REVIEWS

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Precision Attachments: A Review to Guide Clinicians

Precyzyjne elementy retencyjne – przegląd piśmiennictwa

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;
D – writing the article; E – critical revision of the article; F – final approval of article

Abstract

The present paper is intended to compare the results gathered by multiple authors on the different precision attachments available to help clinicians in their daily practice to make the right decision while planning an overdenture. The literature has been gathered through PubMed and from data gathered and published from the Department of Prosthodontics, Poznań University of Medical Sciences.

Patients with overdentures are generally satisfied no matter what type of system is used. The clinician, therefore, is usually guided by the patient's anatomy. Correct planning of the position of the implants is imperative for successful treatment. Moreover, the clinician should also take into account the opposing arch for a correct restoration. The paper aims to clarify the differences between various precision attachment systems for overdentures. Clinicians, therefore, will have a better understanding and confidence in making the right decision while rehabilitating a patient with an overdenture, improving patients' quality of life and satisfaction (**Dent. Med. Probl. 2016, 53, 4, 559–565**).

Key words: overdenture, precision attachments, locators, ball-attachments.

Słowa kluczowe: proteza nakładowa, elementy precyzyjne, lokator, zatrzaski kulkowe.

Complete edentulism is still a common condition worldwide, with higher incidence in lower socio-economic groups [1]. This condition is known to impair the functional and aesthetic status of the patients, thereby affecting their psychological status [1–4]. Many cases are treated with removable dentures that, overall, have a good aesthetic outcome. Unfortunately, in cases of a severely atrophic maxilla, and especially in atrophic mandibles, the stabilization and retention of the denture can be almost impossible, leading to poor masticatory efficiency and poor acceptance. The gold standard treatment for these patients is an implant retained overdenture in the lower arch and a complete denture in the upper arch. The use of implants improves the retention and stability of the denture by limiting vertical and horizontal mobility. This solution is known to improve the chewing efficiency, increase the maximum bite force and,

additionally, increases the satisfaction of these patients [5, 6].

From a biomechanical point of view, treating edentulous patients with overdentures is an optimal solution due to the possibility of transferring occlusal forces to implants or to the implants and mucosa, resulting in a more physiological distribution of these forces. This provides more protection for the alveolar bone. There are several approaches to the treatment of edentulous mandible using an overdenture, for example, using one, two or even six implants, which can be used as separate elements or interlocked with a metal bar. Precision attachments usually consist of two components, matrix and patrix; the matrix – embedded in the prosthesis and the patrix – combined with the implant. Conversely, the patrix may also be attached to the denture, and the matrix placed on the implant. Good retention of the prosthesis is

achieved either to the friction between the surfaces of the matrix and patrix or a magnetic field between the components. A more detailed explanation will be provided below.

Precision attachments can be made out of precious metal alloys, titanium, chromium-nickel, chrome-cobalt and Stellite. The matrices can be made out of metal or plastic. Plastic matrices can be made of poly-oxy-methylene (POM) or poly-ether-ether-ketone (PEEK). No significant difference between the two materials has been demonstrated. However, it has been shown that plastic matrices lose elastic properties under cyclic loading. On the other hand, it should be pointed out that the procedure to replace the attachments is relatively easy. In the systems in which both parts are made of metal, the retention is less likely to become compromised, but replacing the attachments with new ones is much more complicated and costly. Sometimes it may even be indicated to replace the denture.

The clinician has a wide variety of choices when it comes to deciding which precision attachments to use for stabilizing the overdenture. These attachments may offer advantages, but it may be difficult to choose the best one for clinicians who are not familiar with the differences between them. It should be noted that the different attachments selected will influence prosthodontic maintenance, particularly in regard to the type of matrices used, and also [7, 8] the aesthetics, retention and long term success. This paper is divided into 2 parts. In the first part, the different systems available are described, together with their relative indications and limitations. In the second part, different clinical situations are depicted and discussed. Some of the most typically-used precision attachments will be presented separately and subsequently compared.

