

**Review Article****Magnets In Orthodontics****Devendra Singh<sup>1</sup>, Upendra Jain<sup>2</sup>, Amit Prakash<sup>3</sup>**<sup>1</sup> PG student, Dept of Orthodontics and Dentofacial Orthopaedics, Peoples College of Dental Sciences & Research Centre, Bhopal.<sup>2</sup> Professor and Head of Department, Dept of Orthodontics and Dentofacial Orthopaedics, Peoples College of Dental Sciences & Research Centre, Bhopal<sup>3</sup> Reader, Dept of Orthodontics and Dentofacial Orthopaedics, Peoples College of Dental Sciences & Research Centre, Bhopal.

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## ABSTRACT

Magnetism occurs due to a quantum physical effect called exchange coupling, which results in the alignment of the magnetic dipole moments of the atoms. This persistent alignment of magnetic dipole moments in magnetic materials is responsible for the phenomenon of magnetism. Magnets were initially used in dentistry for fixation of dentures. They were also implanted surgically into molar regions of edentulous mandibles for retention of complete dentures. Magnets have been widely used in orthodontics, there have been concerns regarding their safety and possible harmful effects. Magnets are used in number of conditions like, Relocation of Unerupted teeth; Space closure with magnets; Molar intrusion and correction of anterior open bite; Molar distalization; Maxillary expansion; Functional appliances for correction of Class II malocclusion; Functional Appliances for Class III malocclusions; Treatment of obstructive sleep apnea, snoring; Extrusion of crown-root fractured teeth; Closure of mid-line diastema; Correction of hemifacial microsomia. At present the most promising clinical uses for these magnets are mainly confined to tooth movement for impacted teeth, and Class II and Class III malocclusions, as well as for treatment of open bite cases. In particular the long term effects of correction of open bite with magnetic appliances have to be evaluated.

**Introduction****MAGNETS**

Magnetism occurs due to a quantum physical effect called exchange coupling, which results in the alignment of the magnetic dipole moments of the atoms. This persistent alignment of magnetic dipole moments in magnetic materials is responsible for the phenomenon of magnetism.<sup>1</sup>

**Properties of magnets:**

1. All magnets have magnetic fields around them. The field emerges from one pole of the magnet conventionally known as the North Pole and returns to the other or South Pole

2. A magnetic field induces changes in the medium surrounding the magnet, such as air. This is called the flux density of the magnet

3. The flux produced by the magnets causes them to attract or repel other magnets, and attract other materials containing iron

4. The force produced by any two magnets is inversely proportional to the square of the distance between them

5. Thus, the force between two magnets falls dramatically with distance

The development of high energy magnets in the 1970's resulted in magnets capable of producing high forces relative to their sizes. This was due to the property of magneto-crystalline anisotropy, which

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allows single crystals to be preferentially aligned in one direction, thus increasing the magnetism. Recently, the development of rare earth magnets such as Samarium-Cobalt and Neodymium-Iron-boron have taken place. These have a higher ability to be magnetized, and also have high coercivity, which is the ability of the magnet to resist demagnetization.<sup>2</sup>

### **Applications of Magnets in Orthodontics.**

Magnets were initially used in dentistry for fixation of dentures. They were also implanted surgically into molar regions of edentulous mandibles for retention of complete dentures.<sup>3</sup> The development of rare earth magnets with improved properties resulted in growing interest in their use as an alternative to traditional force systems in orthodontics. In 1978, the use of magnetic force to move teeth (in a cat) was reported. Since then, a number of applications have been developed for magnets in orthodontics.<sup>4</sup>

#### **1. Relocation of Unerupted teeth:**

The use of two attracting magnets in the treatment of unerupted teeth was described by Sadler, Meghji and Murray. One magnet was bonded to the impacted tooth, while a second stationary magnet was incorporated in a removable acrylic appliance. The location of the stationary magnet decided the direction of force. Activation was done by repositioning the magnet on the plate occlusally.<sup>5</sup>

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

impacted incisors and canines, and the horizontal magnetic bracket is applied for impacted premolars and molars.<sup>1</sup>

