

## Clinical decision-making review on magnetic attachments *versus* mechanical attachments in dental prosthetics

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### REVIEW

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### ABSTRACT

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#### Background

Conventional dentures in edentulous patients show some limitations due to the lack of retention, support and stability thus resulting in difficulty to chew. The modern implantology allows to use different implant overdentures and different attachment systems. The selection of the attachment by practitioners is mainly influenced by the clinical experience or technical preferences.

#### Aims

The aim of the present review is to provide an adequate background to the clinicians, in order to select the prosthetic attachments according to the current literature. The mechanical attachments have been compared to the magnetic devices, with the aim to guide the decision of the practitioners.

#### Methods

Articles topics selection was based on the use of magnetic attachments in dentistry and the comparison between them and mechanical connectors. The databases used were PubMed/MEDLINE, Google Scholar and ISI Web of Science. A critical evaluation of the selected paper has been made to choose the ones that matched the inclusion criteria.

#### Results

Nowadays, few studies have compared different attachments in a manner useful for clinical decision-making. The main problem limiting long-term durability of magnetic attachments in the oral fluid is the poor corrosion resistance of permanent magnets and the consequent leaching of cytotoxic ions.

#### Conclusion

Magnetic attachments in comparison with other attaching systems can be useful in patients with special needs, in patients with limited interocclusal space, or in patients with neuromuscular limitations, thanks to the automatic reseating properties. However, it's important to highlight

that the mechanical attachments still represent the best choice in common conditions requiring dental prostheses.

### Key Words

Magnetic appliances, mechanical attachments, overdentures

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## What this review adds:

### 1. What is known about this subject?

Nowadays, there are still controversial opinions concerning the effective corrosion resistance of magnetic attachments, despite such appliances could be important in some clinical cases.

### 2. What new information is offered in this review?

A wide excursus on permanent magnets, corrosion behaviour, magnetic properties, biocompatibility and the use of magnets in prosthodontics have been carefully discussed in this review.

### 3. What are the implications for research, policy, or practice?

Prostheses are crucial in oral rehabilitation. The right choice could prevent the inflammatory conditions related to local trauma and preventing the articular damages due to not correct chewing.

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## Introduction

Magnetic devices have been introduced in dentistry since the 1960s<sup>1</sup> both for orthodontics and prosthodontics applications. The main problem limiting their long-term durability in the oral fluid is the poor corrosion resistance of permanent magnets and the consequent leaching of cytotoxic ions. This infamous occurrence has marked the use of magnets in some parts of the world such as in North America.<sup>2-4</sup>

For this reason, nowadays magnetic systems are used only in prosthodontics by encapsulating them in a stainless-steel cap through a laser-welding technique. However, there are still controversial opinions concerning the effective corrosion resistance of this covering technique, moreover its manufacturing cost exceeds significantly the one for magnets.

Despite data about corrosion behaviour, magnetic force and biosafety should be of primary interest for the use of permanent magnets in dentistry, a systematic analysis of different parameters lacks in the present literature other than the advantages in the use of this system in comparison

with conventional ones.<sup>5-8</sup>

For these reasons a wide excursus on permanent magnets, corrosion behaviour, magnetic properties, biocompatibility and the use of magnets in prosthodontics in comparison with conventional ones have been taken into account and carefully discussed in this critical review.

### Data sources

Magnetic attachments systems have been taking into account as the main focus of our literature research and thus the articles which were centred on comparison between these systems and the conventional ones were also analysed. The keys words used have been selected in order to provide a larger information overview on the magnetic properties and advantages/disadvantages in the use of this system.

Examples of keywords combinations are: magnetic dental attachments, conventional prosthetic attachment, magnets in dentistry. The databases utilized were Google Scholar, PubMed/MEDLINE and ISI Web of Science from 1960 up to 2016.

