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Magnets in Dentistry

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Abstract:- The outcome of prosthesis is based on its retention, stability and support. Magnets have been used for past several years in dentistry with numerous applications mainly to assist retention with some success and have created an immense interest in dentistry. Their small size and strong attractive or repulsive properties have gained recognition for magnets in dentistry, as these characteristics allow them to be incorporated in the prosthesis without being detrimental in the mouth. Retentive characteristics of magnets have led to their use in various devices like removable partial dentures, obturators, and also the maxillofacial prosthesis. This article reviews the classification of magnet, design of magnetic attachment, their application, and new magnetic attachment system, followed by the advantage and disadvantage of magnets.

Keywords:- *Magnets, Magnetic Field, Complete denture, Overdenture, Implants.*

I. INTRODUCTION

Magnets have generated immense interest in dentistry and their applications are numerous. [1] Retentive properties of magnets have led to their use in prosthesis like over dentures, removable partial dentures, implants, and in orthodontics they have been used in tooth movement, particularly in the treatment of unerupted teeth, for tooth movement along arch wires, expansion, fixed retention, for corrections of malocclusion. With the use of multiple component prosthesis, magnets have been employed to reconstruct large defects in maxillofacial prosthodontics. [2]

Earlier used magnets were not only bulky but also that samarium–cobalt magnets had a strong tendency for corrosion and showed considerable cytotoxicity whereas neodymium–iron–boron magnets had a lesser tendency for corrosion and were only moderately cytotoxic, but encapsulating samarium–cobalt magnets with tin or titanium made the material non-toxic[3]. Improved safety with coating and advent of rare earth magnets led to drastic reduction in size and induced further attention in the field of dentistry.

Magnets gained recognition due to their small size and attractive forces and these properties allow them to be placed within the prosthesis without being detrimental in the mouth. [1] Although they are small, they have considerable strength to be used as retentive aid in dentistry.

II. HISTORY

Magnets were first documented around 2500-3000 years BC. They were introduced into the field of dentistry in the year 1953 and around the year 1960's conventional magnets were used in restorative dentistry. [5] In 1953, Freedman initially used a magnet to improve retention and seating of complete denture against the alveolar ridges by using mutual repulsion at the time of closing the jaw. [6] In 1956, Nadeau used magnets in combined extraoral and intraoral prosthesis. [7] In 1960, Behrman used the technique of incorporation of magnets in the jaw to increase the retention of the prosthesis. [8] In 1976, Federick used magnets in a sectional denture. [9] Magnets were also incorporated in the maxillofacial prosthesis. [10]

III. MECHANISM OF MAGNETS

The presence of an electron surrounding the nucleus as a moving charge generates a magnetic field and hence each atom in a matter is a magnet. Despite this, the majority of electrons are paired, and the equal and opposing charges cancel each other out. Unpaired electrons in some atoms, such as Ni, Fe, and Co, form a tiny magnetic field. [1]. A high number of these magnetic material atoms with small magnetic fields align in small regions known as domains.

The direction of these domains is random in an un-magnetized state, and no magnetization is experienced on the whole. [1] These domains arrange themselves and attain a saturation point when a magnetic field is exerted. When the material reaches saturation, it is considered to be magnetic.

To obtain saturation, some materials only require a tiny magnetic field, while others require a huge magnetic field. The material is called soft magnet when it only requires a tiny magnetic field to get magnetised, and it is called hard magnet when it requires a large magnetic field to become magnetised. A permanent magnet is one that retains its magnetization (remanence) after the magnetic field has been removed. [5]

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IV. CLASSIFICATION OF MAGNETS [11]

A. Based on Alloys used:
- Those containing cobalt Examples are Alnico, Alnico V, Co-Pt, Co5Sm
- Those not containing cobalt Examples are Nd-Fe- B, samarium iron nitride

B. Based on ability to retain magnetic properties (intrinsic coercivity or hardness)
- Soft (easy to magnetize or demagnetize) (less permanent) Examples are: 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). Examples are: Alnico alloys, Co-Pt, Co5Sm, Nd-Fe-B.