#### **2. Space closure with magnets:**

In 1987, Kawata et al soldered Sm-Co magnets plated with chromium and nickel to Edgewise brackets for administration of mesio-distal magnetic forces. In cases involving extraction, canines were retracted conventionally until magnetic brackets on the 2nd premolars exerted enough force on the canines. The authors reported reduced treatment time, resulting in neither pain nor discomfort, nor periodontal problems.<sup>6</sup>

#### **3. Molar intrusion and correction of anterior open bite:**

Woods and Nanda 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 magnetic and non-magnetic bite blocks, it would appear that the depression of buccal teeth seen in this study could be attributed as much to the muscular response to the artificially-increased vertical dimension as to the presence of the repelling magnets.<sup>7</sup>

In another study done on non-growing baboons, Woods and Nanda found significant intrusion of posterior teeth with magnets as compared to acrylic bite blocks. However, the effects of the magnets were reduced as compared to growing animals. In the absence of other evidence the authors hypothesized that electromagnetic fields might be involved in increasing the response within bone to potential intrusive forces delivered by the repelling magnets.<sup>8</sup>

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.<sup>9</sup> Hwang and Lee (AJODO 2001) reported the use of magnetic force in conjunction with a corticotomy procedure, to intrude over erupted molars following loss of their antagonist.<sup>10</sup>

#### **4. Molar distalization:**

Gianelly et al<sup>11</sup> reported the intra-arch placement of repelling magnets against the maxillary molars in conjunction 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 the distal drift of the second premolars. Bilateral distal extensions (0.045-inch wire) with loops at the end were soldered to the labial aspect of the premolar bands so that the loops approximated the molar tubes. 80% of the space created represented distal movement of the molars. 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<sup>12</sup> 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 Kuroi<sup>13</sup> 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 all maxillary molars were distalized into Class I relationship during a mean time of 16.6 weeks. Whereas the mean molar crown movement was 4.2 mm, anchorage loss in anterior region was about 1.8 mm. Mean distal tipping of the 1st and 2nd molars was 8 and 5.6 degrees respectively.

#### **5. Maxillary expansion:**

Repulsive magnetic forces for maxillary expansion were first described by Vardimon et al<sup>14</sup> in monkeys. Repulsive magnetic force was applied using direct as well as indirect placement of magnets. These were also compared with expansion through conventional jackscrew, 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.

#### **6. Functional appliances for correction of Class II malocclusion:**

One of the major reasons for failure of conventional functional appliances is incompetent sagittal displacement. Normally interjaw tooth contact totals between 8 minutes and 20 minutes during a 24-hour period, but only 1 to 2 minutes during nighttime. These facts indicate a possible limited effective duration—that is, the patient might wear the appliance but in a completely unproductive position. Logically, increasing the construction bite beyond the habitual posture position might provide vertical support. However, increased bite clearance decreases the protrusion performance.<sup>15</sup>

Vardimon et al<sup>16</sup> introduced a new functional appliance to correct Class II dentoskeletal malocclusions, called the functional orthopedic magnetic appliance (FOMA) II. This uses upper and lower attracting magnetic means (Nd2Fe14B) to constrain the lower jaw in an advanced sagittal posture.

In Class II open bite situations, two pairs of lateral magnets in a repelling configuration can be used posteriorly, with the objective that they will produce molar and premolar intrusion, with some distal movement in the upper arch, while pushing the mandible downward and forward. An additional pair of attracting midline magnets located at the retroincisal area will help to achieve symmetry and alignment of upper and lower midlines.

### **7. Functional Appliances for Class III malocclusions:**

Vardimon et al<sup>17</sup> developed an intraoral intermaxillary appliance for the treatment of Class III malocclusions that exhibit midface sagittal deficiency with or without mandibular excess. The functional orthopedic magnetic appliance (FOMA) III consists of upper and lower acrylic plates with a permanent magnet incorporated into each plate. The upper magnet is linked to a retraction screw and is retracted periodically (e.g., monthly) to stimulate maxillary advancement and mandibular retardation. The attractive mode neodymium magnets used in this study produced a horizontal force of 98 gm and a vertical force of 371 gm. The ratio of horizontal to vertical force vectors is dictated by inclination of magnetic interface in the sagittal plane. The more perpendicular the magnetic interface is to the occlusal plane ( $\sin 90^\circ = 1$ ), the greater is the horizontal force vector ( $F_h = \text{attractive force} \sin a$ ).

