

Attachment systems for mandibular implant overdentures: a systematic review

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PURPOSE. The aim of this systematic review was to address treatment outcome according to attachment systems for mandibular implant overdentures in terms of implant survival rate, prosthetic maintenance and complications, and patient satisfaction. **MATERIALS AND METHODS.** A systematic literature search was conducted using PubMed and hand searching of relevant journals considering inclusion and exclusion criteria. Clinical trial studies on mandibular implant overdentures until August, 2010 were selected if more than one type of overdenture attachment was reported. Twenty four studies from 1098 studies were finally included and the data on implant survival rate, prosthetic maintenance and complications, patient satisfaction were analyzed relative to attachment systems. **RESULTS.** Four studies presented implant survival rates (95.8 - 97.5% for bar, 96.2 - 100% for ball, 91.7% for magnet) according to attachment system. Ten other studies presented an implant survival rate ranging from 93.3% to 100% without respect to the attachment groups. Common prosthetic maintenance and complications were replacement of an assay for magnet attachments, and activation of a matrix or clip for ball or bar attachments. Prosthetic maintenance and complications most commonly occurred in the magnet groups. Conflicting findings were found on the rate of prosthetic maintenance and complications comparing ball and bar attachments. Most studies showed no significant differences in patient satisfaction depending upon attachment systems. **CONCLUSION.** The implant survival rate of mandibular overdentures seemed to be high regardless attachment systems. The prosthetic maintenance and complications may be influenced by attachment systems. However patient satisfaction may be independent of the attachment system. [J Adv Prosthodont 2012;4:197-203]

KEY WORDS: Denture; Overlay; Mandibular prosthesis; Dental implants; Outcome assessment; Patient satisfaction

INTRODUCTION

Edentulous patients can have substantial difficulties using their conventional complete dentures due to a lack of retention, support, and stability and the related compromise in chewing ability.¹ The treatment options to manage completely edentulous patients are either a complete denture or an implant-supported prosthesis. A mandibular implant overdenture has been shown to improve masticatory function and patient satisfaction in complete denture patients who prefer an implant overdenture option.² Meanwhile, a mandibular implant overdenture has been reported to be simpler and more cost effective than an implant fixed prosthesis.³ A two-implant overdenture in the mandible opposing a maxillary complete denture has even been considered the first treatment choice for completely edentulous patients.^{4,5}

To enhance retention and stability of denture, various overdenture attachments systems can be used for mandibular implant overdentures. The most popular attachment systems are bar, ball, magnet types, and a number of individual mechanical attachments similar in size and function to the ball type. Generally, the selection of an attachment system has been dependent on the experience and preference of practitioners. Few studies have compared different attachments in a manner useful for clinical decision-making. A few systematic review articles have reported the implant survival rate,⁶ prosthetic complications⁷ and patient satisfaction⁸ of a mandibular overdenture without comparing attachment systems. The review by Trakas *et al.*⁹ compared attachment systems based on various implant survival, prosthetic maintenance and patient satisfaction outcomes. However, this review had a lack of explanation about how data was collected according to inclusion and

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exclusion criteria. Therefore, a systematic review on implant overdenture attachment systems is required to focus on various published outcomes.

This systematic review aimed to address treatment outcomes depending upon attachment systems for mandibular implant supported overdentures in terms of 1) implant survival rate, 2) prosthetic maintenance and complications, and 3) patient satisfaction.

MATERIALS AND METHODS

The PICO format (Population, Intervention, Comparisons, Outcomes)¹⁰ was used to define a clinical question with clear inclusion criteria. The specific question and inclusion criteria were clinical studies involving completely edentulous participants (P) requiring mandibular implant overdentures opposing conventional maxillary complete dentures (I). The chosen studies were then further divided according to overdenture attachment systems (primarily bar, ball, or magnet attachments) that were used (C). Survival rate of implants, prosthetic maintenance and complications, and patient's satisfaction were the outcomes (O) evaluated.