C. Based on surface coating (materials may be stainless steel, Titanium or palladium)
- coated,
- uncoated

D. Based on the type of magnetism
- repulsion,
- attraction

E. Based on type of magnetic field
- Open field,
- Closed field
  - Rectangular closed-field sandwich design,
  - Circular closed-field sandwich design,

F. Based on number of magnets in the system
- single,
- paired.

G. Based on the arrangement of the poles
- reversed poles,
- non reversed poles.

H. Based on number of magnets in the system:
- Duo-system open field
- Mono-system open field
- Mono-system closed field

V. MAGNETIC MATERIALS [1]

During the last century, notable improvements have been made in magnetic materials. Dentistry have been adapting to these advances swiftly. Most commonly used material is rare earth material neodymium iron boron (Nd – Fe – B) and is the powerful available magnet. Rare Earth alloys samariums, cobalt (Sm-Co) are other materials of choice. Before the advent of rare earth magnets, Alnicos – alumiunium, cobalt and nickel based alloy were used frequently even though cobalt platinum magnets also existed.

Samarium iron nitride is a capable new nominee for permanent magnet applications due its high resistance to demagnetization, high magnetization, and better resistance than Nd-Fe-B-type magnets to temperature and corrosion.[12] This material is still under study and will be available in the near future for dental purposes.

VI. MAGNETIC SYSTEMS

- **Open Field System:** Open-field magnetic devices were the first to be used, with one magnet implanted in each jaw and denture. As a result of this design, unprotected magnetic fields can be felt in the oral cavity. So these unprotected, coated magnet, that uses only one pole are categorized as open field system. Magnets or steel plates were placed into decoronated root structures, and the like magnets were attached into the denture base, allowing the prosthesis to be held together by an attractive force. Rare earth magnets were employed to improve the retention of dental prosthetics and the Japanese were the first to incorporate it in dental practice. [5]
- **Closed field systems:** Because of the hazards associated with magnetic fields' potential effects on oral tissues, closed field systems were developed. By connecting the two poles of the magnet with a soft ferro-magnetic material, the external magnetic field is eliminated, and the magnetic field is controlled using the keeper. The term "closed field" refers to this form of attachment. The Gillings split pole magnet was one of the earliest commercially available closed field systems. It is made up of paired magnets with opposite poles next to each other. Two magnetizable keepers, one fixed and one detachable, are placed to transfer the magnetic field from the north pole to the adjacent south pole in a closed circuit, which will eliminate practically all external magnetic field in the mouth, whether the denture is worn or not. [5]

VII. MAGNETS IN COMPLETE DENTURES

Because of their small size and ease of incorporation into a complete denture, magnets have been employed to hold complete denture in place. Attempts to use magnets to retain dentures in the mouth had a lot of problems in the past due to the increased dimensions of the magnets and the inadequate forces that they provided, but breakthroughs in magnetic materials have allowed for smaller and stronger magnetic attachments. [13]

Implantation of magnets based on the magnetic properties is divided into two types:
- Magnetic attraction
- Magnetic repulsion

The first known use of magnets in prosthetic dentistry was to repel like poles of magnets to sustain and enhance complete denture retention. Alnico was the magnetic material of choice; however, it has been discontinued due to the large bulk essential for magnetic strength. [14]

First attempt for the use of attractive forces between two magnets for denture retention was made using Al-Ni-Co V and both rectangular and cylindrical PMMA coated magnets, which were surgically placed in the mandible of an edentulous patient, were reported in early 1960's [13]. The force produced was inadequate to aid in retention of the dentures because of the distance between the two magnets.

