

## Magnets in Orthodontics: An Overview

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**Abstracts:** Magnetic force is an essential ingredient of nature. The electron and the atom are the smallest magnets. The magnetic moment of the atom is caused by its own spin or by orbital motion of its electrons. Magnets have been used in the dentistry for many years, most commonly to aid in the retention of dentures and over dentures as well as obturators. In orthodontics, they have been used for treatment of unerupted teeth, for tooth movement along arch wire, for expansion, fixed retention, in correction of anterior open bite and in functional appliances. [Patel Ch NJIRM 2015; 6(1):102-106]

**Key Words:** Magnets, magnetic orthodontic appliance, tooth movement.

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**Introduction:** A magnet from Greek word means "Magnesian Stone" is a material or object that produces a magnetic field. This magnetic field is invisible and causes the most notable property of a magnet: A force that pulls on nearby magnetic materials, or attracts or repels other magnets. The field emerges from one pole of the magnet conventionally known as the North Pole, and returns to the other or South Pole of the magnet.

### The Advantages Of Magnetic Force Systems Are:

1. They are able to produce a measured force continuously over long period of time.
2. They can be made to attract or repel, and therefore to push or pull the teeth.
3. The force they deliver can be directed.
4. They can exert their force through mucosa and bone as there does not need to be direct contact between them.
5. Less patient discomfort and more patient co-operation.
6. No material fatigue.

### Biophysical Properties of Magnets: Energy Product:

a magnetic field induces changes in the medium surrounding the magnet, such as air. This is called the flux density of the magnet and can be measured simply by a Hall probe. Energy product is calculated by multiplying field flux density and magnetomotive force. It is an indication of stored energy and force generated. At 1 mm air gap force is 50-300 grams.

**Inverse Square Law:** although very high forces can be produced by even small magnets, the force

produced by any two magnets is inversely proportional to the square of the distance between them. 'High energy' magnets are capable of producing high forces relative to their size due to the property of *magnetocrystalline anisotropy*. This property allows single crystals to be preferentially aligned in one direction (along their C-axis), thus increasing the magnetism.<sup>12</sup>

**Biological Safety:** Biological safety testing of magnets containing rare earth elements has evaluated the effects of both the static magnetic field, and possible toxic effects of the materials or their corrosion products. Effects of the corrosion products in *in vitro* testing ranges from 'no cytotoxic effects' to 'mild cytotoxic effects'.<sup>13-15</sup> Rare earth magnets and, in particular, those containing neodymium, are susceptible to corrosion with release of potentially harmful products.<sup>16</sup>

The effects of the static magnetic field produced by the size and type of magnets used in orthodontics is controversial. *In vitro* static magnetic fields can effect certain biological parameters, e.g. stimulating enzyme systems, cell proliferation/attachment, and osteogenesis.<sup>17</sup> In short term animal studies, a number of undesirable effects have been observed (e.g. epithelial thinning) which, fortunately, have shown to be reversible.<sup>18</sup> In clinical trial found that the static magnetic fields produced by orthodontic rare earth magnets did not result in any change in human dental pulp or gingival tissue adjacent to the magnets.<sup>19</sup>

**Types of Magnet: The following types of magnets have been used in Dentistry:**

1. Conventional:
    - A. Platinum Cobalt (PtCo)
    - B. AlNiCo (Al Ni Co<sub>5</sub>)
    - C. Ferrite
  2. Rare earth magnets:
    - A. Samarium Cobalt (SmCo)
    - B. Neodymium Iron Boron (Ne<sub>2</sub>Fe<sub>14</sub>B)
- PtCo magnet has excellent magnetic properties, but its high cost has limited its use.
  - Ferrite and AlNiCo have lost their usage because of the large size needed to produce effective force.
  - The most commonly used magnets are rare earth magnets as their small size can produce optimal orthodontic force.

Shortcomings<sup>20, 21</sup> of magnets are

- A. Brittleness
- B. Low Corrosion resistance.
- C. Low Curie Temperature.

**Applications of Magnetic Appliances:**

1. **Tooth Intrusion:** Removable and fixed appliances with acrylic bite blocks incorporating magnets to intrude the molars have been used for correction of open bite. In 1986, Dellinger<sup>8</sup> reported on the active vertical corrector (AVC). This appliance uses samarium cobalt magnets, oriented in repulsion producing a posterior intrusive force of 600-700 gm per magnetic unit. This appliance was more efficient than usual bite block therapy due to the intermittent electromagnetic field produced by movements of the mandible which would enhance tooth movements but the repulsive elements of the magnets produced lateral mandibular movements and thus increased the risk of developing cross bites.<sup>22</sup> Noar et al<sup>23</sup> (1996) carried out laboratory based experiments to examine to effects of orientation of magnets on the force levels achieved between.