Histologically, the condylar cartilage demonstrated increased osteoclastic activity at the zone of endochondral ossification and a decreased apposition rate at the adjacent bony trabeculae. Conceivably, the two target areas (PMF sutures versus condylar cartilage) demonstrate two diverse time-related

responses that are either unrelated or interrelated to each other. An unrelated tissue response suggests that tissue stimulation (sutural) is always superior to tissue suppression (condylar). Another possible unrelated tissue reaction implies diverse response velocity (high sutural, low condylar). An interrelated mechanism suggests that an applied force will dissipate initially at the less resistant target area (sutures), and will subsequently affect the more resistant target area (condyle) once the sutural resistance exceeds a certain threshold. The fact that no pathologic change was found in the condylar cartilage encourages a long-term use of the FOMA III appliance, initiating treatment at an early skeletal age.

Darendeliler et al<sup>15</sup> reported a case of a 7.5 years old female with Class III dental malocclusion and bilateral cross bite who was treated with a combined MAD III and MED appliance. Upper and lower buccally placed magnets were used for correction of A-P discrepancy. The upper and lower magnets had a tendency to move toward a fully centered contact, thus creating a forward force against the maxilla and a backward force against the mandible. When combined with an MED, the MAD III offers an alternative in the early correction of Class III malocclusions.

### **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. 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.<sup>18</sup> Bernhold and Bondemark used a magnetic appliance to treat 25 male patients with handicapping

snoring or obstructive sleep apnea. It consisted of a maxillary and a mandibular occlusal acrylic splint. In each splint, four cylindrical neodymium-iron-boron magnets were embedded and oriented to produce intermaxillary forces that pulled the mandible forward. The appliance made the mandible rotate downward and backward, mean  $7.8^\circ$ , and this rotation mostly camouflaged the forward movement of the mandible.<sup>19</sup> There was no significant influence on the hyoid bone position, but the hypopharyngeal airway space increased, the tongue base was lowered, and the contact between the tongue and soft palate was reduced significantly. Gavish used the FMS (functional magnetic system) to treat 28 patients with OSA. After 8 weeks of FMS treatment, it was found that the respiratory disturbance index decreased significantly; minimal oxygen saturation increased significantly, reaching a normal value; day time tiredness improved; snoring declined; the oral cavity anterior region increased significantly, and the pharyngeal airway passages did not change. The functional magnetic system operated by increasing the anterior region of the oral cavity, mainly vertically, with no change in the posterior oral cavity region and pharyngeal airway passages. They concluded that the functional magnetic system is a reliable mandibular repositioning appliance that has no apparent adverse effects.<sup>18</sup>

#### **9. Extrusion 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. Bondemark et al<sup>20</sup> described the use of magnets to extrude such teeth with excellent periodontal results.

#### **10. Other Uses:**

Springate and Sandler<sup>5</sup> reported the use of Nd-Fe-Bo micro-magnets as a fixed retainer which does not hinder oral hygiene. 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, which uses magnets incorporated in unilateral bite blocks for correction of hemifacial microsomia.

#### **Biological effects of magnets and safety concerns:**

Though magnets have been widely used in orthodontics, there have been concerns regarding their safety and possible harmful effects. These are particularly attributed to corrosion products of magnets and their cytotoxic effects, as well as the possible harmful effects of the magnetic fields themselves. Bondemark showed that there is a release of water-soluble cytotoxic components from Sa-Co magnets. Hence, it is very important to use non-cytotoxic or coated magnets.<sup>4</sup> A study by Bondemark to investigate the biological effects of magnets on human tissues, showed that weak static fields below 0.09T in commercially available orthodontic magnets did not cause any histologically detectable changes in human dental pulp or gingiva.<sup>21</sup>

This study is in agreement with a number of previous studies in animals and supports the claim that weak static magnetic fields are harmless to oral tissues.

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 promising clinical uses for these magnets are mainly confined to tooth movement for impacted teeth, and Class II and Class III malocclusions, as well as for treatment of open bite cases. In particular the long term effects of correction of open bite with magnetic appliances has to be evaluated. Also smaller, thinner magnets are to be developed for better results.

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