
Treatment Concept for Mandibular Overdentures Supported by Endosseous Implants: A Literature Review

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Edentulous patients with a severely resorbed mandible often experience problems with their dentures. Treatment concepts involving two to four implants for the support of an overdenture have been proposed. The aim of this study was to develop a treatment concept for mandibular overdentures supported by endosseous implants based on a review of the literature. It is proposed that two implants supporting a mandibular overdenture (bar construction) are sufficient for most applications. Four implants are indicated in situations involving a dentulous maxilla, a narrow mandibular arch, extreme resorption of the mandible (bone height greater than 12 mm), and mandibular soreness and pain.

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Key words: implants, mandible, overdenture, review

Edentulous patients with a severely resorbed mandible often experience problems with their conventional dentures because of an impaired load-bearing capacity.^{1,2} These problems include pain during mastication and insufficient stability and retention of the denture, especially with regard to the mandibular denture. Long-term follow-up studies have shown that these problems can be successfully managed using fixed prostheses supported by five or six endosseous implants.^{3,4} However, there appears to be no need to replace every unstable, problematic complete denture with fixed complete-arch prosthe-

ses. Many patients are satisfied with a stable implant-supported overdenture that requires limited clinical time and financial expense.⁵⁻⁷

An overdenture is defined as "a removable partial or complete denture that covers and rests on one or more remaining natural teeth, roots, and/or dental implants; a prosthesis that covers and is partially supported by natural teeth, tooth roots, and/or dental implants."⁸ Most patients seeking improvement in the retention and stability of the mandibular denture and decrease of oral soreness have no objections to removable prostheses and do not desire complete fixed prostheses and their implied more difficult oral hygienic procedures.

The aim of this study was to develop a treatment concept for mandibular overdentures supported by endosseous implants based on a review of the literature, with special emphasis on the number and type of implants, quantity and quality of bone, aspects of the soft tissue, and kind of superstructure used. Because of either differences in the experimental setup and/or shortcomings in the experimental design, the results of most studies are not fully comparable with each other as only general tendencies are discussed.

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Table 1 Overview of Literature Related to Overdentures Supporting Endosseous Mandibular Implants

