# Tissue-supported dental implant prosthesis (overdenture): the search for the ideal protocol. A literature review

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## Summary

***Aims.*** **The success of maxillary and mandibular tissue supported implant prostheses varies in the literature, and the ideal protocol may be elusive from given the numerous studies. The oral rehabilitation option is an alternative to conventional dentures and should improve function, satisfaction, and retention. The purpose of this review article is to clarify these questions.** ***Methods.*** **The search of literature reviews English non-anecdotal implant overdentures articles from 1991 to 2011.** ***Results.*** **The results display an aggregate comprehensive list of categorical variables from the literature review. Overall success of maxillary and mandibular implant overdenture was respectively, 86.6% and 95.8%.** ***Conclusion.*** **The literature indicates that the implant overdenture prosthesis provides predictable results – enhanced stability, function and a high-degree of satisfaction compared to conventional removable dentures.**

**Key words: overdenture, dental implant, osseointegration, edentulous.**

## Introduction

Bone resorption will occur in an edentulous alveolus. The ubiquitous phenomenon is a progressive and irreversible (1). The amount and rate of alveolar bone resorption depend on factors such as age, sex, facial anatomy, metabolism, oral hygiene, parafunctions, general health, nutritional status, systematic diseases, osteoporosis, drug administration and time of edentulism (2,3).
Studies to verify the influence of conventional fully-removable dentures as factor of bone resorption are replete; patients wearing complete dentures will present with smaller edentulous ridges than edentulous patients with never receiving prosthetics (4). The implant-retained prosthesis is an alternative treatment option in edentulous patient's rehabilitation, providing more retention, stability, function and esthetics especially in the mandible. The use of implants for edentulous patients will actually preserve existing bone compared to conventional dentures (5).
This literature review analyzes the current concepts about indications, implant diameter, length, number, position, prosthetic rehabilitation, early and immediate loading, attachment systems, and implant success rate in mandibular and maxillary overdentures.

## Methods

This study searches for the subject's validity and efficacy of available information from English published literature within PUBMED from 1991-2011. The search identifies the key words: *overdenture, dental implant, osseointegration, edentulous.* A manual search of aforementioned articles' reference lists expands this subject's information.
This composite search narrows if the articles meet the following criteria: 1) type of study (*randomized controlled trial, review of the literature with or without meta-analysis, longitudinal experimental clinical studies, longitudinal prospective studies, and longitudinal retrospective studies*); 2) period of publication (*1991 to 2011*); and 3) type of patient (*maxillary and/or mandibular fully edentulism for tooth decay and periodontal disease*).
The exclusion criteria is: 1) type of study (*case reports, case sequence, clinical innovation report, description of the surgery complications, advice from experts*); and 2) type of patient (*oral cancer patients*).

## Results

The data explores mandibular and maxillary overdenture's indications, implant diameter, length, number and position, prosthetic rehabilitation, immediate and early loading, attachment system and implant success rates. The following categorical variables display an aggregate comprehensive list from the literature review:

*Indications*

The following patients would benefit from a tissue-supported implant overdenture:

- advanced atrophy eliminating the potential for total implant-supported prosthesis;
- augmentation procedures are excluded for any reasons;
- possess natural teeth in the opposing arch, fixed or removable prostheses supported by implants and teeth;
- elderly patients who, having had complete dentures for many years, lose their motor skills and no longer feel able to wear complete dentures (6);
- compromised conventional denture retention, e.g. resection defects, xerostomia or parafunction.

*Implant diameter and length*

The implant diameter depends on the alveolar width, whereas the available bone height determines the implant length (7). The implant length should be ≥ 10 mm, and a minimum diameter of 3.3 - 4.1mm for the mandibular anterior while 4.1mm for the maxilla (8). The literature provides evidence of an increased failure rate for short implants – 7 and 10 mm (9). Narrow diameter implants (2.5 to 3 mm) can be successfully used to treat narrow bone ridges although more long-term studies are needed to compare narrow and conventional diameter implant outcomes (10,11). In both the maxilla and the mandible, wide-diameter implants may provide additional support for removable partial dentures. However, the use of wide-diameter implants for anchorage of removable partial dentures still requires critical evaluation to assess whether wide-diameter implants affect the suprastructure design. Using standard-diameter implants, the suprastructure may frequently be better designed and more comfortable for the patient (12).

