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Disparate knack in Orthodontics: Magnets an overview

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Abstract

Native iron oxide attracts iron, also a bar of iron or steel that attracts iron has magnetic polarity this is called a magnet. Whereas the study of properties of magnets, magnetic substances and of associated phenomena is called magnetism. Magnets are used in number of conditions like, Relocation of Unerupted teeth; Molar intrusion and correction of anterior open bite; Maxillary expansion; Molar distalization; Space closure with magnets; Functional appliances for correction of Class II and Class III malocclusion; Closure of midline diastema; Treatment of obstructive sleep apnea, snoring; Correction of hemifacial microsomia; Extrusion of crown-root fractured teeth. The various types of magnets used in the field of orthodontics, along with their biological safety which has been discussed in this article.

Keywords: Magnets, Orthodontics, Tooth movement.

Introduction

For the last two decades, permanent magnets have been used for various medical and dental applications.(1) The reason for amplified use of magnets is the recent development of small magnets made of new, powerful and permanent magnet alloys.

So-called rare earth magnets like samarium-cobalt ($SmCo_5$ and Sm_2Co_{17}) and Neodymium-Iron-Boron (Nd2Fe14B) have been of particular interest as these alloys have properties superior to earlier used magnetic alloys like alnico, ferrite, and Platinum-Cobalt (Pt. Co) magnets.(2)

In dentistry, rare earth magnets have been used successfully for fixation of dentures(3) and in force systems for tooth movements.(4) However, magnets have not yet been routinely used, may be owing to high cost.

Magnets are said to have significant advantages over other materials used to move teeth, such as push-coil or elastic chain, as they are able to generate a measured force continuously over extended periods of time for various kinds of tooth movement. They can be made to repel or attract and the force they convey can be directed and can exert their force through mucosa and bone.(5)

Classification of Magnets

No definite classification of magnets has been given in the literature. Hence, an effort was made to combine different types mentioned in various articles[6] to develop a simplified classification system of magnets used in dentistry.

1. Based on alloys used
   - Cobalt containing, e.g. Alnico, Alnico V, Co- Pt, Co5Sm
   - Non-Cobalt containing, e.g. Nd-Fe-B, samarium iron nitride
2. Based on ability to retain magnetic properties
   - Soft (easy to magnetize or demagnetize and less permanent), e.g. Pd-Co-Ni alloy, Pd-Co alloy, Pd-Co- Cr alloy, Pd, Co-Pt alloy, magnetic stainless steels.
   - Hard (retain magnetism permanently). For example, Alnico alloys, Co-Pt, Co5Sm, Nd-Fe-B.
3. Based on type of magnetic field
   - Open field
   - Closed field

✓ Rectangular closed-field sandwich design
✓ Circular closed-field sandwich design

4. Based on the type of magnetism
   - Repulsion
   - Attraction
5. Based on surface coating (materials may be stainless steel, titanium or palladium)
   - Coated
   - Uncoated
6. Based on the arrangement of the poles
   - Reversed poles
   - Nonreversed poles
7. Based on number of magnets in the system
   - Single
   - Paired

Types of Magnetic Materials

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

- Platinum-Cobalt (Pt-Co)
- Ferrite
- Neodymium-iron-boron (Nd-Fe-B)
- Chromium-cobalt-iron (Cr-Co-Fe)
- Samarium-cobalt (Sm-Co)
- Aluminum-nickel-cobalt (Al-Ni-Co)

Applications of Magnets in Orthodontics

The development of rare earth magnets with improved properties resulted in increasing interest in their use as an substitute to traditional force systems in orthodontics. Earlier used for fixation of dentures, after that implanted surgically into molar regions of edentulous mandibles for retention of complete dentures.[7] The pioneering work and Blechmen and Smiley[8] (1978) indicated that magnets have enough force to move teeth. various applications of magnets in orthodontics are as following:

1. Simple tooth movement without archwires
2. Relocation of Unerupted teeth
3. Space closure with magnets
4. Molar intrusion and correction of anterior open bite
5. Molar distalization
6. Maxillary expansion
7. Functional appliances for correction of Class II malocclusion
8. Functional Appliances for Class III malocclusions
9. Treatment of obstructive sleep apnea, snoring
10. Extrusion of crown-root fractured teeth