### Resource selection

Based on the previously selected search engines, we found 1,724 articles matching the relevant keywords. According to PRISMA flow diagram, we evaluated all these articles in details. 472 articles were removed from our selected paper, as their title described topics out of our interest. After having analysed the abstract of the remaining papers, 105 of them were also excluded, since their findings were judged not interesting and/or not relevant to the scientific community. Finally, we have read the full-text of the remaining articles, focusing our attention on the methods section: from this list, we removed 97 articles, mainly because they showed methodological bias affecting the overall reliability of the research (Figure 1).

## Review

### Permanent magnets and magnetic properties

Magnetism is a physical phenomenon and a form of energy that can be either static or time varying, and originated from the electromagnetic interaction of particles and from the spin of each electron.<sup>2-4</sup> In particular, electrons by moving their charges around their nucleus generate a magnetic field.<sup>5,6</sup> When the electron spin of these atoms aligns to form a domain they produce a magnetic material. When a magnetic material is easily magnetized or demagnetized and need only low fields to reach saturation, it is termed as "soft" on the contrary when it is able to

retain magnetic properties after large fields are applied and it is made by permanent magnets, it is defined as “hard”.<sup>8</sup> When the applied field is removed a hard material retains a certain quantity of magnetization which can be reset to zero by applying an equal but opposite field.<sup>8</sup>

Three typologies of magnetic materials can be identified: diamagnetic, paramagnetic and ferromagnetic materials.<sup>9</sup>

Magnetic field is a vector which possesses both magnitude and direction. Static magnetic fields exist around ferromagnetic or permanent magnetic materials and have been used in dentistry for more than 50 years.<sup>10</sup> Over this period magnets were widely spread among clinical practitioners. However, their use as safe clinical device is controversial due to corrosion, magnetic field scattering around the tissues, poor magnetic properties and large size.<sup>11</sup>

Magnetized permanent magnets are in a thermodynamically metastable state whose stability is dependent, for example, by nucleation of reverse domains and depinning of domain walls. These non-equilibrium processes are strictly linked to the microstructure of the compound.<sup>12</sup>

### **Magnets in prosthodontics**

Conventional dentures in edentulous patients show some limitations due to the lack of retention, support, stability and thus causing difficulty in chewing (Figure 2).

Different options are available in the prosthetic treatment of these cases such as complete denture or an implant-supported prosthesis.

For implant overdentures, different attachment systems can be utilized in order to increase retention and stability of the denture.<sup>13</sup> They can be classified in bar, ball, locators, magnet types and modified ball types. The selection of the attachment by practitioners is not on the basis of the case but mainly it is influenced by the clinical experience and preference.<sup>14,15</sup>

Nowadays, few studies have compared different attachments in a manner useful for clinical decision-making.<sup>14,15</sup>

Magnetic attachments were introduced by Gillings in the 1978,<sup>3</sup> at that time the design of the attachment was composed by the magnetic material and the keeper in direct contact with the oral environment, therefore the lifespan of

the magnets was reduced by corrosion. This infamous occurrence has marked the use of magnets in some parts of the world such as in North America.<sup>16</sup>

There is a wide range of dental magnetic systems commercially available, which differ in types and size. These systems, consisting of a magnet and a keeper unit, are used as an alternative solution to retain full-arch bar and fixed-removable prostheses where there is sufficient alveolar ridge height.<sup>1</sup> Many clinical reports demonstrate the successful use of magnetic attachments as mandibular and maxillary implant-supported overdentures, with magnets incorporated into the denture acting upon keepers that are attached to the tooth abutments or implant.

Magnetic flux of these attachments can be divided in open and close fields. In closed fields, the external magnetic flux fields are eliminated by placing the magnetic components in a series, thus, using both north and south for the attachment to the keeper, thus, shunting the external field into the path of least resistance. The closed-field permits the greater attractive force per unit size, around 5.8N. On the contrary, in an open field system only one pole is used, hence, the surrounded tissues are exposed to the external field. However, it must be considered that most of the companies provide in the product data sheet a magnetic force without the encapsulating cover. This last, in fact, causes a decrease equal to the inverse square of the distance (thickness of the cover).