A systematic literature search was conducted using the combined MeSH terms "mandibular prosthesis" or "Denture, Overlay" and "dental implants" or "dental prosthesis, implant supported" and "clinical study" or "comparative study" or "outcome assessment" or "epidemiologic studies" or "intervention studies" or "patient satisfaction" and limited by "Human" and "English" in the data base, Medical Literature Analysis and Retrieval System Online (MEDLINE). The aim was to identify all publications reporting on attachment systems for mandibular supported overdentures up to August 1, 2010.

The electronic search by combined mesh term was further augmented by hand search through the following journals: Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, Implant Dentistry, International Journal of Oral and Maxillo-facial Implants, International Journal of Oral and Maxillo-facial Surgery, International Journal of Periodontics & Restorative Dentistry, International Journal of Prosthetics, Journal of Clinical Periodontology, Journal of Dental Research, Journal of Oral Implantology, Journal of Oral and Maxillo-facial Surgery, Journal of Oral Rehabilitation, Journal of Periodontology, Journal of Prosthetics, Journal of Prosthetic Dentistry, and Periodontology 2000.

Only RCT, quasi-randomized and comparative clinical trial studies on mandibular implant overdentures (MIO) until August, 2010 were selected if more than one type of overdenture attachment was reported. Included studies also reported at least one of the sought outcomes (implant survival rate, prosthetic maintenance and complications, or patient's satisfaction). To compare the studies between attachments on MIO, the number of implants was fixed to two. Only root form endosseous

Table 1. Final inclusion and exclusion criteria for systematic review

Inclusion Criteria
<ul style="list-style-type: none"> • RCT and clinical trial studies on mandibular implant overdentures (MIO) until August, 2010 • Comparative studies between attachments on MIO with same number of implants • Root form endosseous standard implants • Upper complete denture • Conventional loading • Published in English
Exclusion Criteria
<ul style="list-style-type: none"> • Case reports or technical reports without statistical comparison • Study duration less than 1 year of function • Rigid type of application with milled bar and telescopic abutments • Combination or Cantilevered application of attachments • Paper without abstract

standard implants were considered. The opposing dentition was a complete maxillary denture. All implants were conventionally loaded with delayed healing after extraction and before loading. Finally, studies published in English were included. Meanwhile, case reports or technical reports without statistical comparison were excluded. The duration of follow-up period less than 1 year of function was excluded. Studies with a lack of at least one of the sought outcomes were excluded. Both rigid types of overdenture applications, such as milled bar or combinations of attachment types, and cantilevered applications of attachments were excluded. Papers without abstracts were also excluded (Table 1).

At the outset, two independent reviewers evaluated the selection of the articles according to the inclusion and exclusion criteria. Extracted data were the sample size, patient age, observation period, type of implant, number of implant, type of attachment, treatment outcomes and the outcome of statistical analysis comparing any of the following quantifiable factors: 1) implant survival rate, 2) prosthetic maintenance and complications, 3) patient satisfaction.

The implant survival rate denoted the raw percentage of implants still present at follow-up after initial placement of implants. Prosthetic maintenance and complications denoted mechanical damage of the implant superstructures. Among these, 'matrix or clip loosening', 'detachment or loss of matrix' and 'fracture of denture' were included. Prosthetic maintenance and complications were classified to what type and how often maintenance and complications relative to the attachment systems commonly occurred. Patient satisfaction concerning chewing ability, phonetics, and social function were evaluated by questionnaire, visual analogue scale (VAS), or in some cases by patient preference. Data was insufficient to conduct a statistical meta-analysis on those factors, so data were descriptively analyzed.

RESULTS

The PubMed search yielded 1098 titles. Forty six publications were selected by independent screening of the titles and abstracts from the PubMed search. In addition, 3 publications were also included by hand search. Based upon reading these 49 full text articles, a total of 24 studies were finally included (Fig. 1). Then the data on survival rate of implants, prosthetic maintenance and complications, and patient satisfaction were collected (Table 2).