1. **Simple Tooth Movement Without Archwires:** Muller[9] suggested the use of small magnets (approximately 531 mm) to deliver light continuous forces to close diastemas without archwires, as they deliver predictable, constant low forces. To the labial aspect of the teeth magnets were bonded. The force delivered was determined by the distance between the teeth and, the size of magnet bonded. Muller also suggests that rotations and angulation problems can also be corrected with his technique.
2. **Relocation Of Unerupted Teeth:** Sadler, Meghji and Murray[10] described the use of two attracting magnets in the treatment of unerupted teeth. One of the magnet was bonded to the impacted tooth, while a second stationary magnet was incorporated in a removable acrylic appliance. The direction of force was decided by location of the stationary magnet and activation was done by repositioning the magnet on the plate occlusally.[11]

Vardimon et al[12] introduced a magnetic attraction system, with a magnetic bracket bonded to an impacted tooth and an intraoral magnet linked to a Hawley type retainer. Horizontal and vertical magnetic brackets were designed, with the magnetized, magnetic axis perpendicular and parallel to the base of the bracket, respectively. The, horizontal magnetic bracket is applied for impacted premolars and molars and the vertical type is used for impacted incisors and canines.

3. **Space Closure with Magnets:** In 1987, Kawata et al[13] soldered Sm-Co magnets plated with nickel and chromium to Edgewise brackets for delivering mesio-distal magnetic forces. In extraction cases, canines were retracted conventionally until enough force were exerted on canines by the magnetic brackets on the 2nd premolars. The authors also reported decreased treatment time, resulting in neither discomfort nor pain, nor periodontal problems. (Fig. 1)

Fig. 1: Midline Diastema closure using magnets

4. **Molar Intrusion and correction of anterior open bite:** Woods and Nanda[14] studied the intrusion of posterior teeth in growing baboons, with magnetic and acrylic bite blocks. They postulated that since similar responses were produced with both non-magnetic and magnetic bite blocks(Fig. 2), it would appear that the depression of buccal teeth seen in their study could be attributed as much to the response of muscular to the artificially-increased vertical dimension as to the presence of the repelling magnets.

In another study by same authors [15]done on non-growing baboons, found significant intrusion of posterior teeth with magnets when compared with acrylic bite blocks. However, the effects of the magnets were reduced as compared to growing animals. In the deficiency of evidences the authors hypothesized that electromagnetic fields might be concerned in increasing the response within bone to potential intrusive forces delivered by the repelling magnets.

Bite-block appliances containing magnets enhance the intrusion of buccal segments in cases with Anterior open bite, because of the force produced between the repelling magnets could not be supported by the results of this lab based study.[16] Hwang and Lee[17] (2001) reported the use of magnetic force in conjunction with a corticotomy procedure, to intrude over erupted molars following loss of their antagonist.

Fig. 2: Magnetic Bite Block

5. **Molar Distalization:** Gianelly et al[18] reported the intra-arch placement of repelling magnets against the maxillary molars in combination with a modified Nance appliance cemented on the first premolars, to distalize the Class II molars. The modified Nance appliance was anchored to the first premolars to encourage second premolar's distal drift. Bilateral distal extensions (0.045-inch wire) with loops were soldered to the labial aspect of the premolar bands so that the loops approximated the molar tubes distal movement of the molars were represented by 80% of the space created. Thus for every 5 mm of space opened, the molars were moved posteriorly 4 mm while the premolar-incisor segment moved forward 1 mm.

Itoh et al[19] described an appliance called the Molar Distalization System, which also made use of repelling magnets. The mesial magnet of each pair is mounted so that it can move along a sectional wire.

Bondemark and Kurol[20] carried out distalization of 1st and 2nd molars simultaneously, in a group of 10 patients, using a similar appliance, but including the second premolars as anchorage. They reported that during a mean time of 16.6 weeks, all maxillary molars were distalized into Class I relationship. Whereas the mean molar crown movement was 4.2 mm, about 1.8 mm of anchorage loss in anterior region and mean distal tipping of the 1st and 2nd molars was 8 and 5.6 degrees respectively.

