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...
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 Maxillofacial 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 trials 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 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.

| Table 1. Final inclusion and exclusion criteria for systematic review |
|------------------------|-----------------|------------------|-------------------|
| **Inclusion Criteria**  | **Exclusion Criteria** |
| • RCT and clinical trial studies on mandibular implant overdentures (MIO) until August, 2010 | • Case reports or technical reports without statistical comparison |
| • Comparative studies between attachments on MIO with same number of implants | • Study duration less than 1 year of function |
| • Root form endosseous standard implants | • Rigid type of application with milled bar and telescopic abutments |
| • Upper complete denture | • Combination or Cantilevered application of attachments |
| • Conventional loading | • Paper without abstract |
| • Published in English | |
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 studies\textsuperscript{11–14} presented data on the implant survival rate according to attachment systems (Table 3). The 3 year randomized controlled study by Davis et al.\textsuperscript{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.\textsuperscript{15} Meanwhile, another the 3 year prospective study by Davis et al.\textsuperscript{12} showed an implant survival rate of 95.8%.

**Table 2.** Included papers by inclusion criteria

| Study             | Year | Study design | Follow-up (year) | Implant type                      | Type of attachment                                      |
|-------------------|------|--------------|------------------|----------------------------------|---------------------------------------------------------|
| Mericske-Stern et al.\textsuperscript{16} | 1994 | PS           | 5                | Straumann                        | Bar (Bonefit), Ball (Bonefit)                           |
| Naert et al.\textsuperscript{17} | 1994 | RCT          | 3                | Nobelbiocare                     | Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)   |
| Davis et al.\textsuperscript{13} | 1996 | QRCT         | 3                | Astra                            | Ball (Gold), Magnet (Nd-Fe-Bo)                          |
| Davis et al.\textsuperscript{15} | 1997 | QRCT         | 4                | Astra                            | Bar (Gold), Ball (Gold), Magnet (Nd-Fe-Bo)             |
| Gotfredsen et al.\textsuperscript{16} | 1997 | PS           | 4.5              | Astra                            | Bar (CM rider), Ball (Astra ball housing)              |
| Wismeijer et al.\textsuperscript{29} | 1997 | RCT          | 1.3              | Straumann                        | Bar (Dolder bar), Ball (Dalla Bona)                    |
| Naert et al.\textsuperscript{19} | 1998 | RCT          | 5                | Nobelbiocare                     | Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)   |
| Davis et al.\textsuperscript{31} | 1999 | QRCT         | 5                | Astra                            | Bar (Gold), Magnet (Nd-Fe-Bo)                          |
| Naert et al.\textsuperscript{20} | 1999 | RCT          | 5                | Nobelbiocare                     | Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)   |
| Wismeijer et al.\textsuperscript{14} | 1999 | RCT          | 1.6              | Straumann                        | Bar (Dolder bar), Ball (Dalla Bona)                    |
| Gotfredsen et al.\textsuperscript{31} | 2000 | RCT          | 5                | Astra                            | Bar (CM rider), Ball (Astra ball and housing)          |
| Payne et al.\textsuperscript{28} | 2000 | RCT          | 3                | Nobelbiocare                     | Bar (Nobelbiocare), Ball (plastic cap, rubber O-ring)  |
| Davis et al.\textsuperscript{12} | 2000 | PS           | 3                | Astra                            | Bar (Gold), Ball (Gold), Magnet (Nd-Fe-Bo)             |
| Walton et al.\textsuperscript{26} | 2002 | RCT          | 1                | Nobelbiocare                     | Bar (Nobelbiocare round gold bar), Ball (Nobelbiocare ball, titanium cap) |
| Walton\textsuperscript{22} | 2003 | RCT          | 3                | Nobelbiocare                     | Bar (Nobelbiocare round gold bar), Ball (Nobelbiocare ball, titanium cap) |
| Assad et al.\textsuperscript{41} | 2004 | PS           | 1.5              | Dyna                             | Bar (metal housing & plastic clip), Magnet (Dyna)       |
| Naert et al.\textsuperscript{25} | 2004 | RCT          | 10               | Nobelbiocare                     | Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)   |
| Naert et al.\textsuperscript{32} | 2004 | RCT          | 10               | Nobelbiocare                     | Bar (Dolder bar), Ball (Nobelbiocare), Magnet (Dyna)   |
| Timmerman et al.\textsuperscript{31} | 2004 | RCT          | 8                | Straumann                        | Bar (Dolderbar), Ball (Dalla Bona)                     |
| MacEntee et al.\textsuperscript{27} | 2005 | RCT          | 3                | Nobelbiocare                     | Bar (Nobel Biocare round gold bar), Ball (Nobiblocareball, titanium cap) |
| Stoker et al.\textsuperscript{25} | 2007 | RCT          | 8                | Straumann                        | Bar (Dolderbar), Ball (Dalla Bona)                     |
| Abd El-Dayem\textsuperscript{46} | 2009 | RCT          | 1.5              | Dyna                             | Cast bar, Prefabricated bar (Dyna)                     |
| Cune et al.\textsuperscript{27} | 2010 | RCT/CO       | 10               | Friadent                         | Bar (Friadent), Ball (Friadent), Magnet (Dyna)         |
| Kleis et al.\textsuperscript{44} | 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 et al. | 33/66                    | bar, ball             | 95                        | NR                                             | NR                                              | NR                     |
| Naert et al.         | 36/72                    | bar, ball, magnet     | 100                       | bar: clip activation                           | ball, magnet > bar                              | NS                     |
| Davis et al.         | 25/52                    | ball, magnet          | 95.7                      | ball: matrix retightening                       | NS                                              | NR                     |
| Davis et al.         | 25/52                    | bar, ball, magnet     | 96.2                      | ball: matrix retightening                       | NS                                              | NR                     |
