

Dentistry with nature's power - A review

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ABSTRACT

Many of the attachments and retentive devices used to improve the mechanical stability of prosthesis require specialized equipment and accessories, with sophisticated chairside and laboratory techniques. The attachments are subject to wear and may require adjustment or replacement in service. A method of prosthesis retention which overcomes some of these difficulties uses small, but very strong, permanent magnets. These magnets are applied in various ways by several investigators for the well-being of the patients.

Introduction

Magnets have generated great interest within dentistry, and their applications are numerous. The reason for their popularity in prosthodontics since 1960's, is related to their small size and strong attractive forces; these attributes allow them to be placed within prostheses without being obtrusive in the mouth.[1] As the technology advanced, then their use included the placement 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.[2] In the last 20 years, the design of magnetic attachments has changed with new rare earth materials based on neodymium-Iron-Boron alloy.[3]

Historical Background

More than 20 centuries ago, an iron-ore called magnite was discovered. The ancients called it a load stone. It attracted tiny bits of iron. Though the action was not understood, it was attributed to the invisible effect called magnetism named after magnesias, the area in ancient Greece where this type of rock was found.[4] The use of magnets in medical literature dates back to the early 19th century. An Englishman by name J.H. Abraham demonstrated the use of magnets in Paris in 1820. Magnets are being widely used by the orthopedic surgeons to overcome the non-union of fractures.[4] In dentistry, prosthodontists recognized the value of these magnets first. These magnetic alloys were used for fixation of dentures (Freedman 1953, Thompson 1964 & Winkler 1967).[3,5,6] They were surgically incorporated in the edentulous mandible for retention of the complete dentures in the molar region (Behrman 1960) (1), and also used in sectional dentures (Fredrick 1976).[1,4] Additionally, they are also used in maxillofacial prosthesis for obturators.[3,6] restoring eyelid and lip closure (Nadear 1956, Robinson 1963, Javid 1971, Orlay and Cher 1981). Pharmacology and toxicology of rare

earth magnets and retentive characteristics of different magnetic systems for dental application are also studied (F.J Haley 1965 and Ron Highton 1986).[1-17]

Types of Magnetic Materials used

In the various dental applications of magnets, the following materials have been used:

I. Conventional Magnets

1. Platinum cobalt
2. Aluminum-nickel-cobalt (alnico) [4]
3. Ferrite
4. Chromium-cobalt-iron[4]

II. Rare Earth Magnets

1. Samarium-cobalt (SMCO)
2. Neodymium-iron-boron[1]

Early work with magnets involved platinum cobalt alloys which were very expensive and prevented frequent experimentation. Alnico alloy was then used owing to its favorable height-diameter ratio. They were bulky, but showed a way for future clinical use of magnets. Further developments seldom seen till the late 1970's, when the rare earth cobalt magnets were developed and put to practical use.[7] The miniaturization of magnets as a result of the introduction of rare earths or lanthanide elements enhanced the potential for this relatively non-fatiguing source of stored energy. Experiments were done using SMCO alloys and the stored energy and forces were found to be superior to alnico.

Though the conventional magnets have been used as retentive devices for removable partial dentures, obturators and maxillofacial prosthesis[3,4,6], the rare earth magnets overtook conventional magnets with its unique properties of permanent

retentive force, stress-breaking characteristics, corrosion resistance, biocompatibility and compactness which have resulted in widespread use for the overdentures.[5]

The hardness or softness of the magnets is described by the term intrinsic coercivity [1] (the opposing magnetic force necessary to remove previous magnetization or residual magnetization) Soft magnets are easy to magnetize or demagnetize. Soft magnet is the metal core of a relay, which becomes a strong magnet when exposed to a weak magnetic field, but loses its strength almost completely when the field is removed. [4] Hard magnets are able to retain magnetic properties and be made to permanent magnets.[1] They have a high coercivity and are resistant to magnetization, once magnetized, however they are resistant to demagnetization. The coercivity of cobalt samarium is five times that of cobalt platinum and more than ten times that of best alnico alloys.

This unique property makes it possible for the magnet to be made extremely short, 2mm or less, yet still retains their high magnetic field strength. The hard alloy must be exposed to a strong magnetic field before it becomes strong magnet, but remains a strong magnet when the field is removed.[4]

The first devices were of an Open-field type in which two magnets were used, one in the jaw and one in the denture.[4] Closed field type of system used a soft ferromagnetic material such as ferritic or martensitic stainless steel or a Pd-Co-Ni alloy, which is known as the 'keeper' is implanted into the jaw rather than a magnet.

