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RESEARCH ARTICLE

REVIEW ARTICLE- MAGNETS IN PROSTHODONTICS

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ABSTRACT

A well accepted prosthesis is a successful prosthesis. The success of the prosthesis is based on factors such as Retention, Stability, Support and Aesthetics. These factors are incorporated during the various stages of fabrication of the prosthesis starting from impression. However, sometimes all the factors cannot be incorporated into the prosthesis due to reasons related to patients health or the condition of the oral cavity. So to improve the success rate of the prosthesis we can make use of additional factors of which magnets are one of them.

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INTRODUCTION

Magnets have generated great interest in dentistry and have gained popularity due to their small size and strong attractive forces; that attributes and allows them to be placed within the prosthesis without being obstructive in the mouth of the patient. As the technology advanced, the placement of root magnet with a soft magnetic material that is magnetized when the denture is in place, but returns to a demagnetized state on removal of denture were used resulting in a more success rate of magnets.

History and evolution

Magnets have a history comprising of approximately 3000 years and are in use since then for various applications. More than 20 centuries ago an iron-ore called magnate was discovered. The ancients called it "load stone" and it attracted tiny bits of iron. Though the action was not understood, it was attributed to the invisible effect called "magnetism" named after magnesia, the area in ancient Greece where this type of rock was found. Prosthodontics was first to recognise the value of magnets.

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These magnetic alloys were used for the fixation of dentures (Freedman 1953, Thompson 1964 & Winkler 1967). They were surgically incorporated in the edentulous mandible for retention of complete dentures in the molar region (Behrman 1960) and also used in sectional dentures (Fredrick 1976). Additionally they are also used in maxillofacial prosthesis for obturators, restoring eyelid and lip closure (Nadear 1956, Robinson 1963, Javid 1971, Orlay and Cher 1981).

Classification

BASED ON ALLOYS USED: (Devlin and Barker, 1992) (Fig. 3,4)

Those containing cobalt

Example: Alnico, Alnico V, Co-Pt, Co_5Sm.

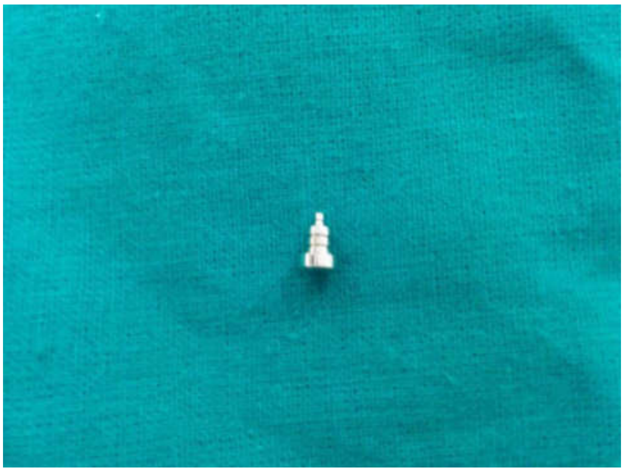
Those not containing cobalt

Example: Nd-Fe-B, samarium iron nitride.

Based on ability to retain magnetic properties

Soft (easy to magnetize or demagnetize) (less permanent)

Examples: Pd-Co-Ni alloy, Pd-Co alloy, Pd-Co-Cr alloy, Pd, Co-Pt alloy, Magnetic stainless steels, Permendur (alloy of Fe-Co), Cr-Molybdenum alloy.



Hard (retain magnetism permanently)

Example: Alnico alloys, Co-Pt, Co_5Sm, Nd-Fe-B.

BASED ON SURFACE COATING: (Devlin and Barker, 1992)

•Materials may be stainless steel, Titanium / palladium

- Coated.
- Uncoated.

BASED ON THE TYPE OF MAGNETISM: (Devlin and Barker, 1992)

- Repulsion.
- Attraction.

BASED ON TYPE OF MAGNETIC FIELD: (Devlin and Barker, 1992)

- Open field.
- Closed field.

Closed field:

- Rectangular Closed-field Sandwich Design.
- Circular Closed-field Sandwich Design.

BASED ON NUMBER OF MAGNETS IN THE SYSTEM: (Devlin and Barker, 1992)

- Single.
- Paired.

BASED ON THE ARRANGEMENT OF THE POLE: (Devlin and Barker, 1992)

- Reversed Poles.
- Non Reversed Poles.