The World Health Organization (WHO) stated that the limits of continuous exposure to static magnetic fields is 40mT.<sup>8,16</sup> Therefore, Nishida et al. in the 2007s analysed the external flux density of a dental magnetic attachment and attested that parameters were within the limits of safety. Moreover, in prosthetic applications the magnetic assembly is embedded in a denture or a prosthetic base, while the keeper is set at the top of the retaining tooth abutment or of an implant fixture consequently avoiding the direct contact with gingiva and bone. However, the clinicians should pay attention in the long-term use of the magnetic device because the magnet could be taken far from the keeper with a consequent leak of magnetic flux.<sup>1</sup>

There are many reasons to implement intra-oral magnets in clinical practice instead of other methodologies.

Magnetic attachments are less bulky than mechanical ones and this can be useful for patients with limited interocclusal space and for challenging aesthetic demands.

They can also accommodate a moderate divergence of alignment between abutments, since they are not path insertion-dependent. Moreover, they are easy to incorporate into a denture simplifying both the technique and the clinical procedure.<sup>17</sup> The patients physically disabled and/or neuromuscular compromised benefit of the automatic reseating property, of the easy cleaning and placement. For example, in edentulous patients with weak muscle disease such as in Parkinson's disease, magnetic attachments not only keep the denture stable, but also permitted to apply less force for the insertion and removal of the denture.<sup>13</sup>

In comparison with mechanical connectors, magnetic attachments permit the minimum bending moment transmission to the implant and to the bone/implant interface during overdenture dislodgement, which might be in part explained by the denture forward shift caused by load application in the chewing area. After comparing magnetic attachments with bar attachments, it was shown that bar attachments induce a major axial load and bending moment on implant with consequent reduced movement of the overdenture. Ball attachments have been reported to possess the minimum axial force and bending moment to the implant and less movement of the overdenture.<sup>18</sup> For this reason, different studies have analysed the resonance frequencies of magnetic retained implant overdentures, to assess the implant stability quotient (ISQ). Some authors in preliminary studies conducted on magnetic attachments supporting implant overdentures, found a decrease in implant stability after 6 months. On the contrary, Elsyad et al. found that magnetic attachments showed higher implant stability than locator attachments after 1 year. This may be attributed to the increased vertical bone loss with locators compared to magnets.<sup>19</sup>

Magnetic attachment provides unrestricted lateral movement and excellent force transfer characteristics. In addition, the surrounding gingival tissue is not affected by the smoother surface of magnetic systems.

Magnetic connectors, despite their many advantages, do have some drawbacks.

Many patients claimed more retention performance.<sup>20</sup> In addition, spherical and magnetic connectors showed the need of more aftercare than bar construction.<sup>21</sup>

Magnet is reported to retain more plaque than spherical connector,<sup>22</sup> to reduce comfort and chewing efficacy thus leading to patient dissatisfaction.<sup>23</sup> Other studies confirmed

the increase in plaque scores for magnetic and locator attachments. This may be due to the resiliency of both attachments, which allow denture movements and accumulation of food particles and plaque under the denture. Another explanation may be attributed to the decreased awareness caused by increased patient age which affects oral hygiene practice of the patients.

However, magnets recorded significantly higher plaque score than locators after a 1-year follow-up. A similar finding was reported in another study in which the authors found that magnets attracted microbial plaque.<sup>24</sup>

For the same reason, interleukin-1b (IL-1b) was measured in peri-implant crevicular fluid as an indicator for inflammatory process of implant supporting structure. The results confirmed that IL-1b significantly increased with magnetic attachments than locators even though the bleeding index did not significantly increase with time.<sup>25</sup> In addition to these findings, Wilson et al. demonstrated how permanent magnet corrosion is triggered by the presence of bacterial plaque. In fact, they suffered a 3.2 per cent decrease in mass fraction after 21 days, in the presence of a plaque biofilm.<sup>26</sup>

Wear and corrosion are the main limits that affect long-term durability of magnetic attachments. Corrosion, such as tarnish and pitting, occurs by breakdown of the coating and diffusion of ions through the seal. NdFeB magnets, due to their microstructure composition are highly susceptible to corrosion in oral environments containing chloride.<sup>27</sup>

In order to prevent this problem, laser-welding techniques were introduced in the beginning of the 1990s. In fact, recently commercially available magnetic attachments have been sealed in a ferromagnetic material-housing called yoke, which allow a reduction of magnet replacement over time.