Literature	Retro/ prosp	Implant type	Overdentures (N)	Implants (N)	Implants/ overdenture (N)	Attachment design	Observation time (mean)	Survival rate (%)
Engquist et al ¹⁵	Retro	Brånemark	?	148	Avg 3	Bar/single	3–40 mo (?)	93.9
Naert et al ⁵	Retro	Brånemark	44	88	2	Bar	1–30 mo (?)	97.7
Quirijnen et al ^{44,45,46}	Retro	Brånemark	80	163	2	Bar/single	4–48 mo (19.7)	98.6
Naert et al ^{6,17}	Retro	Brånemark	80	163	2	Bar/single	4–48 mo (19.7)	98.6
Parel ⁴⁷	Retro	Brånemark	15	45	3	Bar/single	31–58 mo (?)	95.6
Cune/de Putter ³⁹	Retro	ITI Bonefit/IMZ Brånemark/Screw Vent	303	827	?	Bar/single	? mo (21.2)	99.8
van Steenberghe et al ⁹	Prosp	Brånemark	43	98	2	Not reported	0–52 mo (?)	98.5
Haraldson et al ⁴⁸	Prosp	Brånemark	9	36	2	Bar/single	12 mo (12)	100
Engquist ⁴⁹	Prosp	Brånemark	24	54	2/3	Bar/single	6–56 mo (29)	87
Zarb/Schmitt ⁵⁰	Prosp	Brånemark	28	79	2/3	Bar/single	1–72 mo (?)	94.9
McNamara/Henry ⁵¹	Prosp	Brånemark	9	18	2	Bar	? mo (18)	100
Johns et al ¹⁸	Prosp	Brånemark	103	393	2	Bar	12 mo (12)	96.2
Hutton et al ²³	Prosp	Brånemark	103	393	2	Bar	36 mo (36)	94.2
Jemt et al ⁵²	Prosp	Brånemark	103	393	2	Bar	5 y	94.5
Mericske-Stern/Zarb ¹¹	Prosp	ITI Bonefit Brånemark	34 (Bern) 25 (Toronto)	74 68	Avg 2.7 Avg 2.2	Bar/single Bar/single	> 5 y > 5 y	92.2 91.2
Donatsky ¹⁹	Prosp	Brånemark	25	93	2/3/4	Single	12–27 mo (?)	97
Naert et al ²²	Prosp	Brånemark	36	72	2	Bar/single	3–24 mo (12.4)	100
Boerrigter et al ²⁷	Prosp	Brånemark/IMZ	60	120	2	Bar	12 mo (12)	94.9
Geertman et al ²⁸	Prosp	Brånemark/IMZ	58	116	2	Bar	12 mo (12)	98.3
Mericske-Stern ³³	Retro	ITI type F	37	74	2	Bar/single	6–52 mo (32)	93.8
ten Bruggenkate et al ³⁴	Retro	ITI type F	19	68	?	Bar	12–60 mo (?)	100
Mericske-Stern ²¹	Retro	ITI type F/Bonefit	44	88	2	Bar/single	36–84 mo (61)	98.9
Versteegh et al ²⁵	Retro	ITI type F	36	135	3/4	Bar	45–109 mo (70)	74.8
Mericske-Stern et al ¹²	Prosp	ITI type F/Bonefit	33	66	2	Bar/single	> 5 y	97
Mericske-Stern ¹⁶	Retro	ITI Bonefit	62	137	2/3/4	Bar/single	6–66 mo (?)	95.6
Geering/Mericske-Stern ⁵³	Retro	ITI Bonefit	62	137	1/2/3/4	Bar/single	12–66 mo (?)	98.5
Donatsky/Hillerup ⁵⁴	Prosp	ITI Bonefit	40	156	3/4	Single	1–3 y (?)	99
Kirsch ⁵⁵	Retro	IMZ	143	365	2/4	Bar	0–11 y (?)	98
Batenburg et al ³¹	Retro	IMZ	57	114	2	Bar	12–57 mo (30)	97.4
Spiekermann et al ³⁵	Retro	IMZ / TPS	136	300	2/3/4	Bar	0–11 y (5.7)	95/97
Kwakman ³²	Prosp	IMZ	29	58	2	Bar	4–5y (5)	100
Leimola-Virtanen et al ²⁶	Retro	TPS	42	166	4	Bar	3–10 y (5.6)	91.5
Wismeyer et al ⁵⁶	Retro	TPS	64	218	2/3/4	Bar	66–119 mo (80)	96.8
Chiapasco et al ⁵⁷	Retro	TPS/ITI/Hi-Ti/NLS	226	904	4	Bar	2–13 y (6.4)	96.9
Block et al ⁵⁸	Retro	Integral	75	175	2/4	Bar/single	6–56 mo (?)	97.2
Goffredsen et al ²⁰	Prosp	Astra	20	40	2	Bar/single	24 mo (24)	97.5
Davis et al ⁵⁹	Prosp	Astra	25	52	2/3	Single	3 y	99

Retro = retrospective study; prosp = prospective study.

Implants

Approximately 10 years ago, van Steenberghe et al⁹ reported on the possibility of using overdentures supported by two Brånemark implants to treat mandibular denture problems (98% success rate, observation time 0 to 52 months). Prior studies emphasizing the treatment of edentulous patients with fixed prostheses supported by six implants had been described.^{3,10} Van Steenberghe et al⁹ were among the first authors who proposed the placement of fewer implants in advantageous sites, rather than placing as many implants in limited space as possible to achieve the original goal of six endosseous implants for the rehabilitation of a completely edentulous jaw.

Long-term studies on mandibular overdentures supported by endosseous implants are scarce. The

mean observation time is often less than 5 years (Table 1), which does not meet the generally accepted long-term criteria for success of Albrektsson et al.¹⁰ To date, literature on prospective studies involving overdentures supported by endosseous implants with a follow-up period of at least 5 years are limited to the studies of Mericske-Stern and Zarb¹¹ and Mericske-Stern et al.¹² Mericske-Stern and Zarb¹¹ described a group of 34 ITI Bonefit and 25 Brånemark mandibular overdenture patients. Soft tissue and radiographic evaluations of both groups revealed that health of the marginal tissue was maintained and peri-implant bone loss was minimal (less than 0.5 mm/year) during the 5-year follow-up. Since data collection was done by different investigators (no calibration) and different parameters were used (dental versus panoramic radiographs, up to 50% of

the radiographs were missing), the conclusions of the study should be interpreted with some caution. In a second study, Mericske-Stern et al¹² reported the 5-year results of a group of 33 patients with mandibular overdentures supported by either ITI type F or ITI Bonefit implants. Again, healthy marginal tissues were observed in this rather small group of patients.