6. **Maxillary Expansion**: Repulsive magnetic forces for maxillary expansion were first described by Vardimon et al[21] in monkeys. Repulsive magnetic force was applied using direct as well as indirect placement of magnets. These were also compared with conventional jackscrew expansion, by means of the implant method.

Advantages in the use of magnetic forces are a predetermined force range with upper and lower limits, for example, 435 to 80 g, and thus the elimination of potential iatrogenic sequelae in the form of uncontrolled force levels.[22]

7. **Functional appliances for correction of Class II and Class III Malocclusions:** Magnets have been used for the correction of class II and III malocclusions. Vardimon et al[23] introduced a new functional appliance to correct Class II dentoskeletal malocclusions, called the functional orthopedic magnetic appliance (FOMA II). Same authors also developed the functional orthopedic device (FOMA III), which has shown positive treatment effects in monkeys.[24] In the case of FOMA II, attracting upper and lower neodymium-iron-boron magnets maintain the mandible in an advanced sagittal position. The objectives of the study were to establish a skeletal response and to develop an appliance capable of leaving the mandible in the advanced position. The first clinical experience for the correction of a class II division 1 malocclusion with a magnetic activator device (MAD) and another device for class III cases has recently been described.[25] Several types have been designed to deal with differing clinical problems, e.g. lateral displacement (MAD I), class II malocclusions (MAD II), class III malocclusion (MAD III), and open bite cases (MAD IV). Chate describes the propellant unilateral magnetic appliance (PUMA) in the treatment of hemifacial microsomia.[26] This appliance uses samarium-cobalt magnets. Moss has described the use of the twin block appliance.[27]
8. **Treatment of obstructive sleep apnea, snoring:** The treatment is directed toward improving the air flow by various surgical and non surgical methods. Non-surgical methods have included treatment with dental appliances, usually removable functional appliances.[28] The mandible is supposed to advance forward, and it is assumed that widening of the upper airway space is created and breathing during sleep enhanced.[29]
9. **Extrusion in case of crown-root fractured teeth:** A subgingival crown-root fracture presents the clinician with a difficult restorative problem, including reaching the fracture line, and is complicated by the need to maintain the periodontal tissues in good health.[30,31] Bondemark et al[32] described the use of magnets to extrude such teeth with excellent periodontal results.
10. **Other Uses:** Springate and Sandler[11] reported the use of Nd-Fe-Bo micro-magnets as a fixed retainer which does not hinder oral hygiene Fig. 3. Two such micro magnets bonded to central incisors mesio-lingual surface were used to retain closure of mid-line diastema. RAC Chate 20 has reported the development of the PUMA or Propellant unilateral magnetic appliance,[33] which uses magnets incorporated in unilateral bite blocks for correction of hemifacial microsomia.

Fig. 3: Magnets as Lingual Retainer

Biological Safety

It is imperative to ensure that magnets used intraorally for clinical use should not produce any local or systemic side-effects.[34] A full evaluation must include three testing levels as follows:

- Level 1: In vitro testing in order to establish the allergic, carcinogenic or toxic nature of the material.[35]
- Level 2: In use testing on animals.
- Level 3: Clinical trials.

Static magnetic fields are produced by magnets used in orthodontics. Biological testing of magnets containing rare earth elements has evaluated the effects of both the static magnetic field, and their corrosion products or possible toxic effects of the materials.[36] Lars Bondemark and Jure Kurol[37] compared in vitro the cytotoxic effects of uncoated and parylene coated rare earth magnet by using two methods as follows:

1. Millipore filter method
2. Extraction method

It is important to note that the WHO report of 1987 states that static magnetic fields up to 2T show no significant health effects.

Conclusion

The development of powerful, rare earth magnets has resulted in their application in many areas of orthodontics. However, at present the most potential clinical uses for these magnets are mainly restricted to tooth movement for impacted teeth, and Class II and Class III malocclusions, as well as for treatment of open bite cases. In Specific the long term effects of open bite correction with magnetic appliances has to be evaluated. Also smaller, thinner magnets are to be developed for better results.

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