommended parameters for choice of anchorage design.

IMMEDIATE LOADING

Gatti et al[57] completed a prospective study in which 21 patients were restored immediately after implant placement in the anterior mandible, and a U-shaped bar connecting 4 implants was loaded with an implant-retained overdenture. The authors recorded a 96% implant success rate over a mean observation period of 37 months. Cooper et al[58] used a single-stage surgical placement of 2 microthreaded screw implants to immediately support a relieved mandibular overdenture, followed by ball attachments 3 months later; a 95.6% success rate was reported. Recently, Roynesdal et al[59] used 2 titanium-sprayed solid screw implants in the interforaminal region in a prospective, 24-month study. After 3 weeks, the overdenture prosthesis was connected to the ball attachments. The implant survival rate was 100%. Despite the small sample size and short observation period, the high satisfaction rate indicates that this is a promising treatment concept.

MAINTENANCE

Prospective and retrospective reports of postinsertion complications with 2 implants (splinted or unsplinted) retaining a mandibular overdenture are numerous.[4,10,25,26,43,44,60-64] The consensus of many studies is that maintenance requirements were greatest during the first year of service[4,10,61-71] and related to alteration of contour and repair of the matrix or patrix.[65] Controversy persists as to whether the bar or ball design requires more maintenance.[4,43,44] Wear or fracture of the ball attachment head seems less frequent than that of gold alloy bars.[66,67] In a 5-year multicenter study, replacement of O-rings was reported in 50% of patients, usually within the first year. Clip adjustments and fractures occurred in as many as 62% and 33% of patients, respectively.[10] The shorter the bar segment, the greater the chance of clip loosening in the acrylic resin.[38]

The importance of using a metal reinforcement in the mandibular overdenture prosthesis is still debatable. Questions have arisen because of low fracture rates with high-impact resin,[25] additional expenditures, and increased implant loading with metal frameworks.[71] In one study, bar groups revealed more mucositis and gingival hyperplasia, whereas unsplinted groups displayed more decubitus ulcers.[4] In another investigation, when the burden of prosthodontic maintenance was compared with that of implant-supported mandibular overdentures with more than 2 implants, no statistical difference was found, and all designs appeared to function as hinging overdentures after 5 years.[25] Few studies have reported any difference in the frequency of relines (8% to 40%) between splinted and unsplinted attachments or among 2, 3, or 4 implants.[65]

PATIENT SATISFACTION

Numerous authors have addressed patient satisfaction with the mandibular implant overdenture.[4,54,72-81] Meijer et al[79] found that, after 5 years, patients with mandibular overdentures retained by 2 implants interforaminally had higher satisfaction scores than complete denture patients. Raghoebar et al[72] confirmed this finding in another randomized study, even with complete denture patients who had undergone preprosthetic surgery.

In a crossover study, Feine et al[74] compared a group with fixed implant prostheses with another group with a long-bar, removable, implant-supported prosthesis on the mandible. The authors found that 50% of the patients chose the removable design for ease of cleaning and esthetics. There was a tendency for the removable prosthesis to be chosen by older (>50 years) subjects. Those that chose the fixed alternative rated stability and ability to chew most important.

In another crossover study, de Grandmont et al[75] compared psychometric and functional measurements on 15 edentulous patients who wore both a fixed implant prosthesis and a long-bar overdenture. Although the patients found the fixed implant complete denture to be significantly better for chewing harder foods, there was no difference in general satisfaction.

Wismeijer et al[81] investigated 110 edentulous patients who had received mandibular implant overdenture treatment with 1 of the following: 2 implants with ball attachments, 2 implants with an interconnecting bar, or 4 interconnected implants. Most of the implants were at least 10 mm long. No significant differences were found, and almost all subjects expressed satisfaction.

TREATMENT CONSIDERATIONS

On the basis of the available literature, the following clinical treatment concepts should be considered:

1. The mandibular overdenture retained by implants in the interforaminal region appears to maintain bone in the anterior mandible.
2. In younger patients or those edentulous for less than 10 years, a fixed implant denture may preserve posterior bone better than an implant overdenture in the mandible.
3. Although reports are conflicting, patients with mandibular implant overdentures may experience a loss of fit of their antagonist denture. Occlusal schemes with no anterior contact in the centric relation position and minimal anterior contact in excursions may reduce the combination syndrome effect. Frequent recalls to assess stability and

retention should be scheduled, and relines of prostheses should be made when necessary.

