Magnets in Prosthetic Dentistry
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Abstract: Magnetic retention is a popular method of attaching removable prostheses to either retained roots or osseointegrated implants. Use of retention magnets simplify the clinical and laboratorial phase, retains the denture, and makes it stable and comfortable for the patient. This treatment is one successful approach to the restoration of oral function and increases the patient's quality of life.

Key words: Magnets, Magnetic Materials, Magnetic Field

INTRODUCTION
Magnets have generated great interest within dentistry, and their applications are numerous. The 2 main areas of their use are orthodontics and removable prosthodontics. The reason for their popularity is related to their small size and strong attractive forces; despite their many advantages, magnets have poor corrosive resistance within oral fluids and therefore require encapsulation within a relatively inert alloy such as stainless steel or titanium. When such casings are breached, contact with saliva rapidly brings about corrosion and loss of magnetism.

MAGNETIC MATERIALS
The main magnetic material used is the rare earth material neodymium iron boron (Nd-Fe-B) which is the most powerful commercially available magnet material. Other materials used include the samarium cobalt (Sm-Co). Before the development of rare earth magnets, Alnicos—alloys based on aluminum, cobalt, and nickel—were the main materials in use, although cobalt platinum (Co-Pt) magnets also existed. (fig1, fig2) Samarium iron nitride is a promising new candidate for permanent magnet applications because of its high magnetization, resistance to demagnetization and better resistance than Nd-Fe-B-type magnets to temperature and corrosion. This material is still under development, but it is expected to become available for medical and dental applications in the near future.

TYPES OF MAGNETISM
Magnetic materials may be termed either “soft” (easy to magnetize or demagnetize) or “hard” (able to retain magnetic properties and be made into permanent magnets). Whether a material is hard or soft depends on whether it retains its magnetic properties after the removal of an applied magnetic field. Every atom is a magnet because electrons orbit its nucleus and, as moving charges, produce a magnetic field. However, most electrons are paired, and the equal and opposite fields cancel out. In some atoms such as Fe, Ni, and Co, there are unpaired electrons that create a tiny magnetic field. In a magnetic material, a large portion of these atoms align in small regions called “domains.”

In an unmagnetized state, the orientation of these domains is random and no overall magnetization is experienced. On the application of a magnetic field (H), the domains align and there by produce an overall magnetization in the specimen, which will reach a saturation point (Ms). Magnetically soft materials require only small fields to reach saturation, whereas magnetically hard materials require large fields to reach saturation. When the applied field is removed, a permanent magnet or hard material retains much of the magnetization or remanence. This magnetization in the specimen is reduced to zero by the application of an equal but opposite field to the magnetization in the specimen. The value of H at this point is the intrinsic coercivity (iHc). If the applied field is reversed between the same positive and negative limits, a symmetrical loop called a hysteresis loop is traced out.

REMOVABLE PROSTHODONTICS
Various devices such as springs, suction cups, clips, and studs (fig3) all have been used to retain complete and removable partial dentures within the mouth. Magnets also have been used for this purpose because they are easy to incorporate into a denture and can simplify both clinical and technical procedures. However, there are limitations to their use; these limitations are related mainly to their low corrosion resistance within the mouth. The first attempts at using magnets to retain dentures involved implanting them within the jaw however problems ensued because of the large size of the magnets and the inadequate forces that they provided. As material technology improved, smaller magnets were made that could be incorporated into retained roots with similar units built into the denture. Later developments included the replacement of the root magnet with a soft magnetic material that is magnetized while the denture is in place but returns to a demagnetized state on removal of the denture. In the last 20 years, the design of magnetic attachments has changed to reduce the external magnetic fields present while the denture is in place. The methods of corrosion protection have also improved. Improvements in magnetic materials have allowed smaller and more powerful magnetic attachments to be produced from Sm-Co and Nd-Fe-B alloys.
Magnet repulsion

The first recorded use of magnets in prosthetic dentistry involved using the repulsion of like poles of magnets to maintain and improve the seating of complete dentures. The magnetic material used was an Alnico type that has been discontinued in dental applications because of the large bulk necessary for magnet strength. The magnets were embedded in molar regions in the bases of complete dentures so that the like poles were orientated toward each other. As the patient closed his or her jaws together, mutual repulsion of the like poles of the magnets seated the denture against the alveolar ridges. However, the constant repelling force promoted resorption of bone in the alveolar ridge, and the seating effect fell dramatically when the jaws were apart and the need for the seating effect was at its greatest. (fig. 4)

Magnet attraction

The use of the attractive force between 2 magnets for denture retention was reported in the early 1960s. These first attempts were made with Alnico V and both rectangular and cylindrical PMMAcoated magnets, which were surgically implanted in the mandible of an edentulous patient. This trial showed that, because of the distance between the 2 magnets, they provided inadequate force to aid denture retention. The introduction of smaller, stronger Co-Pt magnets allowed continuation of clinical trials. Unfortunately, several disadvantages were associated with Co-Pt magnets, including their high cost, limited availability, and difficult fabrication. It was also found that the implanted magnet migrated through the bone and tissues until it became exposed in the oral cavity. The procedure was eventually abandoned because of the high costs involved and poor success rates. With the introduction of the powerful magnet material Sm-Co, the use of implanted magnets to aid denture retention was investigated again. These magnets could be produced in dimensions approximately one fifth of the Co-Pt magnets and still provide the same force. Because of the susceptibility of the magnets to corrosion, a proplast coating (polytetrafluoroethylene [PTFE] and pyrolytic graphite) was used. Proplast is no longer used as a coating material, but PTFE is used as the binder in polymer-bonded magnets. However, these are unsuitable for long-term use within the body because diffusion of moisture through the polymer results in inadequate corrosion protection of the magnet material. (fig. 5)

CONVENTIONAL USE OF MAGNETS

Open-field systems

The first reported use of magnets for the retention of overdentures (fig. 6) took place in the 1960s with the rehabilitation of a patient with a cleft lip and palate. (fig. 7) The magnetic Co-Pt alloy was used to produce crowns for 3 remaining teeth with cast Co-Pt also built into the denture. This was soon followed by the technique of cementing magnets within retained roots for the retention of overdentures. An Sm-Co magnet was cemented into a prepared cavity in the root surface, and a similar magnet was placed in the denture. The technique was modified to prevent corrosion of the magnets in the oral environment with the use of a cast gold coping to cover the magnet. Various studies have been carried out on the effects of magnetic fields and magnetic materials with conflicting results. The details of this work are beyond the scope of this article, but there is no evidence to suggest that adverse clinical effects have occurred over the past 40 years of magnetic applications within medicine and dentistry. However, because of fears over the effects of magnetic fields on the soft tissues, a soft magnetic material, Pd-Co-Ni alloy, was developed for use. It was also shown that Pd-Co-Pt alloys are the most corrosion-resistant. The advantage of these alloys is that no magnetic fields are experienced within the oral environment once the dentures are removed. (fig. 8)

Clinical usage

Magnetic attachments have most commonly been used for the retention of mandibular overdentures. There has been renewed interest in using magnetic attachments for the provision of mandibular overdentures with osseointegrated implants. The implant-supported overdenture consists of an implant-supported keeper and a magnet that is built into the denture. Two to 4 implants may be used, and these are placed in the anterior region of the mouth and spaced as widely as possible to provide maximum support and stability. The magnets may be used as attachments on freestanding implants or in combination with a bar attachment.

CONCLUSION

The material science and application of magnets since its early days of inception till the present day has been explained. Magnets still have a place in overlay removable partial dentures as an alternative to other existing methods to aid in retention of prostheses.

REFERENCES


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