Magnets

The use of magnets to stabilize an overdenture made its first appearance in 1960 [9]. The first generation had some limitations due to their size and an open magnetic field, which could have cytotoxic effects. Therefore new magnets were designed, based on a magnet sandwiched between 2 keepers, producing a closed circuit, which were safer for the patient [10]. Magnets are made of alloys of rare earth elements like samarium-cobalt (Sm-Co) and neodymium-iron-boron (Nd-Fe-b). Moreover, they can be divided into monomagnetic and duomagnetic types. Monomagnetic systems (magnet + a ferromagnetic) are ones in which the ferromagnetic part is placed on the implant and the perma-

nent magnet is placed on the prosthesis, as for example the Dyna[®] and Dyna Direct[®] System, and the Magna Cap[®] System. Duomagnetic systems (magnet + magnet) instead are ones in which one magnet (the primary one) is placed on the implant, and a second one (the secondary one) is placed on the prosthesis, as for example the Steco Titanmagnetics[®] and MicroPlant[®]. Despite the improvements in the structure, in the oral cavity environment they are subject to corrosion, reducing their retentive capabilities in the long-term [10, 11]. This system should be limited to use in cases of reduced vertical space available for the attachment. Patients with magnetic elements should be informed that this kind of precision attachment makes it impossible for them to undergo an MRI in the future.

Fig. 1. a) magnet (on top) with keeper (abutment and screw) and b) assembled magnet-keeper unit [12]

Fig. 2. Clinical application of magnetic attachment: a) the keeper abutments placed on the implant b) the magnet capsules positioned on the keeper [12]

Ball Attachments

Ball attachments are the most commonly used type of attachments for non-splinted implants. They are very easy to install and can be used to stabilize a pre-existing denture, keeping the prosthetic costs lower [13]. The advantages of ball attachments include their small size, allowing more space for the acrylic, and in turn increasing the strength of the denture. In case of limited vertical dimensions, their use can be impaired, producing discomfort for the patient [13]. It has been reported in the York [acc. 14] and McGill [acc. 15] consensus that the use of 2 implants is recommended to ensure a successful rehabilitation of the mandibular edentulous patient. However, other authors [16, 17] have concluded that even a single implant might be used to achieve a good stability of the overdenture. Ball attachments are able to prevent horizontal movement of the denture on the mucosa, but it is not possible to prevent the vertical axial movement of the balls in the matrix. The clinician should be aware that the occlusal forces are transferred to the alveolar ridge unevenly, causing greater subsidence of the prosthesis in the lateral sections, which may require relining dentures. Therefore, more maintenance is needed [18, 19]. Ball attachments are available with different angulations, giving the clinician the possibility of using them in cases of divergent implants up to 10 degrees [20].

Fig. 3. a) Straight ball attachment b) angulated ball attachment

Fig. 4. Ball attachment in place in severely resorbed mandible

Locators

A locator is a modern, prefabricated, self-aligning method that is able to maintain both the vertical and hinge resiliency [21]. It is considered the system with the lowest profile height [22], 0 to 6 mm depending on the gingival thickness. Consequently, they are especially indicated when the height of the denture and the inter-arch distance is inadequate for ball attachments or other attachments systems [21]. The minimal height required is 3.7 mm, but by virtue of a larger diameter, this factor is also responsible for increasing its strength [23]. Locators are widely used by clinicians due to their high compatibility with most of the implant systems available [24, 25]. The system is composed of two parts, a straight abutment and a male component inside the denture that incorporates a nylon liner, which can solve the problems related to differences in angulation [26]. The clinician is able to choose between different male components. The standard ones can be used if the divergence is up to 10 degrees for a single implant or up to 20 degrees for 2 implants. In the case of divergence up to 40 degrees, extended-range male components can be used [26]. Locators are known to be highly retentive when compared to other systems like ball or magnet attachments [27].

Fig. 5. a) Scheme of a locator b) maximal divergence of the locator

Metal Bar

Some clinicians prefer to retain the overdenture with a customized metal bar.

There are different designs of metal bars. The U-shaped gold bar is widely used due to its ability to transfer loads to the implants mostly in a vertical direction [28]. Other designs like the

Dolder bar or the Ackermann bars have an egg-shaped and round cross-section, respectively. Unless it has a U-shaped arrangement, it may not be able to prevent rotation of the prosthesis sufficiently.