4. It appears that retention, stability, and chewing ability improve only slightly with an implant-supported mandibular overdenture as compared with an implant-mucosa–supported overdenture.
5. Multiple implants can be recommended for the mandibular overdenture when sensitive jaw anatomy, increased occlusal forces, or high retention needs are present or when implant length is <8 mm or implant width is <3.5 mm.
6. When 2 implants are used in the anterior mandible to retain an overdenture, solitary ball attachments appear to be less costly, less technique sensitive, and more accommodating of tapered arches. However, ball attachments seem to be less retentive than the bar design.
7. The use of immediately loaded implants in the anterior mandible for the overdenture design is a promising treatment concept.
8. Overdentures retained by 2 implants in the anterior mandible appear to demonstrate a higher burden of maintenance during the first year than in subsequent years. Controversy persists as to whether the ball or bar design requires more maintenance.
9. There appears to be no statistical difference when long-term maintenance is compared among mandibular implant overdentures retained by 2 implants in contrast to those retained by 3 or more implants.
10. Mandibular implant overdentures appear to show higher patient satisfaction scores than complete dentures, even with patients who have undergone preprosthetic surgery.
11. Patients appear to be similarly satisfied with a fixed implant complete denture or a removable implant overdenture on the mandible. Patients who rate stability more important than hygiene tend to choose a fixed prosthesis.
12. When the anchorage system or number of implants is varied, there may be no significant differences in satisfaction with moderately resorbed edentulous patients restored with mandibular implant overdentures.

I gratefully acknowledge Cari Burnham and Elena Siegel for their word processing assistance.

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0022-3913/2001/$35.00 + 0. **10/1/119921**

doi:10.1067/mpr.2001.119921

Noteworthy Abstracts of the Current Literature

Thermal analysis on the cure speed of dual cured resin cements under porcelain inlays.
Lee IB, Um CM. *J Oral Rehabil* 2001;28:186-97.

Purpose. Much is unknown about cementation of porcelain inlays with dual polymerized resin cements. Little data are available on polymerization reactions at different levels in the cement space, polymerization effectiveness under differing porcelain thicknesses, and the relation of porcelain thickness to optimum polymerization time. This study recorded the reaction kinetics of dual-polymerized resin cements polymerized with chemical or light activation under varying thicknesses of porcelain inlays. The effect of the porcelain disks on the rate of cement polymerization during light exposure also was evaluated with thermal analysis.
Material and methods. Five dual-polymerized resin cements (Bistite, Dual, Scotchbond, Duolink, and Duo) were polymerized under varying thicknesses (1, 2, and 4 mm) of porcelain inlays with chemical or light activation. The effect of the porcelain disk on the rate of polymerization during light exposure was evaluated with thermal analysis, thermogravimetric analysis, and differential scanning calorimetry. Inorganic filler weight percent, the heat of polymerization (H), the maximum rate of heat output, and the peak heat flow time were measured when polymerization reaction occurred by chemical only or by light exposure. In the 4-mm-thick porcelain disk, exposure time was varied from 40 to 60 seconds to investigate the effect of exposure time on polymerization reaction.
Results. Polymerization by light exposure was 5 to 20 times faster than by chemical polymerization. The dual-polymerized resin cements differed markedly in their sensitivity to light and chemical activation. The peak heat flow time increased by 1.5, 1.9, and 3.2 times as light polymerization was applied to 1-, 2-, and 4-mm-thick porcelain disks. Exposure times recommended by the manufacturers were insufficient to compensate for the attenuation of light by the 4-mm-thick porcelain disk.
Conclusions. The results confirmed that porcelain thickness has a significant impact on the initial polymerization of dual-polymerized cements. In the thinner specimens of 1 and 2 mm, polymerization was almost complete within 40 seconds, and the reaction was carried out primarily by light activation. 19 References. —*ME Razzoog*