The available prospective and retrospective studies on overdentures supported by two, three or four implants indicate that implant survival rates are comparable to those involving implant-supported prostheses.^{13,14} In most studies, the implant survival rate is at least 90% (Table 1). Furthermore, the studies of Engquist et al¹⁵ and Mericske-Stern¹⁶ indicated that, with regard to health of the peri-implant tissues, clinically there were no differences among mandibular overdentures supported by two, three, or four implants in the interforaminal region. In the same study, Engquist et al¹⁵ showed that there is no need to splint the implants with a bar. However, the ball-shaped attachments employed did not always provide adequate retention, particularly in patients with severe resorption of the alveolar ridge. While the female retainers for bar attachments can be activated, female retainers for single attachments often require replacement after loss of retention. The majority of edentulous patients with extreme mandibular resorption complaining about lack of stability and retention of the mandibular denture are satisfied after treatment with a mandibular overdenture supported by two implants.⁷

Bone

According to the literature, the Lekholm/Zarb classification,²⁴ the Cawood classification,²⁹ and bone height as measured on radiographs are methods commonly used for diagnostic purposes.^{6,15,17-29} The significance of these diagnostic parameters on both the treatment concept and treatment outcome still needs further study. Engquist et al¹⁵ concluded that Lekholm/Zarb classes 1 to 3 are favorable prerequisites for overdenture treatment. However, in 64% of their treated patients, the choice of overdenture therapy was made by exclusion: the jawbone did not allow placement of a sufficient number of endosseous implants to support a fixed prosthesis, or such placement had failed. Hutton et al²³ reported that dental arch (maxilla or mandible) and bone quality were the only significant predictors of overdenture treatment failure. The group with the highest risk for implant failure had type E bone quantity and type 4 bone quality (Lekholm/Zarb classification²⁴).

The quantity and shape of mandibular bone determines the position and number of implants that can

be placed. In severely resorbed mandibles, only short implants can be placed. The shorter the implant, the less contact between implant and bone. This implies that a very small amount of bone must withstand the forces exerted on the implants. By increasing the number of implants, the amount of contact between implant surface and bone is also increased, and thus the load-bearing capacity increases. Preliminary results of a retrospective study by Triplett et al³⁰ indicate that endosseous cylinder implants of 10 mm or less supporting a fixed prosthesis or an overdenture in the mandible are useful and effective and show success rates of 96% and 93%, respectively. The applicability of short implants warrants further study.

Soft Tissue

There is still discussion in the literature as to whether implants should be surrounded by keratinized mucosa. Some authors favor the use of a standard grafting procedure or the use of a modified vestibuloplasty³² in situations involving unattached oral mucosa around the abutment.^{5,6,17,31} Other authors suggest mucosal grafting where muscle pull or severe gingival hyperplasia exist.²⁵ Mericske-Stern et al¹² and Mericske-Stern¹⁶ report that while, theoretically, keratinized attached mucosa provides better mechanical resistance, clinically, no significant differences in the health of peri-implant tissues were observed between abutments surrounded with keratinized or nonkeratinized mucosa. Other authors have also concluded that there is no definite need for keratinized peri-implant mucosa.^{11,20,25,27,28,33-35} There is need for prospective controlled studies of nonkeratinized peri-implant mucosa to prove this hypothesis.

Superstructure

Design of the prosthesis superstructure and the number of supporting implants influences masticatory function. However, from a within-subject comparative study Feine et al³⁶ concluded that, contrary to expectations, masticatory function of subjects with an overdenture was no less effective than in subjects with a fixed prosthesis. Geertman et al³⁷ reported no differences in masticatory performance between patients with a mandibular overdenture supported by a TMI implant or two IMZ implants. Both studies suggest that the degree of support provided by implants and/or alveolar mucosa does not determine the ability to masticate food. In a study by Wismeier³⁸ of patient satisfaction, no significant differences were found between three groups of patients treated with mandibular overdentures supported by two or four implants with either ball or bar attachments.³⁸

Table 2 Treatment Concept Proposal for the Edentulous Mandible

	No. of implants/attachment		
	Four/bar	Two/bar	Two/single
General application		✓	
Bone height < 12 mm	✓		
Narrow mandibular arch	✓		✓
Maxillary denture (partial)	✓		
Chronic soreness	✓		
Difficulty with oral hygiene			✓

With regard to superstructure type, Naert et al^{6,17} indicated that the bar concept involves more effort by the dentist and technician compared to the use of single attachments. They also showed that single attachments provide lower retention capacity than bars, and that Dolder-bar-supported overdentures were less demanding than magnets and ball attachments.²² While the bar concept may be prosthetically preferred, single attachments may be the best choice in patients experiencing problems with oral hygiene maintenance because of their superior accessibility. The choice of this concept in these patients is supported by the outcome of a study on the comparative evaluation of different implant and attachment systems. In this study, Cune and de Putter³⁹ observed no differences in peri-implant tissues between implants with single attachments and bar retainers.