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With the advancement in the material technology, smaller magnets were introduced that could be incorporated into the retained roots with similar units integrated into the denture. In addition to these developments, root magnets were then replaced with a soft magnetic material that is magnetized only when the denture is placed but becomes demagnetized on removal of the denture. [13]

VIII. MAGNET RETAINED OVERDENTURE

Magnets have improved retention in tooth supported and implant supported overdentures, with Samarium-cobalt being the most widely used magnet in dentistry. Rare earth magnets with very small size having high attractive forces, is a prime consideration in dental prosthesis. Magnetic systems do not direct undue stress to root-abutments, as mechanical "lock-on" attachments do.[3] Also magnets do not resist lateral movement of overlay appliances; they simply slide along the faces of the keepers, the ferromagnetic inserts cemented into the abutment tooth.[15] Various types of keepers used for overdenture retention are:[16]

- Cement-in keeper
- Screw-on keeper
- Cement-on keeper
- Cast root cap and dowel keeper

IX. MAGNETS IN MAXILLOFACIAL PROSTHESIS

Improvements in maxillofacial materials and techniques have become significant in the past decade. In order to reduce the psychological trauma that is related to facial defect, maxillofacial prosthodontist should meet the challenges coupled with the fabrication of prosthesis which meets functional and esthetic needs of the patient. Magnets that have been placed for retention, stabilization and maintenance of combined maxillofacial prosthesis were successful. [7, 10, 18]

With the introduction of iron platinum magnetic attachment system (magnet and keeper) used for retention of prosthesis, can be cast to any desired shape or size of castable magnetic attachment in a dental casting machine and hence they can incorporated into various maxillofacial prosthesis to improve retention, stability and enhance the maintainance. [4, 19, 20]

X. MAGNETS ON IMPLANTS

Osseointegrated implants with magnetic attachments are available. Universal Ti inter-connectors are available, that connects Keeper screws to implant bodies. Because top thread are of standard type, either magnetic attachment or TSI screw for fixed prosthesis may be used with the same Ti inter- connectors. Hence Patient can change from removable magnetic attachment to fixed prosthesis or vice versa.

XI. MAGNETS IN ORTHODONTICS

Magnets have been used in orthodontics for correction of hemifacial microsomia, for relocation of unerupted teeth, as retainer, to close diastemas .for and for molar intrusion. [3]

A. Effect of magnet on tissue and safety factors: [11]

Injury to the tissue can be induced by a magnet in two ways:

- Physical effect due to magnetism.
- Chemical effect due to corrosion product.

Behran researched the physical effects of magnetism on bone and soft tissues in 450 people in 1960; he came to the conclusion that magnetism is absolutely harmless to tissues. [21] Cerny discovered in 1979 that embedded magnets have no negative effects in experimental animals. There is no claim of tissue damage when used in dental applications. In comparison to an open-field system, a closed-field system offers better tissue compatibility. Tsutsui and colleagues [22] reported in 1979 that cobalt-samarium is not chemically hazardous. Samarium salts are not considered toxic. Coated magnets were also noted to have no influence on human dental pulp, gingiva, osteoblasts, or blood flow. [23] The cells are only cytotoxic to uncoated magnets. The influences of these rare earth magnets are especially pronounced in oral mucosal fibroblasts.

XII. ADVANTAGES OF MAGNETS: [3]

- Easy placement
- It can be automatically reseated
- Enhanced retention
- If needed it is easier to replace
- Could used to position in the prosthesis
- Distribute lateral forces
- Parallel abutments rarely required
- Could be utilized for implant-supported prosthesis
- Can be easily maintained

XIII. DRAWBACKS OF MAGNET: [3]

- Low corrosion resistance
- Leachants from magnets having cytotoxic effects
- Highly expensive
- Short track record

XIV. LIMITATIONS OF DENTAL MAGNETS

The application of magnets as a retentive device is hampered by corrosion. Magnets made of Sm-Co and Nd-Fe-B are both prone to corrosion, particularly in chloride rich environments. As a result, before being used in dental applications, magnetic materials must be properly separated from the oral fluids. Despite the fact that most current magnet assemblies are coated in stainless steel or titanium, some devices fail after 18 months of clinical usage due to corrosion and the loss of the attachment's retention. [13]

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XV. CONCLUSION

Dentistry is a constantly evolving science. Ever since the introduction of magnets, dentistry has been adapting to the rapid progress in the developments of magnet over the years. Several decades ago, magnets were only used occasionally for dental purposes due to their large size and insufficient forces they provided but with the advent of rare earth magnets and recent developments of permanent magnetic alloys, great interest have been resurged for the application of magnets in both dentistry and medicine.

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