The metal bar attachment is indicated in cases where it is not possible to achieve a good parallelism between the implants due to anatomical limits or surgical misjudgment [29, 30], but of course the bite forces are best transmitted on the implants and the alveolar bone if the implants are parallel to each other.

The metal bar can be modified and extended distally from the previous implants as long as it is done symmetrically. This results in a more stable and reliable anchorage of the prosthesis onto the bar. According to Mericske-Stern et al. [31], the length of a cantilever bar may be up to approx. 1 cm and should not exceed the area of the first premolar, although the optimal length of a cantilever bar is no more than 7 mm [32]. When compared to metal bars of 9 and 11 mm in length, the shorter ones generate less stress on the implants, therefore reducing the possibility of significant changes around the implant. A common solution nowadays is to combine a traditional cantilever bar adding two ball attachments on its ends on both sides distal to the implants.

Effective retention of the overdentures on the prosthodontic area can be achieved using key slides. This system needs a special type of bar and to remove the denture the clinicians needs a special key to unlock the slide and push button studs, mostly situated in the lingual part of the prosthesis. Key slides provide additional stability. However, they require complicated laboratory procedures, very good oral hygiene and are quite expensive, which means that this solution is rarely used.

Fig. 6. Example of a 2 piece metal bars for overdenture

Discussion

Every type of precision attachment is designed to improve the stability and retention of a removable denture. The data collected in *in vitro* studies [21, 27, 33] showed differences between the retention or distribution of forces. Some authors suggest that the retention of the overdenture changes over time due to wearing of the attachments. Systems like the locator and metal bar are less likely to wear over time, even after the simulation of 5000 cycles of insertion [21]. Therefore, they should have a better clinical outcome than ball attachments and magnets [10, 11, 21, 27]. In a clinical trial, it has been reported that the locator and ball attachments need to be replaced with almost the same frequency [24]. Conflicting results are reported when the maintenance of ball attachments was compared to metal bars [34, 35]. Even if the *in vitro* studies show differences between the systems, the clinical results do not always show the same pattern. Patients that have severely atrophic mandibles, when rehabilitated with an overdenture, feel a significant improvement in the quality of life, regardless of the different attachment systems used or on the number of implants [5, 6, 13, 16, 22]. However, prosthetic maintenance and possible complications may be influenced by the system used [25].

To successfully rehabilitate a patient with an overdenture, the clinician can rely on any system available, as previously stated, but to improve the long-term outcome, he or she should take into consideration the variables present in every patient's mouth, such as implant position, oral hygiene, space available for the restoration, aesthetic space, the opposing arch and the restorative space.

Ideally the implants should be placed parallel to each other [16]. However, in the case of severely resorbed ridges or due to the position of the mental foramina, parallelism cannot always be achieved. In that case, the clinician should use a metal bar solution or the locator system (with divergence up to 40 degrees) [23, 29, 30]. When a shallow vestibule is present, the restoration has to counteract the lateral loads present. Therefore, a customized milled bar or locator may be a good choice for such cases [36]. In some cases, it has been reported that the number of implants is not criti-

Table 1. Precision attachments comparison

	Ball attachments	Magnets	Locator	Metal bar
Retention	low	decreasing fast	high	highest
Can be used with divergent implants	$\leq 10^\circ$	–	if $\leq 40^\circ$	yes
Vertical space needed	10–12 mm	10–12 mm	8.5 mm	13–14 mm

cal in stabilizing the denture and/or satisfying the patient [16]. The first choice of treatment for the edentulous atrophic mandible is the placement of 2 implants [14, 15]. However, if the overdenture is implant supported, especially when there is limited space for the restoration, the clinician should utilize the principle of spreading the load anterior-posteriorly by increasing the number of implants to decrease the lateral load of forces. As a general rule, the cantilever can extend distally to the most posterior abutment 1.5 times the distance between the anterior and posterior implant, after which the cantilever becomes mechanically unfavorable [37].