*Implant number*

The two-implant overdenture therapy is a very reliable therapy for patients with an edentulous mandible (13). A several authors hypothesizes that it is appropriate to use two implants with an interconnector parallel to the hinge axis and a resilient overdenture on an ovoid or round bar (14-16). The bar's purpose is to enhance free rotation during dorsal loading with twist-free load transmission to the implants (17). Comparative prospective studies validate the benefit of two or four implants in the edentulous mandible (18-22). Survival rates in the two-implants overdenture groups compared with four-implant overdenture groups appear to be equivalent for patient satisfaction (23). One ten-year trial displays no significant clinical and radiographic differences in patients treated with two or four implants overdenture (24). However, a mandibular overdenture with two implants and a bar has fewer complications (25).

There are no specific guidelines for the number of implants necessary to support a maxillary overdenture (26,27). A minimum of four well-spaced implants is often recommended for an implant-supported and retained-overdenture. The increased minimum of implants compared to the mandible is due to the softer bone and type of distribution of occlusal forces in the maxilla. However, the use of only two maxillary implants may not compromise implant survival or patient satisfaction. The most posterior implant should be inserted as far distally as possible to reduce the extension of cantilever (28).

*Implant position*

Although not standard, studies recommend four intraforaminal implants for cases of advanced atrophy or thin mandibular ridges. For these instances, implants should be equidistant apart, or as an alternative one can mount a cantilever-fixed prosthesis; in fact, the bar segments may become rather short, and short female bar retainers are subject to frequent loosening or loss. The length of the bar segments can range from 15 to 25 mm. The total number of intraforaminal implants distribution should be related to the shape of the ridge. If a large or V-shaped anterior ridges exists, three to four implants will provide for a more favorable design of the bar and the prosthesis. In presence of U-shaped mandibular jaw, two anterior implants could provide for a bar of adequate length. A U-shaped mandible with large curvature allow for an adequate placement of four implants and a connecting bar. Alignment of the implants in a rather straight line is not favorable for fixed prostheses.

The best anchorage design for the maxilla is four equidistance implant, but six implants for compromised bone (29). Positioning the implants in anterior maxilla, mesial to the first premolars enhances the stability of the overdenture. For a design without palatal coverage, the consensus favors a minimum of four implants (30-34). In order to avoid dramatic changes in prosthetic design, one investigator recommends six implants (35). Despite this recommendation, others clinicians implant prognosis were not compromised with the presence of compromised quality and quantity of bone, off-ridge relations, or high applied forces, and palatal coverage (36).

*Prosthetic rehabilitation*

There is a direct correlation between the number of implants and prosthetic design. The number of implants influences type and design of prosthesis whereas the prosthetic design determines the number of implants. Additionally, the distribution of the implants over the arch is related to size, curvature and shape of the ridges.

A rigid bar connecting multiple implants and cast metal framework reinforce denture base to ensures stability and stiffness. Several investigators demonstrate, *in vitro* and *in vivo,* that bars provide more retention than solitary anchors when subjected to both vertical and oblique forces (37-39). If a bar connector interferes with space for tongue, then ball anchors are best. Anterior

positioned mandibular implants may result in a shorter prosthetic bar length; however, it may be adequate in presence of three or four intraforaminal implants. As an alternative, four intraforaminal implants can support a fixed-cantilever mandibular prostheses. The attachment system seems not to interfere with prognosis of two implants mandibular overdenture writes a ten-year randomized clinical trial of splinted and unsplinted oral implants retaining mandibular overdentures (40).

An *in vitro* edentulous maxilla study utilizing four implants demonstrates improved retention of bar overdentures with distal ERA® attachments rather than a cantilevered bar with Hader clips (41). The distribution of supporting implants may influence their survival due to forces acting on the prosthesis in the maxilla (42). The rationale of fabricating a single bar supported by two or more implants, allowing pure rotational movement of the prosthesis to equitably share support with the mucosa, is not practical because of the difficulty of optimal positioning of the implants. This type of hinging design does not improve implant survival (43). A broadly distributed implant-supported design, spanning the anterior-premolar region and tuberosities, shows the most favorable stress transfer to bone compared to a concentrated array of implants in the anterior region supporting a cantilever (44). Bars with distal cantilevers tend to increase the loads on the terminal implants by more than three-times in the maxilla (45). If parallel alignment of the implant axes is possible, a ball anchor-supporting maxillary overdenture can be a long-term provisional restoration. However, the use of two ball anchors results in a hinging movement of the denture that may cause discomfort.