In the closed field configuration each single magnet is functioning in a closed loop, where the entire magnetic field contributes to the retentive effect.[4]

Properties

- o Density - 8.1G/cm³
- o Co-efficient of thermal expansion - 12.6*10⁻⁶/C similar to cobalt chromium casting alloy.
- o Hardness - very high and elongation nearly zero resulting in a slightly brittle.
- o Fabrication - the magnet is difficult to process, though possible to file it with dental tools. Since, it is necessary to prepare standardized magnets which are designed commercially for specific applications. Most current rare earth magnets are produced by sintering with a fine alloy powder being pressed together into a mold, forming a cohesive non-porous mass.

Biocompatibility of Magnets

- o It is concluded that the magnetic potential produced by intraoral magnets in the surrounding blood vessels is very negligible (2*10⁻⁵V) compared to resting membrane potential of cell membranes (60-100V).
- o Though rare earth metals are biocompatible and acid resistant, it is advisable to seal them hermetically for dental use.
- o No clinical, microscopic, roentgenologic evidence of cytotoxic effects to magnets.

Mechanics of Magnets

Magnetic attachments offer many advantages over mechanical attachments, as they serve to dissipate lateral forces preventing from being transferred to the implants and surrounding bone.[1,4]

Design

Though various types of magnetic attachments are available, a magnetic attachment consists of two parts: the magnetic assembly which houses the magnet in a cap shaped yoke which is laser welded on the bottom of the disc forming a non-magnetic ring which is an integral part of the magnetic circuit design and a stainless steel keeper which attracts to it. In order to protect the internal magnet from corrosion, the outer parts are hermetically sealed together with micro-laser welding.[1] The dimensions of the magnetic attachment are: cross-sectional diameter of 4.0mm, height of 1.4mm. The magnetic attachment is compatible with 6 major implant companies like Branemark, ITI, 3i, etc. Various devices such as springs, suction cups, clips, and studs all have been used to retain complete and removable partial dentures within the mouth.[1]

Advantages

- o Magnets provide both retention and stability.[1-17]
- o Magnets allows for a 24 degrees of abutment divergence which provides for an easy non-critical path of prosthesis insertion and removal
- o The roots or implants do not need to be parallel.
- o Soft tissue undercuts may be engaged.
- o Potentially pathologic lateral or rotating forces are eliminated providing maximum abutment protection.
- o Enables automatic reseating of the denture if dislodged during chewing.
- o If misaligned placement occurs, then orthodontic movement of the root will result in correct contact being reached.
- o Roots with as little as 3mm of bone support are adequate for use as abutments with magnetic appliances.
- o They do not directly induce stress to root abutments.

Disadvantages

Corrosion of magnetic attachments may occur by two different mechanisms

1. Corrosion of the magnet due to the breakdown of the encapsulating material.[1]
 2. Corrosion of the magnet due to diffusion of moisture and ionsthrough the epoxy seal.[1]
- o The main problem associated with the use of magnets as retentive devices is corrosion. Both Sm-Co and Nd-Fe-B magnets.[1,4] are extremely brittle and susceptible to corrosion, especially in chloride-containing environments such as saliva and the presence of bacteria increases the corrosion of Nd -Fe-B magnets.
 - o It is therefore necessary to encapsulate or coat the magnets for use in dental applications. However, continual wear of the encapsulating material leads to exposure of the magnet(1).

- o Wear presents in the form of deep scratches and gouges on the surface caused by wear debris and other particles that become trapped between the magnet and the root. Finally there will be loss of retention provided by the attachment.
- o The excessive wear of the magnet may be due to the abrasive nature of the titanium nitride-coated soft magnetic tooth keeper that is used with some implant systems.
- o Currently available magnets based on Nd-Fe-B have attractive forces that enable them to provide retention. Problem of corrosion can be overcome with encapsulating materials such as stainless steel which are effective.

Future Improvements

The lifetime of dental magnetic attachments depends on several factors, but the main problem is the inadequate protection of the encapsulation materials; once they are breached, rapid corrosion of the internal magnet occurs. Improvements in sealing techniques (namely, laser welding) have resulted in more effective sealing of magnet encapsulations. However, further work is required to find more corrosion- and wear-resistant encapsulation materials (1).

Conclusion

The development of samarium-iron-nitride may offer better resistance to corrosion and its introduction into prosthodontics will be viewed with much enthusiasm. The magnetic denture retention system is not advocated as a replacement for conventional precision retainers but as a useful alternative where, for reasons of convenience, cost, patient motivation or poor prognosis, conventional retainers are unsuitable.

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