The patient's oral hygiene can also help determine the type of attachments to be chosen. In case of poor oral hygiene, the patient should be educated. Otherwise, no matter what kind of attachment the clinician chooses, the gums will be inflamed and swollen, which sometimes makes it impossible for the overdenture to be retained. Compared to ball attachments, such occurrences are more likely with metal bars, because mucosal hyperplasia can take place underneath, and also with magnets [38].

During the planning of the overdenture, the space available should be evaluated. In the case of a complete denture, the boundaries are dictated by: the proposed occlusal plane, the denture bearing tissues, and the tongue, cheeks and lips [39]. The same space, in the case of an overdenture, will also have to be sufficient for an attachment system. In the case of reduced space availability, the system of choice is the locator, which has a minimum requirement of 8.5 mm in the vertical dimension and 9 mm horizontally [40]. When the clinician wishes to use other types of attachments, he or she would need 10–12 mm, or even 13–14 mm, in the case of a metal bar [41]. To determine the vertical

distance between the lip at rest and the crest of the ridge, the lip ruler can be used (Nobilium CMP Industries), making the choice of attachment system simpler [36]. If the vertical dimension is not properly recorded during the planning, the aesthetic outcome, phonetics and rest position of the final overdenture could be impaired [36].

It is imperative that the planning should be done considering not only the arch that is to be restored but also the opposite opposing arch. In many cases, a lower overdenture is opposed by a traditional complete denture. In such cases, some authors advise using single ball attachments instead of a bar attachment, which could destabilize the upper complete denture, however further studies on the topic are needed to support this thesis [36].

Conclusions

Patients with overdentures are generally satisfied no matter what type of system used. However, the patient's anatomy is critical for the clinician in determining which precision attachment system should be used. Therefore, the clinician should perform complete diagnosis of the patient, including an assessment of the clinical situation in the opposing arch, and what the likely aesthetic and functional outcome of the case will be. When rehabilitating a patient with an overdenture, the correct position and angulation of the implants should be taken into account during the planning. Even if the literature provides a wide range of studies and results, it should be kept in mind that *in vitro* studies cannot fully simulate the oral environment and may produce results different from the clinical experiences.

References

- [1] D'SOUZA K.M., ARAS M.: Association between socio-demographic variables and partial edentulism in the Goan population: An epidemiological study in India. *Indian J. Dent. Res.* 2014, 25, 434–438.
- [2] TEOFILO L.T., LELES C.R.: Patients' self-perceived impacts and prosthodontic needs at the time and after tooth loss. *Braz. Dent. J.* 2007, 18, 91–96.
- [3] SHIMAZAKI Y., SOH I., SAITO T., YAMASHITA Y., KOGA T., MIYAZAKI H., TAKEHARA T.: Influence of dentition status on physical disability, mental impairment, and mortality in institutionalized elderly people. *J. Dent. Res.* 2001, 80, 340–345.
- [4] JOHNSON N.W., GLICK M., MBUGUYE T.N.: Oral health and general health. *Adv. Dent. Res.* 2006, 19, 118–121.
- [5] BOVEN G.C., RAGHOEBAR G.M., VISSINK A., MEIJER H.J.: Improving masticatory performance, bite force, nutritional state and patient's satisfaction with implant overdentures: A systematic review of the literature. *J. Oral. Rehabil.* 2014, 42, 220–232.
- [6] SUN X., ZHAI J.J., LIAO J., TENG M.G., TIAN A., LIANG X.: Masticatory efficiency and oral health-related quality of life with implant-retained mandibular overdentures. *Saudi Med. J.* 2014, 35, 1195–1202.
- [7] RENTSCH-KOLLAR A., HUBER S., MERICSKE-STERN R.: Mandibular implant overdentures followed for over 10 years: Patient compliance and prosthetic maintenance. *Int. J. Prosthodont.* 2010, 23, 91–98.
- [8] WATSON G.K., PAYNE A.G., PURTON D.G., THOMSON W.M.: Mandibular overdentures: Comparative evaluation of prosthodontic maintenance of three different implant systems during the first year of service. *Int. J. Prosthodont.* 2002, 15, 259–266.
- [9] BEHRMAN S.J.: The implantation of magnets in the jaw to aid denture retention. *J. Prosthet. Dent.* 1960, 10, 807–841.