Magnets display the least retentive of all attachment systems, but may be appropriate for patients with bruxism or dexterity problems (46). Unsplinted anchorage systems may require less space within the prosthesis, may be easier to clean and more economical, as well as less technique sensitive (47). In the vertical axis, a minimum distance of 13-14 mm from the implant platform to the incisal edges is necessary with a bar design, allowing 4.0 mm for the bar and 1.0 mm below the bar for hygiene, as well as space for the clip and acrylic/tooth housing (48). However, the use of attaching mechanisms such as a bar-clip (Hader, Attachments Intl., Inc., San Mateo, Ca, USA) requires a minimum distance of 10-12 mm between implants, otherwise a milled bar with a frictional fit superstructure is needed (49). Solitary anchors require only 10 to 11 mm of vertical space above the implant platform to incisal edges and also allow for more flexibility in positioning, given anatomic limitations (50,51).

*Attachment systems*

Implant overdentures use one of three attachment systems: 1) resilient attachments on freestanding implant abutments; 2) resilient attachments to join the denture to a rigid bar assembly that interconnects osseointegrated implants (52,53); 3) or magnets system (54).

The comparison between the retentive properties of single attachments to bars, there are data shows that bars are more retentive while the magnetic attachments are less retentive (54,55). The data hints that bars-clip assembles appear to be more retentive for the break load when subject to both vertical and oblique forces. These attachments also provide the fastest release periods. Their selection is ideal when there is a requirement for high degree of retention, e.g. cases with extremely resorbed ridges without tissue undercuts. The retentive forces of most attachment systems are in the range of about 20N (56). Forces of 20N are probably sufficient for overdentures in the edentulous mandibles is a believable documented assumption. Published research agrees on the fact that the least retentive attachments are the magnets. This clinical approach lost popularity, particularly when clinicians discovered that this attachment system corrode rapidly in saliva. Their attractive force is weaker (mean of 2N or less) than ball or bar attachments (57,58). Since magnets will displace with excessive force, some investigators suggest their use with bruxers (55). However, newly designed rare-earth alloys seems to provide more magnetic force per unit size, and new laser-welding techniques contribute to the construction of strong and durable containers for protecting the magnets from salivary corrosion (59).

Literature data about peri-implantitis shows no significant differences between different attachment systems. Cehereli in his systematic review writes that no differences exist regarding bone loss around mandibular implant retained/supported overdentures with different types of attachment systems (60). However, investigators speculate for the reason this loss due to different loading patterns or bone conditions.

Evaluation of soft tissue reactions to different attachment systems exists. The maxilla is more prone to hyperplasia and mucositis around implants. The excellent denture retention avoiding a sufficient cleaning mechanism of saliva may be responsible for these adverse reactions. Plaque accumulation is significantly higher for magnets than for ball attachments whereas there is no significant differences between bar and ball design, or bar and magnets.

Another study finds less bleeding with ball attachments, when compared to a single bar attached to two implants or triple bar to four implants. Ball attachments are, in fact, easier to clean than bars (18). Two studies conclude that implant-supported overdentures may maintain health and stability independent of the retentive device used for anchorage (61). It is likely that peri-implant health for overdentures is not influenced by the number of implants (62). However, by increasing the number of implants, the potential for single axis fulcrum movement decreases and so do the retention-release episodes during function. Different stress distribution is a result of the type of attachment system.

Photoelastic studies demonstrate the ideal stress distribution concerning length, geometry, and diameter of implants, although some limitations exist with this type of study. The best design would compare different stress