| Gotfredsen et al.    | 32/69                    | ball, magnet          | 98.4                      | NR                                              | NR                                              | NR                     |
| Wismeijer et al.     | 110/283                  | bar, ball             | NR                        | bar: matrix retightening                       | NS                                              | NS                     |
| Naert et al.         | 36/72                    | bar, ball, magnet     | 98.7                      | bar: matrix retightening                       | NS                                              | NS                     |
| Davis et al.         | 25/52                    | ball, magnet          | 96.2                      | bar: matrix retightening                       | magnet > bar > bar                              | NS                     |
| Naert et al.         | 36/72                    | bar, ball, magnet     | 98.7                      | NR                                              | NS                                              | NR                     |
| Wismeijer et al.     | 110/283                  | bar, ball             | 97.7                      | bar: matrix retightening                       | NS                                              | NS                     |
| Gotfredsen et al.    | 26/52                    | bar, ball             | 98.1                      | NR                                              | NS                                              | NS                     |
| Payne et al.         | 59/104                   | bar, ball             | NR                        | bar: matrix retightening                       | NS                                              | NS                     |
| Davis et al.         | 37/74                    | bar, ball, magnet     | 95.8                      | bar: matrix retightening                       | ball, magnet > bar                              | NS                     |
| Walton et al.        | 64/128                   | bar, ball             | NR                        | bar: matrix retightening                       | ball > bar                                      | NR                     |
| Walton               | 100/200                  | bar, ball             | 100                       | bar: clip activation                           | bar > bar                                       | NR                     |
| Assad et al.         | 10/20                    | bar, magnet           | NR                        | NR                                              | NR                                              | NR                     |
| Naert et al.         | 36/72                    | bar, ball, magnet     | 100                       | NR                                              | NR                                              | NR                     |
| Naert et al.         | 36/72                    | bar, ball, magnet     | NR                        | bar: matrix retightening                       | magnet > ball > bar                              | bar & ball are better than magnet |
| Timmerman et al.     | 111/294                  | single bar, triple bar, ball | NR                      | NR                                              | NR                                              | bar is better than ball |
| MacEntee et al.      | 68/136                   | bar, ball             | NR                        | bar: matrix retightening                       | ball > bar                                      | bar is better than ball |
| Stoker et al.        | 110/294                  | single bar, triple bar | NR                        | bar: matrix retightening                       | ball > bar                                      | NR                     |
| Abd El-Dayem et al.  | 10/20                    | single bar, triple bar, ball cast bar, prefabricated bar | NR                      | NR                                              | NR                                              | NR                     |
| Cune et al.          | 18/36                    | bar, ball, magnet     | NR                        | ball: O-Ring change                            | locator > ball                                  | NS                     |
| Keis et al.          | 60/120                   | ball, locator         | 93.3                      | ball: O-Ring 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., 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 studies 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.

Fourteen studies compared the rate of prosthetic maintenance and complications according to attachment systems. According to Naert et al. and Davis et al., 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 bar and ball attachments. The study of Walton, Walton et al. and MacEntee et al. showed ball attachment had more prosthetic maintenance and complications. On the other hand, Gotfredsen and Holm showed that the bar attachments had more prosthetic maintenance and complications than ball attachments during the first year. Kleis et al. 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 mentioned that the patient satisfaction of magnet attachment was lower than that of other attachments. The studies by Davis et al. 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. 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. reported that both ball and magnet attachments improved patient satisfaction with chewing compared to complete dentures without implants. In addition Naert et al. 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. Four studies 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. 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. 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. 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. 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). 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. On the other hands, Gotfredsen and Holm 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 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 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. 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. 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. Conversely a surgeon's ability to place parallel implants may affects not only the implant survival rate but also, prosthetic maintenance and complications, and patient satisfaction. In one study, Walton et al. 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. 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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