2. **Tooth Extrusion:** Impaction and non-eruption of teeth is a common problem encountered in orthodontics. In many cases exposure alone, or exposure and applying an attachment to the tooth is used. A method of using small high energy

magnets to provide the traction force to aid the eruption of an impacted maxillary canine has been described by Sandler<sup>3, 4</sup>. Small neodymium-iron-boron magnets (3x3x1 mm) are bonded onto the unerupted canine and a second larger magnet (5x5x2 mm) is incorporated into a removable appliance in an appropriate position. The magnets can produce constant physiological forces over long periods of time and the direction of the force can be chosen by the clinician so the tooth can be encouraged to erupt into the ideal place. Advantages include, the patient does not have to attach elastics or hooks to the chain, few adjustments are needed, and the attachment is less likely to be knocked and dislodged from the tooth. Great care must be taken to ensure the polarity of the magnets are correctly positioned particularly in cases where there are bilateral impacted canines to ensure the teeth move in an appropriate direction. The magnets may also be subject to corrosion if their coating is damaged.

**3. Simple Tooth Movement without Arch Wires:**

Muller<sup>24</sup> suggested that small magnets (approximately 5x3x1 mm) could be used to deliver light continuous forces to close diastases without arch wires. The magnets were bonded to the labial aspect of the teeth using the indirect bonding technique. Muller suggests that rotations and angulation problems can also be corrected with this technique. Magnets produce a light continuous that increases as the teeth get nearer is the reason the teeth move quickly. Advantages are chair side time is low; there is no need to reactivate the appliance as long as the magnets have been correctly placed, and maintaining good oral hygiene is easy. Disadvantage is the difficulty in correctly positioning the magnets and the risk of inhalation if one is dislodged.

4. **Complex Intra-And Inter-Arch Mechanics:** The magnets can be used in attraction or repulsion to move teeth along arch wire, provide Class II traction and to intrude/Extrude individual teeth. Double tubes are used on the molars and the magnets mounted on sectional arch wires. A base full arch is used to control the direction the direction of the tooth movement.

**5. Molar Distalization:** Maxillary 1<sup>st</sup> molars have been moved distally with an intra-oral device using repelling magnets in conjunction with a modified Nance appliance. Distal movement was recorded at a rate of 3 mm in 7 weeks<sup>25</sup>. Bondemark and kuroi<sup>26</sup> reported simultaneous movement of first and second molars using repelling samarium-cobalt magnets. Repelling force levels of 58-215 gm were used and all of the maxillary molars were moved to a Class I relationship within an average time span of 16.6 weeks.

#### **Functional Magnetic System:**

#### **The Functional Magnetic System Can Be Discussed Under Two Headings:**

1. Functional Orthopedic Magnetic System (FOMA), and
2. Magnetic Active Devices(MAD).

Vardimon and co-workers developed the functional orthopedic device (FOMA II & III) which has shown positive treatment effects in monkeys<sup>9,10</sup>. In the case of FOMA II, upper and lower attracting neodymium-iron-boron magnets maintain the mandible in an advanced sagittal position. In contrast to the regular passive Functional appliances, FOMA II is an active appliance that directs its inherent magnetic forces to the jaws and thereby constrains the lower jaw in an advanced posture. The results showed that 570 gm of magnetic force when the magnets were in apposition and 219 gm of force if the jaws were in the rest position.

Darendeliet et al<sup>11</sup> 1993 done first clinical experience with a magnetic activator device (MAD) for the correction of a Class II division 1 malocclusion. Several types of magnetic activator device have been designed to deal with differing clinical problems, e.g. lateral displacement (MAD I), Class II malocclusions (MAD II), Class III malocclusions (MAD III), and open bite cases (MAD IV). Chate<sup>27</sup> describes the propellant unilateral magnetic appliance (PUMA) in the treatment of hemifacialmicrosomia. This appliance uses samarium-cobalt magnets embedded in unilateral blocks of acrylic to stimulate the autogenous costochondral graft. Moss et al<sup>28</sup>. (1993), has described the use of the twin block appliance with magnets incorporated in the

treatment of Class II division 1 malocclusions. He noted that incorporating magnets into the appliance decreased the time taken to produce the sagittal changes and increased the soft tissue changes compared to those appliance without magnets.

**Magnetic Brackets:** Kawata et al<sup>29</sup> introduced a new force system of magnetised edgewise brackets. The magnetic brackets were chromium-plated samarium-cobalt magnets soldered to the base of an edgewise bracket which were directly bonded to the teeth and were designed to form an ideal arch shape in the maxilla and mandible at the completion of treatment. Force levels delivered to the teeth were estimated at 250 gm. Bracket placement allowed mesial and distal movement of teeth only if the inter bracket distance was less than 3 mm. Darendeliet and Joho<sup>30</sup>, described a similar system called the autonomous fixed appliance which has no brackets or arch wires, but uses individual samarium-cobalt magnets bonded to each tooth exerting a continuous force to create an ideal arch form.

**Conclusion:** Magnets can be used to give predictable forces in either attraction or repulsion, they can be made small enough to suit most dental applications and can produce high forces. Use of magnets in orthodontics is limited due to a number of factors.

- A. 1.The force between two magnets drops dramatically with distance and even at small distances apart the forces can be very low.
- B. When heated (when coated in acrylic or subjected to hot liquids) they can suffer considerable loss of flux and therefore force.
- C. The orientation of one magnet to another is of the utmost importance and when not in perfect alignment the force between them drops significantly.
- D. Neodymium-iron-boron magnets are subject to severe corrosion in the oral environment and must be coated with a substance that is not subject to frictional wear.

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