Fourteen studies reported the implant survival rate of implant supported overdentures. Among them, four studies¹¹⁻¹⁴ presented data on the implant survival rate according to attachment systems (Table 3). The 3 year randomized controlled study by Davis *et al.*¹³ showed a survival rate of 100% in the ball group and 91.7% in the magnet group. However, a follow-up publication of apparently the same study showed a slightly reduced survival rate 96.2% in the ball group and 91.7% in the magnet group.¹⁵ Meanwhile, another the 3 year prospective study by Davis *et al.*¹² showed an implant survival rate of 95.8%

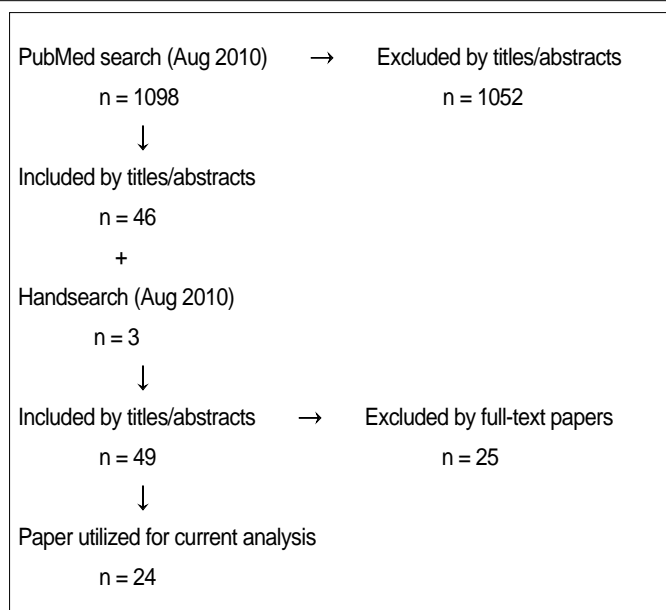


Fig. 1. Flowchart of search strategy.

Table 2. Included papers by inclusion criteria

Study	Year	Study design	Follow-up (year)	Implant type	Type of attachment
Mericske-Stern <i>et al.</i> ¹⁶	1994	PS	5	Straumann	Bar (Bonefit), Ball (Bonefit)
Naert <i>et al.</i> ¹⁷	1994	RCT	3	Nobelbiocare	Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)
Davis <i>et al.</i> ¹³	1996	QRCT	3	Astra	Ball (Gold), Magnet (Nd-Fe-Bo)
Davis <i>et al.</i> ¹⁵	1997	QRCT	4	Astra	Bar (Gold), Ball (Gold), Magnet (Nd-Fe-Bo)
Gotfredsen <i>et al.</i> ¹⁸	1997	PS	4.5	Astra	Bar (CM rider), Ball (Astra ball housing)
Wismeijer <i>et al.</i> ²⁹	1997	RCT	1.3	Straumann	Bar (Dolder bar), Ball (Dalla Bona)
Naert <i>et al.</i> ¹⁹	1998	RCT	5	Nobelbiocare	Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)
Davis <i>et al.</i> ¹¹	1999	QRCT	5	Astra	Ball (Gold), Magnet (Nd-Fe-Bo)
Naert <i>et al.</i> ²⁰	1999	RCT	5	Nobelbiocare	Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)
Wismeijer <i>et al.</i> ¹⁴	1999	RCT	1.6	Straumann	Bar (Dolder bar), Ball (Dalla Bona)
Gotfredsen <i>et al.</i> ²¹	2000	RCT	5	Astra	Bar (CM rider), Ball (Astra ball and housing)
Payne <i>et al.</i> ²⁸	2000	RCT	3	Nobelbiocare	Bar (Nobelbiocare), Ball (plastic cap, rubber O-ring)
Davis <i>et al.</i> ¹²	2000	PS	3	Astra	Bar (Gold), Ball (Gold), Magnet (Nd-Fe-Bo)
Walton <i>et al.</i> ²⁶	2002	RCT	1	Nobelbiocare	Bar (Nobelbiocare round gold bar), Ball (Nobelbiocare ball, titanium cap)
Walton ²²	2003	RCT	3	Nobelbiocare	Bar (Nobelbiocare round gold bar), Ball (Nobelbiocare ball, titanium cap)
Assad <i>et al.</i> ⁴¹	2004	PS	1.5	Dyna	Bar (metal housing & plastic clip), Magnet (Dyna)
Naert <i>et al.</i> ²³	2004	RCT	10	Nobelbiocare	Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)
Naert <i>et al.</i> ³²	2004	RCT	10	Nobelbiocare	Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)
Timmerman <i>et al.</i> ³¹	2004	RCT	8	Straumann	Bar (Dolderbar), Ball (Dalla Bona)
MacEntee <i>et al.</i> ²⁷	2005	RCT	3	Nobelbiocare	Bar (Nobel Biocare round gold bar), Ball (Nobelbiocareball, titanium cap)
Stoker <i>et al.</i> ²⁵	2007	RCT	8	Straumann	Bar (Dolderbar), Ball (Dalla Bona)
Abd El-Dayem ⁴²	2009	RCT	1.5	Dyna	Cast bar, Prefabricated bar (Dyna)
Cune <i>et al.</i> ²⁹	2010	RCT/CO	10	Friadent	Bar (Friadent), Ball (Friadent), Magnet (Dyna)
Kleis <i>et al.</i> ²⁴	2010	RCT/PS	1	BIOMET 3i	Ball (Dal-Ro/O-Ring), Locator (Zest Anchor)