patterns from different retentive mechanisms from implants of the same length, geometry, and diameter.
The ball (O-ring) attachments transfers less stress than bar and clips when applying vertical forces on a two implant supported mandibular overdenture. *In vitro* and *in vivo* studies compare the stresses on the bone surrounding two implants with either a bar- clip or ball attachments for overdentures (63,64). Their discovery is a greater stress exist on the peri-implant bone with a bar- clip attachment. Photoelastic studies reproduce the findings (18). *In vitro* and *in vivo* studies verify the higher stability with ball attachments and how load is evenly dispersed onto the residual ridge of both site of the dental arch (63,65,66). This finding may result from an allowed flexure of the mandible.
Advocates of the bar-clip attachment design speculates that the denture can freely rotate around the bar, thus compensating for the resilience of the supporting mucosa and reducing the torsion forces to the implants (57). However, measured force transmission onto implants supporting overdentures with piezoelectric transducers show the maximum forces measured in the vertical direction are higher with single telescopes than with bars and clips. And, rigid bars contribute to load sharing between the implants (67). Contrary to the rationale and theory of free rotation, recent data suggests that even if a bar that allows rotational movement, a higher load will transfer to the implants because of the difficulty to obtain optimum implant position, which would allow a pure rotational movement (43). Therefore, a design should be an equilibrium between load of implant and denture bearing area.
Nevertheless, the literature is in disagreement – longitudinal prospective studies conclude that is no differences in implant survival rate, peri-implantitis, or marginal bone loss in the two different anchorage systems on two implants retaining an overdenture (68,69). Furthermore, another study concludes that the direction of occlusal forces is more influential than the connection of implants and that the difference in stress concentration between models with and without a bar is small (70). In an *in vivo* study using a two-implant supported model, investigators observe that the anchorage system may has less of an influence than other parameters, such as superstructure fit and occlusion, and may also determine loading of implants (71).
There is no significant difference in stress distribution between stud attachments and resilient bar-clip designs if the prostheses are well-designed prosthesis and both under ideal conditions. However, rigid designs and cantilever bars are more will increase the force transmitted to the implant fixtures.

*Immediate-loading of Implant-supported overdentures*
The literature review draws the following conclusions about mandibular overdentures: immediate loading of mandibular overdentures does not jeopardizes the survival rate when designed with four implants (72); and, success is a function of bone quality and primary stability (73). Insufficient data exist to support early and immediate loading for the maxillary overdentures (74-76).

*Early-loading of the implant-supported mandible overdentures*
The literature review draws the following conclusions about mandibular overdentures: success or survival of implant is not in jeopardy with early-loading, but few studies exist; both splinted and unsplinted implants withstand the biomechanical demands of early-loading (77); success is a function of bone quality and primary stability; and, survival and success rates for early-loaded implants are comparable to conventionally-loading protocols.
No deleterious effects up to twenty-four months exist with immediate or early-loading, although there appears to be more support for early over immediate-loading. In order to provide the most astute evidence to support the most appropriate time to load implants, study designs should be randomized -controlled clinical and a follow-up period greater than twenty-four months (78).
One review exists that compares three different timing of loads: early progressive loading, early functional loading, and immediate-early functional loading. In the early progressive loading, the patient does not wear their dentures for one to two weeks, or else worn, but completely relieved from the healing abutment. Typically, the practitioner relines the prosthesis at three to four months when the definitive prosthesis connects to attachments (ball or bar assembly). In early functional loading, there is a hiatus after surgery for two weeks prior to relining the dentures. Then, the protocol connects the retentive components (ball attachments) within three weeks. Finally, for immediate-early functional loading protocols, the protocol requires to connect the retentive attachments within five days. The authors stated that the loading differences between the three groups are rather tenuous, since the time and method of loading overlaps (79).
Studies also suggest that implants splinted together with a bar within a short period of time to prevents axial rotation and implant micromotion (80,81). However, other studies describe the use of fewer implants (minimum of two) that were left exposed and unsplinted after an initial healing phase of two to three weeks. Therefore, one can contend that splinting implants in the anterior mandible is not a definite requirement for osseointegration with these protocols (82). In addition splinted or unsplinted design seems to not influence implant survival rate and periimplant outcome (83).

*Implant success rate*
Studies carried out in the last years to assess the benefits of implant-supported overdenture with at least five years of follow-up show that survival of implants supporting overdentures in the medium and long term is very high. Table-1 displays a report of several studies.
The analysis of the available literature shows that im-

plant-supported prosthetic restoration offers excellent rates of success in mandible and maxilla if practitioners follow common protocols (84,85).
In many cases, the edentulous maxilla rehabilitation requires more elective procedures rather than in mandible, because a different degree of atrophy, prospective location of the implants and inclination of the implant axis, tissue volume dimensions, facial morphology, esthetics, function and phonetics exists.
There is a high failure rate for maxillary overdentures, i.e. over 20% (86). A critical analysis of the treatment outcomes reveals that overdenture is often a treatment option in compromised patients, where fixed prostheses fails (71). Otherwise, there is high survival rate of implant when the overdenture is well planned (43).