The laser-welding technique use a Nd:YAG laser under argon atmosphere to weld a shield ring made of stainless steel or titanium in the boundary between the cup and the disc yokes until to a depth of about 70µm. Riley et al. affirmed that this new sealing technique reduced the corrosion of intra-oral magnets, however, in the long-period the system seems to fail, due to mechanical and electrochemical stresses.<sup>8</sup>

## Conclusions

Prostheses are the crucial element in oral and maxillofacial rehabilitation. The right choice of biomaterials, technique,

pre-prosthetic surgery and clinical planning is the only way to ensure a good clinical result, reducing the inflammatory conditions related to local trauma and preventing the articular damages due to not correct chewing.<sup>28-31</sup> The future of dentistry is running towards concepts like tissue engineering and regenerative medicine: the oral cavity is a little-world where to find the right resources to restore many pathologies even far from maxillary district. The use of mesenchymal stem cells (MSCs), for example, has been largely studied just to replace the actual prostheses, as we know them.<sup>32-35</sup> Bone tissue, MSCs, PRF, platelets' concentrates and the biomimetic biomaterials will be, in the next years, the main actors in oral surgery and dental prosthesis to get a natural and biological restoration of many dental and periodontal diseases.<sup>36-40</sup> All the above reported improvements will be available in the next future, however, the actual alternative to classic removable prostheses could be the laser-welded magnets used in prosthodontics applications, despite they still require long-term clinical trials to assess both the biocompatibility than the durability under clinical function, thus permitting to increase their use worldwide. On the other hand, many disadvantages are right now present in magnetic attachments, in comparison with the mechanical ones, highlighting how the magnetic system is not able to withstand corrosion phenomena and to manage correctly the magnetic forces for a proper retention of prosthetic denture.

The poor corrosive resistance of magnets within oral fluid requires encapsulation within a new hybrid material. Anyway, magnetic attachments represent a reasonable option, in order to avoid high rigidity at the bone/implant interface in all the clinical trial selected in the present review. Moreover, they can be used in those rare clinical needs, such as non-common aesthetic demands, limited interocclusal space and patients with Parkinson's disease. However, it's important to highlight that the mechanical attachments still represent the best choice in dental prosthetics.

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#### PEER REVIEW

Not commissioned. Externally peer reviewed.

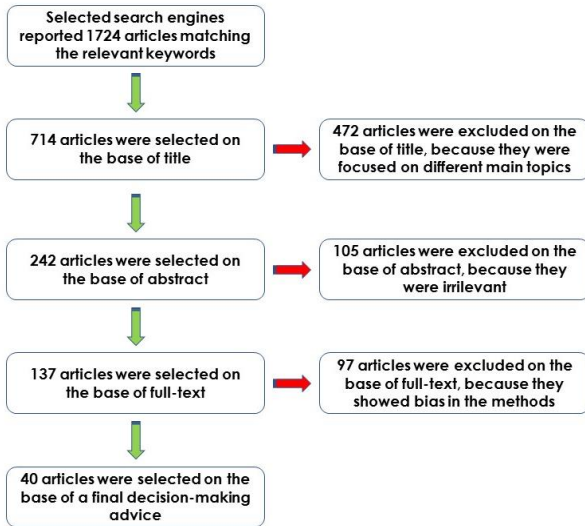
#### CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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None

**Figure 1: Flow chart of the search strategy for relevant publications**



**Figure 2: Scheme of magnetic appliance used in dental prosthetics**