- [10] RILEY M.A., WILLIAMS A.J., SPEIGHT J.D., WALMSLEY A.D., HARRIS I.R.: Investigations into the failure of dental magnets. *Int. J. Prosthodont.* 1999, 12, 249–254.
- [11] VRIJHOEF M.M., MEZGER P.R., VAN DER ZEL J.M., GREENER E.H.: Corrosion of ferromagnetic alloys used for magnetic retention of overdentures. *J. Dent. Res.* 1987, 66, 1456–1459.
- [12] CERUTI S.R.B., LEE J.-H., MACENTEE M.I.: Magnet-retained implant supported overdentures: Review and 1 year clinical report. *J. Can. Dent. Assoc.* 2010, 76, 6–14.
- [13] BILHAN H., GECKILI O., SULUN T., BILGIN T.: A Quality-of-life comparison between self-aligning and ball attachment systems for 2-implant-retained mandibular overdentures. *J. Oral Implantol.* 2011, 37, 167–173.
- [14] THOMASON J.M., FEINE J., EXLEY C., MOYNIHAN P., MULLER F., NAERT I., ELLIS J.S., BARCLAY C., BUTTERWORTH C., SCOTT B., LYNCH C., STEWARDSON D., SMITH P., WELFARE R., HYDE P., MCANDREW R., FENLON M., BARCLAY S., BARKER D.: Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients – the York consensus statement. *Br. Dent. J.* 2009, 207, 185–186.
- [15] FEINE J.S., CARLSSON G.E., AWAD M.A., CHEHADE A., DUNCAN W.I., GIZANI S., HEAD T., HEYDECKE G., LUND J.P., MACENTEE M., MERICSKE-STERN R., MOJON P., MORAIS J.A., NAERT I., PAYNE A.G., PENROD J., STOKER G.T., TAWSE-SMITH A., TAYLOR T.D., THOMASON J.M., THOMSON W.M., WISMEIJER D.: The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. *Gerodontology.* 2002, 19, 3–4.
- [16] WALTON J.N., GLICK N., MACENTEE M.I.: A randomized clinical trial comparing patient satisfaction and prosthetic outcomes with mandibular overdentures retained by one or two implants. *Int. J. Prosthodont.* 2009, 22, 331–339.
- [17] KRONSTROM M., DAVIS B., LONEY R., GERROW J., HOLLENDER L.: A prospective randomized study on the immediate loading of mandibular overdentures supported by one or two implants; A 3 year follow-up report. *Clin. Implant Dent. Relat. Res.* 2014, 16, 323–329.
- [18] MACENTEE M.: Mandibular overdentures retained by a bar on two implants need less aftercare and costs less than overdentures retained by two bars on three implants or by ball attachments on two implants. *J. Evid. Based Dent. Pract.* 2008, 8, 2, 76–77.
- [19] RUCHALA-TYSZLER A., LOSTER B.W.: Application of dental implant supported overdentures in edentulous patients – academic literature review. *Implantoprotet.* 2007, 8, 4, 38–42 [in Polish].
- [20] BANTON B., HENRY M.D.: Overdenture retention and stabilization with ball-and-socket attachments: Principles and technique. *J. Dent. Technol.* 1997, 14, 7, 14–20.
- [21] TURK P.E., GECKILI O., TURK Y., GUNAY V., BILGIN T.: *In vitro* comparison of the retentive properties of ball and locator attachments for implant overdentures. *Int. J. Oral Maxillofac. Implants* 2014, 29, 1106–1113.
- [22] KLEIS W.K., KAMMERER P.W., HARTMANN S., AL-NAWAS B., WAGNER W.: A comparison of three different attachment systems for mandibular two-implant overdentures: One-year report. *Clin. Implant. Dent. Relat. Res.* 2010, 12, 209–218.
- [23] EVTIMOVSKA E., MASRI R., DRISCOLL C.F., ROMBERG E.: The change in retentive values of locator attachments and hader clips over time. *J. Prosthodont.* 2009, 18, 479–483.