## Discussion

A variety of treatment options exist to rehabilitate fully edentulous patients: two to up to six or more implants, removable implant-retained overdenture, fixed implant-supported bridge, etc (87). The basis for individual treatment options is a factor of:

- Patient-related factors: patient's expectations, subjective aesthetics, phonetics, financial commitment, comfort, compliance, and maintenance of oral hygiene;
- Absence of signs and symptoms: persistent pain, infection, neuropathy, invasion of the mandibular channel or chronic sinusitis;
- Extraoral factors: patient's co-morbidities, objective aesthetics, facial profile, type of smile line, and lip support;
- Intraoral factors: local anatomy (fibromas, bands, muscle attachments, floor of mouth frenula), maxillo-mandibular relationship, presence or absence of buccal fold, keratinized attached mucosa and jaw bone quality and quantity, edentulous crestal morphology (shape, height and width) and prosthesis crown position in the sagittal plane.

The implant-retained overdenture proves to be predictable and effective management for edentulous patients. Biological (e.g. non-osseointegration, peri-implantitis, mucositis with or without inflammatory hyperplasia) and biomechanical complications (e.g. bar fracture, fracture or detachment of the clip anchorage fracture of the prosthesis or its parts, etc.) can occur, but the literature still reports years of success (88).
The implant-supported overdenture's biggest advantage is a better distribution of occlusal forces between implant and bone. This results in a reduction of alveolar ridge resorption; longitudinal clinical studies report a loss of bone height adjacent to implants of approximately 1.2 mm at the end of the first-year and 0.2 mm annually. This resorption is lower compared with a reduction of 4 mm at the end of the first year and 0.4 mm annually after tooth extraction when fitting with conventional dentures (89). Many options are available for retention of the prosthesis, including magnets, clips, bars and ball. The resultant implant-supported overdenture has good stability and retention. Most authors agree on a requirement of a passive fit between the prosthesis framework and osseointegrated dental implants.
In 1983, Branemark defined passive fit, and he proposed this should be at the level of 10 µm to enable bone maturation and remodeling in response to occlusal loads (90).
In 1991, Jemt defined passive fit as the level that did not cause any long-term clinical complications (91). And he suggests misfits of smaller than 150 µm as acceptable. Although these preceding values are a reference, they are of empirical origin.
The survival rates for the mandible are clearly better than the maxilla – a function of the mandible's denser bone and shorter prosthetic lever arms that promote resist a hinging movement. Treatment considerations for implant overdentures on the maxilla appear to be different than for those on the mandible. 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. The maxilla's bone trabecular bone is less dense and not as capable of stabilizing and supporting implants. Anatomic limitations and bony morphology may compromise implant number, length, and inclination. The maxillary overdenture reports a greater burden of maintenance care and higher failure rates in contrast to the mandible.
In longitudinal studies, the average annual alveolar ridge height resportion is approximately 0.4 mm in the edentulous anterior mandible. The anterior mandibular bone under an implant overdenture may resorb as little as 0.5 mm over a five-year period, and long-term resorption may remain at 0.1 mm annually (57,58). One study observes that the functioning or loading of implants creates positive bone remodeling in the anterior mandible (89). This effect appears to be independent of the attachment system (18).
Overdenture wearers show a masticatory performance and chewing cycles similar to those with natural teeth. They also document an increase of comfort and satis-

| Study | Implant success rate | | Follow up |
|---|---|---|---|
| | Maxilla | Mandible | |
| *Naert* [33] | 88,6% | | 4 years |
| *Bergendal* [43] | 75.4% | 100% | 7 years |
| *Naert* [40] | | 100% | 10years |
| *Jemt* [91] | 72.4% | 94.5% | 5-years |
| *Kiener* [30] | 95.5% | | 8 years |
| *Visser* [21] | | 99.9% | 5 years |

Table 1. Clinical studies showing implant success rate in maxillary and mandibular overdentures.

faction in patients with their overdentures compared to patients wearing conventional dentures. A study addressing two mandibular implant-supported overdenture concludes that this significantly improves measure of oral function. After ten years of function, values for maximum bite force and masticatory performance remain unaltered. Thus, the improved oral function lasts for a long period of time with high levels of satisfaction regarding various aspects of patients denture function. If similar oral functions problems exist, implant-supported patients report a greater level of satisfaction (92,93).
The literature indicates that the implant overdenture prosthesis provides predictable results – enhanced stability, function and a high-degree of satisfaction compared to conventional removable dentures. This is as a result of positive outcomes of long-term clinical studies, specifically using a conventional loading protocol. Further studies focusing on immediate and early loading in maxillary overdenture are necessary.

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