Different types of magnets commercially available

There are four classes of modern commercialized magnets, each based on their material composition. Within each class is a family of grades with their own magnetic properties. These general classes are:

- Alnico
- Samarium Cobalt (Sm-Co)
- Neodymium Iron Boron (Nd-Fe-B)
- Ceramic (Ferrite)

Nd-Fe-B and Sm-Co are collectively known as Rare Earth magnets because they are both composed of materials from the Rare Earth group of elements.

ALNICO MAGNETS (Maroso, 2011; Devlin and Barker, 1992)

Alnico magnets (general composition Al-Ni-Co) were commercialized in the 1930's and are still extensively used today. They are magnets composed of aluminium, nickel, cobalt and iron and exhibit remarkable magnetic properties. They are one of the stronger alloy magnets.

There are two varieties of alnico magnets:

- Cast Alnico
- Sintered Alnico

SAMARIUM COBALT MAGNETS (Maroso, 2011; Devlin and Barker, 1992)

Samarium Cobalt magnets are manufactured in two compositions:

- Sm_1Co_5 (Sm-Co 1:5)
- Sm_2Co_{17} (Sm-Co 2:17)

Sm-Co 1:5 types are a variety of rare earth magnets.

Sm-Co 2:17 types, have higher Hci values, and offer greater inherent stability than the Sm-Co 1:5 types.

Samarium Cobalt magnets are permanent magnets which have the following characteristics:

- Very high magnetic properties with good stability.
- Superior resistance to high temperature.
- Curie temperature of majority is over 800°C.
- Excellent corrosion resistance.
- Good mechanical characteristics.
- More brittle than Neodymium material. (Fig. 10,11)

CERAMIC MAGNETS (FERRITE) (Maroso, 2011; Devlin and Barker, 1992)

Ceramic, also known as Ferrite, magnets (general composition $BaFe_2O_3$ or $SrFe_2O_3$) have been commercialized since the 1950's and continue to be extensively used today due to their low cost. Ceramic magnets are of two varieties:

- Hard Ferrite Magnets
- Flexible ferrite magnets

Hard Ferrite Magnets

Hard ferrite (ceramic) magnets were developed in the 1960's as a low cost alternative to metallic magnets. Even though they exhibit low energy compared with other permanent magnet materials and are relatively brittle and hard, ferrite magnets have won wide acceptance due to their good resistance to demagnetization, excellent corrosion resistance and low price.

Flexible Ferrite Magnets

A special form of Ceramic magnet is a Flexible Ferrite Magnet, made by bonding Ceramic powder in a flexible binder. The flexibility and ease of machining of these materials permit design innovations and automated manufacturing techniques not possible with rigid or brittle materials. It offers product designers a uniquely desirable combination of properties at lower cost than other magnetic materials.

NEODYMIUM IRON BORON MAGNETS (Maroso, 2011; Devlin and Barker, 1992)

These are known as the third generation of Rare Earth magnets. Neodymium-iron-boron (Nd-Fe-B) magnets are the most powerful and advanced commercialized permanent magnets today. Since they are made from Neodymium, one of the most plentiful rare earth elements, and inexpensive iron, Nd-Fe-B magnets offer the best value in cost and performance. A Neodymium Iron Boron magnet (general composition, $Nd_2Fe_{14}B$ often abbreviated to Nd-Fe-B) is the most recent commercial addition to the family of modern magnetic materials. At room temperatures, Nd-Fe-B magnets exhibit the highest properties of all magnet materials. These magnets are very strong in comparison to their mass, but are also mechanically fragile and lose their magnetism at temperatures above 80^0 C.

Effect of magnets on tissue

There are two ways in which cobalt- samarium magnets could have an effect on tissues: physical effect and chemical effect.

- Physical effect is because of the presence of a magnetic field gradient.
- Chemical effect may be local from the alloy, its wear particles are corrosion products, or a systemic effect following their ingestion.

Behman (1960) concluded from animal studies and clinical results with embedded magnets in over 450 patients, that magnetism is completely innocuous to tissues. In 1975 Tsutsui and his colleagues found the alloy to be innocuous in tissue culture tests. However, Walmsley suggested that magnets used in any of the materials have to be encapsulated. He observed that if the coating wears out the magnet can come in contact with saliva resulting in magnetic corrosion.