Model Studies

Meijer et al⁴⁰ showed that differences in stress value between models with and without a bar are small when the superstructures are loaded. They also reported that structural stress in the mandible is not reduced when using four instead of two implants splinted with a bar. In addition, Jäger and Wirz⁴¹ showed that when two implants are placed in the canine region, the most favorable anchorage/load ratios were observed with a bar/clip retention system.

Economic Considerations

Literature on the economic aspects of implants supporting overdentures is limited to a cost-effectiveness analysis of different treatment modalities in a Dutch population.⁴² A comparison of costs was made between patients in whom a transmandibular implant was supplied supporting an overdenture and those treated with overdentures supported by two implants in the mandible. It was concluded that prosthetic care and maintenance in all treatment concepts are expensive. The transmandibular implant is far more expensive, primarily because of a period of hospital-

ization and costs of the implant hardware. To the authors' knowledge, comparisons of costs using two or four implants are not available in the literature, but it seems reasonable to assume that the more implants placed, the more expensive the treatment.

Treatment Concept Proposal

From review of the literature, it seems evident that many treatment concepts involving mandibular overdentures supported by endosseous implants are based on empirical experiences or are merely opinions of members of individual centers. Long-term comparative prospective controlled studies are needed to reach agreement on an accepted treatment concept. Factors such as the number and type of implants used, quality and quantity of bone, keratinized versus nonkeratinized peri-implant mucosa, and type of superstructure should be part of these studies. Although it is not possible to reach a definite conclusion based on the current literature, the treatment concept proposed in Table 2, which is based on the available data in the literature, may form the linchpin of such studies.

General Concept. If the patient desires increased stability of the mandibular denture and increased chewing ability, two implants connected by a bar in the interforaminal region supporting an overdenture are sufficient as a general rule. When anatomic restrictions or other patient-related complicating factors are involved, the fabrication of an overdenture supported by either four implants with a bar or two implants with single attachments may be preferable.

Bone Height. When mandibular interforaminal bone height is less than 12 mm, a Zarb/Lekholm classification²⁴ of D/E exists, and implants of 10 mm or less are indicated, four implants are needed because of the decreased available bone volume, an increased intermaxillary distance, and the tendency for gradual stress increase.

Narrow Mandibular Arch. In none of the published overdenture studies was the placement of more than two implants in the interforaminal region

based on the anatomy of the mandible. However, when a narrow mandibular arch exists, a straight bar between two implants would likely be situated over the floor of the mouth rather than over bone, limiting the function of the tongue. Using an angulated bar in a more labial position would induce a concentration of stress in the bone around the implants,⁴³ and the placement of two implants closer together would result in a smaller bar with insufficient retention for the overdenture. Therefore, four implants for a narrow mandibular arch and bar connection are needed, while single attachments are indicated for a narrow mandibular arch provided with two implants.

Dentulous Maxilla. A dentulous or partially dentulous maxilla increases the risk of overloading mandibular implants. Therefore, the placement of four implants in the interforaminal region is indicated to divide the exerted forces over a larger contact area between implant and bone.

Chronic Soreness. If the main complaint of a patient is chronic soreness of the inferior alveolar mucosa resulting from decreased load-bearing capacity, four implants are indicated. An overdenture with the support of four implants decreases oral soreness. The four implants should not be placed in a two-by-two configuration. This allows for only two clips in the overdenture, resulting in loading of both the implants and the mucosa of the inferior alveolar ridge. Therefore, to enable an appropriate bar configuration, the implants should be placed with equal interimplant distances in the anterior area, allowing placement of at least three retention clips in the overdenture. This will decrease the mucosal loading. A bar design with distal extensions will decrease the mucosal loading even more.

Problems with Oral Hygiene Maintenance. Single attachments are indicated in those patients for whom problems with oral hygiene maintenance are to be expected, eg, patients with a physical handicap. However, patient skill for performing adequate oral hygiene is not predictable in all cases.

Summary

Based on a review of the current literature, a treatment concept proposal has been conceived for the design of mandibular overdentures supported by endosseous implants. To confirm the efficacy of such a proposal, prospective studies of implants supporting overdentures are needed.

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