- [24] KRENNMAIR G., SEEMANN R., FAZEKAS A., EWERS R., PIEHSLINGER E.: Patient preference and satisfaction with implant-supported mandibular overdentures retained with ball or locator attachments: A crossover clinical trial. *Int. J. Oral Maxillofac. Implants*, 2012, 27, 1560–1568.
- [25] KIM H.Y., LEE J.Y., SHIN S.W., BRYANT S.R.: Attachment systems for mandibular implant overdentures: A systematic review. *J. Adv. Prosthodont.* 2012, 4, 197–203.
- [26] SCHNEIDER A.L., KURTZMAN G.M.: Restoration of divergent free-standing implants in the maxilla. *J. Oral Implantol.* 2002, 28, 113–116.
- [27] SADIG W.: A comparative *in vitro* study on the retention and stability of implant-supported overdentures. *Quintess. Int.* 2009, 40, 313–319.
- [28] CHIAPASCO M., GATTI C., ROSSI E., HAEFLIGER W., MARKWALDER T.H.: Implant-retained mandibular overdentures with immediate loading. A retrospective multicenter study on 226 consecutive cases. *Clin. Oral Implants Res.* 1997, 8, 48–57.
- [29] KHADIVI V.: Correcting a nonparallel implant abutment for a mandibular overdenture retained by two implants: A clinical report. *J. Prosthet. Dent.* 2004, 92, 216–219.
- [30] ASVANUND C., MORGANO S.M.: Restoration of unfavorably positioned implants for a partially edentulous patient by using an overdenture retained with a milled bar and attachments: A clinical report. *J. Prosthet. Dent.* 2004, 91, 6–10.
- [31] MERICSKE-STERN R.D., TAYLOR T.D., BELSER U.: Management of the edentulous patient. *Clin. Oral Implants Res.* 2000, 11, Suppl 1, 108–125.
- [32] ELSYAD M.A., AL-MAHDY Y.F., SALLOUM M.G., ELSAHI E.A.: The effect of cantilevered bar length on strain around two implants supporting a mandibular overdenture. *Int. J. Oral Maxillofac. Implants* 2013, 28, e143–150.
- [33] KONO K., KURIHARA D., SUZUKI Y., OHKUBO C.: *In vitro* assessment of mandibular single/two implant-retained overdentures using stress-breaking attachments. *Implant Dent.* 2014, 23, 456–462.
- [34] GOTFREDSSEN K., HOLM B.: Implant-supported mandibular overdentures retained with ball or bar attachments: A randomized prospective 5-year study. *Int. J. Prosthodont.* 2000, 13, 125–130.
- [35] MACENTEE M.I., WALTON J.N., GLICK N.: A clinical trial of patient satisfaction and prosthodontic needs with ball and bar attachments for implant-retained complete overdentures: Three-year results. *J. Prosthet. Dent.* 2005, 93, 28–37.
- [36] MASSAD J.J., AHUJA S., CAGNA D.: Implant overdentures: Selections for attachment systems. *Dent. Today*, 2013, 32, 128–132.
- [37] ENGLISH C.E.: Critical A-P spread. *Implant Soc.* 1990, 1, 1, 2–3.

- [38] DAVIS D.M., PACKER M.E.: Mandibular overdentures stabilized by Astra Tech implants with either ball attachments or magnets: 5-year results. *Int. J. Prosthodont.* 1999, 12, 222–229.
- [39] AHUJA S., CAGNA D.R.: Classification and management of restorative space in edentulous implant overdenture patients. *J. Prosthet. Dent.* 2011, 105, 332–327.
- [40] LEE C.K., AGAR J.R.: Surgical and prosthetic planning for a two-implant-retained mandibular overdenture: A clinical report. *J. Prosthet. Dent.* 2006, 95, 102–105.
- [41] SADOWSKY S.J.: Treatment considerations for maxillary implant overdentures: A systematic review. *J. Prosthet. Dent.* 2007, 97, 340–348.

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