Biocompatibility of Magnets

- It is concluded that the magnetic potential produced by intra oral magnets in the surrounding blood vessels is very negligible (2*10-5 V) compared to the resting membrane potential of cell membranes (60-100 V)
- The hermetical sealing of rare earth metals is adviced inspite of them being biocompatible and acid resistant

Retention of the denture using magnets

Langevin theory of paramagnetism (Behrman, 1964 Maroso, 2011)

Langevin considered a paramagnetic gas in which each atom or molecule possesses a permanent magnetic moment. These magnetic moments arise from a particular combination of orbital and spin magnetic moments of the electrons. These magnetic moments, in the absence of any external field, point in random directions so that there is no resultant external magnetic moment. This happens because the interaction energy between the dipoles is smaller than the thermal energy at that temperature. The thermal energy is given by kT where k is Boltzman's constant. When an external field is applied, the magnetic moments tend to line up along the field direction and produce a net magnetization, counteracting the thermal agitation. When the atoms and ions are acted upon individually with no mutual interaction between them, the effect is called Paramagnitism. Paramagnitism depends upon the magnetic moment of ions or atoms. So the state of magnetization will be determined by the applied magnetic field and the thermal agitation.

Theory of ferromagnetism (domain theory) (Behrman, 1964; Maroso, 2011)

Weiss proposed the concept of Domain in 1907.

The theory can explain the following

- If a magnet is broken into pieces, each piece will be a magnet with the north and a south pole. This is because the domains continue to remain in the broken pieces.
- A magnet heated or roughly handled tends to lose its magnetism. This is because the alignment of domains in the magnet is likely to be disturbed during heating and rough handling.
- Domains of soft iron are easily rotated with a comparatively small magnetizing force and hence they get easily demagnetized.

- A specimen when magnetized suddenly experiences a slight increase in length which is due to the rearrangement of domains inside. This is called Magnetostriction. They are imaginary lines of force in a magnetic field which are lines or curves along which an isolated free north pole would move when placed at a point in it.

There are two types of magnetic fields which retain the denture.

They are:

- Open field system
- Closed field system

Open-field system (Riley, 2001; Maroso, 2011)

An example of the open field system is the 'Saco' magnetic ball slide attachment. This attachment has two parts:

- A denture element
- A root element

A cone shaped diamond bur is used to prepare a root cavity into which the root element is cemented with the round head projecting beyond the root surface. The denture element is cured into the denture such that when the denture is seated the face of the magnet makes light contact with the round head of the root element. The retention provided by this system is about 150g/root

Closed field system (Riley, 2001; Maroso, 2011)

This system attempts to reduce both the oral and systemic complications that may be induced due to the use of open field system on the human tissues.In magnets with keepers, the entire magnetic field is confined to the magnet and the low permeability path provided by the keeper making it a "closed field magnetic system", with hardly any exposure of the tissues to any unknown effect of long term exposure to magnetic field.

Applications

Magnetically retained dentures

The magnetic retention unit consists of a denture retention element and a detachable "keeper" element which are "cemented in", "screwed on" or made using root cap and dowel casting.

Transitional over dentures

Since magnetic denture retention elements can be recovered from a denture and reused, this transitional denture can be provided with magnetic retention at no additional expense

Magnetically assembled sectional denture and partial dentures

It consists of paired magnets, an attached keeper and a detachable keeper. The former is cured into the pontic area of the denture base. When the denture is assembled, the buccal section is located by the parallel pins and the magnetic attraction between the retention element in the denture base and the keeper element in the buccal section holds the parts together.

Magnets in maxillofacial prosthesis

The use of magnets is the most efficient means of providing combined prosthesis with retention and stability in patients with deformities requiring complex rehabilitations. The majority of prosthesis are designed using magnets in section. When assembled the magnets are attracted to each other retaining the sections. Magnets are used in orbital prosthesis, auricular prosthesis, large and small maxillary defects and intra-oral extra-oral combination prosthesis.

Advantages

- Magnets provide both retention and stability
- Parallelism of the roots or implants is not must.
- Soft tissue undercuts maybe engaged.
- Enables automatic reseating of the denture if dislodged during chewing.
- Shorter roots equal to 3mm of bone support also are adequate and can function as abutments with magnetic appliances

Disadvantages

- Corrosion is the main problem associated with the use of magnets.
- Deep scratches and gouges caused due to wear on the surface and also by debris and other particles that become trapped between the magnet and the root.
- The abrasive nature of the titanium nitride coated keeper may lead to excessive wear of the magnet.

Conclusion

Magnets were used only occasionally for dental purpose several decades ago. Since the advent of rare earth magnet alloys, the intra oral magnets are shaping the course of esthetic and retention for both complete and removable partial denture. Their benefits include simplicity, low cost, self-adjustment, inherent stress breaking, comparative freedom of lateral movement, a low potential for trauma to the retained root, and the elimination of the need for adjustment in service. The clinical procedures for the fabrication do not require any special skill and the option offered by the various manufacturers gives the dentist a wide variety of choice in selecting the appropriate treatment plan

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