RCT: randomized controlled trial, QRCT: quasi- randomized controlled trial, PS: prospective study.

Table 3. Survival rate, prosthetic maintenance and complications, and patient satisfaction of the implant supported mandibular overdentures

Study	No. of Patients/ Implants	Attachment systems	Implant survival rate (%)	Type of prosthetic maintenance and complication	Rate of prosthetic maintenance and complication	Patient's satisfaction
Mericske-Stern <i>et al.</i> ¹⁶	33/66	bar, ball	95	NR	NR	NR
Naert <i>et al.</i> ¹⁷	36/72	bar, ball, magnet	100	bar: clip activation ball: matrix retightening magnet: wear, corrosion	ball, magnet > bar	NS
Davis <i>et al.</i> ¹³	25/52	ball, magnet	ball: 100 magnet: 91.7	ball: matrix retightening magnet: base adjustment	NS	NR
Davis <i>et al.</i> ¹⁵	25/52	bar, ball magnet	96.2	ball: matrix retightening magnet: assay replace	NS	NR
Gotfredsen <i>et al.</i> ¹⁸	32/69	ball, magnet	98.5	NR	NR	NR
Wismeijer <i>et al.</i> ³⁰	110/283	bar, ball	NR	NR	NR	NS
Naert <i>et al.</i> ¹⁹	36/72	bar, ball, magnet	98.7	ball: matrix retightening magnet: assay replace	NS	ball is better than magnet
Davis <i>et al.</i> ¹¹	25/52	ball, magnet	ball: 96.2 magnet: 91.7	bar: clip activation ball: matrix retightening magnet: wear, corrosion	magnet > ball > bar	NS
Naert <i>et al.</i> ²⁰	36/72	bar, ball, magnet	98.7	NR	NR	NR
Wismeijer <i>et al.</i> ¹⁴	110/283	bar, ball	bar: 97.5 ball: 100	bar: clip activation ball: matrix activation	bar > ball (1 yr), no difference (2-5 yr)	NR
Gotfredsen <i>et al.</i> ²¹	26/52	bar, ball	98.1	NR	NR	NR
Payne <i>et al.</i> ²⁸	59/104	bar, ball	NR	bar: clip activation ball: O-ring change	NS (single > multiple)	NS
Davis <i>et al.</i> ¹²	37/74	bar, ball, magnet	bar: 95.8 ball: 100 magnet: 91.7	bar: clip activation ball: matrix retightening magnet: wear, corrosion	ball, magnet > bar	NR
Walton <i>et al.</i> ²⁶	64/128	bar, ball	NR	bar: clip replacement ball: cap-spring replacement	ball > bar	NR
Walton ²²	100/200	bar, ball	100	bar: clip activation ball: matrix activation	ball > bar	NR
Assad <i>et al.</i> ⁴¹	10/20	bar, magnet	NR	NR	NR	NR
Naert <i>et al.</i> ²³	36/72	bar, ball, magnet	100	NR	NR	NR
Naert <i>et al.</i> ³²	36/72	bar, ball, magnet	NR	bar: clip activation ball: matrix retightening magnet: wear, corrosion	magnet > ball > bar	bar & ball are better than magnet
Timmerman <i>et al.</i> ³¹	111/294	single bar, triple bar, ball	NR	NR	NR	bar is better than ball
MacEntee <i>et al.</i> ²⁷	68/136	bar, ball	NR	bar: clip activation ball: matrix activation	ball > bar	bar is better than ball
Stoker <i>et al.</i> ²⁵	110/294	single bar, triple bar, ball	NR	NR	ball > bar	NR
Abd El-Dayem <i>et al.</i> ⁴²	10/20	cast bar, prefabricated bar	NR	NR	NR	NR
Cune <i>et al.</i> ²⁹	18/36	bar, ball, magnet	NR	NR	NR	NS
Keis <i>et al.</i> ²⁴	60/120	ball, locator	93.3	ball: O-Ring change locator: female part change	locator > ball	NS

NS: Not significant; NR: Not recorded.

in the bar, 100% in the ball, and 91.7% in the magnet attachment groups. According to a 19 month randomized controlled study by Wismeijer *et al.*,¹⁴ an overall implant survival rate of 97.5% was found in the bar attachment groups (97.2% in single bar, 97.7% in triple bar) and 100% in the ball attachment group. Ten other studies¹⁵⁻²⁴ presented data of the implant survival rate without respect to the attachment groups ranging from 93.3% to 100%.

Thirteen studies presented data on the type of routine prosthetic maintenance and complications (Table 3). Most common prosthetic maintenance and complications events were replacement of an assay for magnet attachment, activation of a matrix or clip for ball or bar attachment. Meanwhile the study by Stoker *et al.* showed denture base adjustment as the main complication for bar and ball attachment overdentures.²⁵

Fourteen studies compared the rate of prosthetic maintenance and complications according to attachment systems. According to Naert *et al.*^{17,20,23} and Davis *et al.*,¹² the most frequent prosthetic maintenance and complications occurred for magnet attachments due to wear and corrosion. There was conflicting information among studies on the rate of prosthetic maintenance and complications for the ball and bar attachments. The study of Walton,²² Walton *et al.*²⁶ and MacEntee *et al.*²⁷ showed ball attachment had more prosthetic maintenance and complications. On the other hand, Gotfredsen and Holm²¹ showed that the bar attachments had more prosthetic maintenance and complications than ball attachments during the first year. Kleis *et al.*²⁴ found more maintenance and complications for Locator type attachments than ball attachments. Locators are an individual mechanical attachment roughly similar in size and function to a ball attachment. Several studies^{11,13,15,21,28} showed the type and rate of prosthetic maintenance and complications in mandibular overdentures did not differ significantly according to the attachment system (Table 3).

Ten studies presented data on patient satisfaction. Most of these^{17,20,24,27-31} showed no significant differences in patient complaint, overall satisfaction according to VAS and preference where available according to attachment systems. Two studies^{11,32} mentioned that the patient satisfaction of magnet attachment was lower than that of other attachments. The studies by Davis *et al.*¹¹ showed the magnet group was less stable and chewing ability was less effective according to patients compared to the ball group. The 10-year randomized controlled study by Naert *et al.*³² found that prosthesis stability and chewing comfort of mandibular overdentures were significantly lower in the magnet group than the bar and ball groups. However, Davis *et al.*¹¹ reported that both ball and magnet attachments improved patient satisfaction with chewing compared to complete dentures without implants. In addition Naert *et al.*³² also reported that overall patient satisfaction with overdentures was higher than with complete dentures in bar, ball, and magnet attachment groups.

DISCUSSION

This systematic review addressed implant survival rate, prosthetic maintenance and complications, and patient satisfaction of mandibular implant supported overdentures according to different attachment systems for edentulous patients. This included twenty RCTs comparing different attachment systems and four prospective clinical trials which were of a lower level of evidence than RCTs.

Based on the articles in which an observation period ranged from 1 to 10 years, the survival rates of the implants which supported the overdentures in the mandible, ranged from 91.7% to 100%, and the mean implant survival rate was over 98%, both of which supports the presumption that this treatment has a good prognosis in a long-term perspective. This high implant survival rate was coincident with the result of previous reports which showed an implant survival rate of more than 97.2% for mandibular fixed prosthesis and more than 97.1% for mandibular overdentures.³³ Four studies¹¹⁻¹⁴ presenting data on implant survival according to attachment systems, did not specify censored data for a cumulative survival rate making it impossible to calculate an implant survival rate according to different attachment systems through meta-analysis.

It has previously been reported that most prosthetic maintenance and complications occur during the first year of loading.²⁷ In the present review pooled evidence was inconclusive in this regard. Magnet attachments showed the most common prosthetic maintenance and complications due to wear and corrosion. Corrosion of magnetic attachments occurs by breakdown of the encapsulating material and diffusion of moisture and ions through the seal.³⁴ AlNiCo alloys, which have been used in dentistry for many years as a magnet material, were especially easily corroded in saliva rapidly weakening their attractive force.³⁵ However, recently rare-earth alloys, such as neodymium (NdFeB) and new laser-welding technique make it possible to produce a stronger and potentially more durable magnetic force.^{36,37} In spite of the improved performance of magnet attachments, well-organized long-term randomized controlled clinical trials have not been reported to date.

The other most common maintenance requirements related to clip loosening in bar attachments and matrix loosening in ball attachments. However, there were conflicting data on whether bar or ball attachments required more maintenance. A Vancouver group found that ball attachments (2.25 mm ball abutment with titanium alloy cap, Nobel Biocare) had more prosthetic maintenance and complications than bar attachments (round gold bar system, Nobel Biocare).^{22,26,27} The C-spring in the Ti alloy cap which they used had a tendency to be loose or fractured due to excessive wear of the patrices to the springs encased within the matrix housings.^{38,39} On the other hands, Gotfredsen and Holm²¹ found that the bar attachment had more prosthetic maintenance and complications than the ball

attachment (Dalla Bona Spherical Gold alloy male and female) at the first year. In addition it was generally more time consuming to replace clips or repair overdentures in the bar group compared to that in the ball group. New developed elliptical gold matrices of ball attachment had large wings to avoid detachment from denture base and made it possible to reduce complication and maintenance rate.

Some studies^{27,31} demonstrated that implant supported overdentures improved the participants' overall satisfaction in comparison with the previous conventional complete dentures. In ten studies, it was mentioned that there were no significant differences in the preference of a specific attachment system in regard to aspects of pain, comfort, appearance, mastication, speech, stability and oral hygiene. Two studies^{11,32} mentioned that patient satisfaction with magnet attachments were less than with bar and ball attachments. When comparing magnet with ball attachments, the magnet group also showed significantly less retention.¹¹ Although overall patients satisfaction was similar for the three attachment types, patients in the magnet group were less satisfied with denture stability and chewing ability.³² However, recently developed magnets with improved corrosion resistance and a stronger magnetic force, may still be a useful treatment option for edentulous patient with weak muscle disease such as Parkinson's disease patients, because they not only keep the denture stable, but also need less force to insert and remove the denture.

The survival rate of implants appears likely primarily influenced by non-prosthetic factors, such as implant surface roughness, bone quantity and quality, smoking habits, and history of periodontitis.⁹ Conversely a surgeon's ability to place parallel implants may affect not only the implant survival rate but also, prosthetic maintenance and complications, and patient satisfaction. In one study, Walton *et al.*⁴⁰ found that a high complication rate with a ball attachment matrix could be due to the misalignment implants. The number of repairs was significantly higher when the implant analogues were inclined lingually more than 6.0 degrees or facially fewer than 6.5 degrees, which is usually the inclination of the lower incisor teeth.⁴⁰ Better consistency in the horizontal level, angulation, and distance from the midline of the two implants might bring fewer prosthetic complications and better patient satisfaction. However, the evidence for this is unclear.

CONCLUSION

The implant survival rate of mandibular implant overdentures seemed to be high regardless attachment systems. The prosthetic maintenance and complications may be influenced by attachment systems. However patient satisfaction may be independent depending upon attachment system.

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