



## Review Article

## Application of magnets in orthodontics –A review

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## ABSTRACT

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.

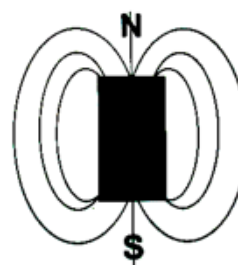
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## 1. Introduction

Magnetic force is an essential ingredient of nature. Magnets have generated great interest within dentistry. They have been used for various applications in orthodontics and prosthodontics. Earlier use of magnets was limited due to the unavailability of small size magnets, but after the introduction of rare earth magnets and their availability in smaller sizes, their use has increased considerably.<sup>1</sup> The force they deliver can be directed, and they can exert their force through mucosa and bone as well as within the mouth.<sup>2,3</sup> In orthodontics, they are used for intrusion of teeth, tooth movement along archwires, expansion, retention, in functional appliances and in the treatment of impacted teeth.<sup>4-7</sup> There are various types of magnets used in the field of orthodontics with their advantages and disadvantages, along with their biological safety which has been discussed in this article. This article reviews various uses of magnets in the field of orthodontics.

## 1.1. Physical Properties of Magnets

All magnets have magnetic fields around them. The field emerges from one pole of the magnet conventionally known as 'N' pole and goes to other pole that is 'S' pole. Magnetic field can be either Static or Time varying.



## 1.2. Coulomb's Law

All magnets obey this law which states that 'force between two magnetic poles is proportional to their magnitudes (M) and inversely proportional to the square of the distance between them.'

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$$F = \frac{M}{d^2}$$

The rare earth magnets give maximum force at short distance in comparison to elastics, which attain maximum force at more distance.

### 1.3. Curie point

Rare earth magnets tend to lose their magnetism at room temperature. To overcome this in orthodontics it has been combined with other element such as boron so that they can be incorporated into appliances and heat stabilized.

Pierre Curie observed that magnets tend to lose their properties at specific temperature which causes their domain to return to random distribution. This point of temperature is called Curie Point.

#### 1.3.1. Important Intra-Oral Properties

1. Three dimensional centripetal orientation of attractive magnetic force.
2. Interruption of magnetic force line by Intermediate media.
3. No energy loss.
4. When two magnets are displaced in all the three planes they attract to a complete overlap. Centripetal attraction in all 3 spatial dimensions gives the operator complete teeth control on precise engagement.
5. Intra oral magnets are attracted to each other even if soft or hard tissues are interspersed in the gap between the two magnets eg: impacted canines.
6. When compared to elastics which shows force degradation & deteriorate over a short time, the rare earth magnets can maintain constant energy if protected against corrosion, curie temperature etc.

#### 1.3.2. Types of Magnetic Appliances

1. Platinum Cobalt
2. Al-Ni-Co
3. Ferrite
4. Cr-Co-Fe
5. Samarium Cobalt
6. Neodymium Iron Boron

#### 1.3.3. Rare earth magnets

1. High cohesive forces that is high resistance to demagnetization
2. Capable of producing high forces relative to their size due to the property of Magnetocrystalline Anisotropy
3. Strong permanent magnets made from alloys of rare earth elements. They are substantially stronger than ferrite or alnico magnets.
4. **Anisotropy** is the property of substances to exhibit variations in physical properties along different molecular axis.

### Samarium Cobalt magnets (SmCo5 & Sm2Co17):

Introduced by Becker in 1970. They have Superior magnetic properties compared to other rare earth magnets

#### 1.3.4. Advantages

1. Force necessary in orthodontics can be obtained from small size of the magnets
2. High resistance to demagnetization
3. High Curie point (more stable)
4. High Corrosion resistance

#### 1.3.5. Biologic concept of Magnetic force and Histologic changes

1. No subcutaneous changes as inflammation or adverse reaction under the magnets
2. Resorption of bone occurred under magnets after 3-4 weeks
3. Reduced chances of necrosis of bone as magnets make erythrocytes thinner
4. Magnetic forces inflicted a minimum of stress that induces various bio-chemical changes in a patient during orthodontic tooth movement.

#### 1.3.6. Lars Bondemark & J. Kurol

1. Studied changes in human dental pulp and gingival tissue on exposure to magnetic field. They found no difference in clinical gingival condition and pulpal condition.

#### 1.3.7. McDonald (1993)

1. Reported increased proliferation and systemic activity in fibroblasts in presence of static magnetic field

#### 1.3.8. Lars Bondemark & A. Wennberg (1994): Study showed that-

1. Uncoated Samarium magnets showed severe toxicity
2. Parylene coated Samarium magnets showed mild toxicity
3. Coated & uncoated Neodymium magnets showed negligible toxicity
4. Short term exposure to magnet fields did not cause any cytotoxic effect on cells

#### 1.3.9. Application of magnets in orthodontics

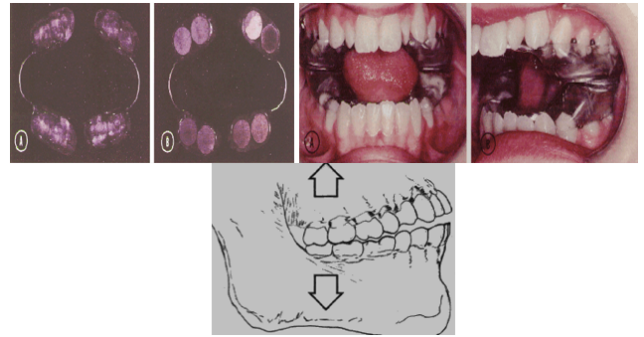
##### 1.3.10. Orthopedic

1. Expansion of arch
2. Growth modulation- Class II correction with functional appliances (eg; Magnetic Twin block, FOMA)

##### 1.3.11. Orthodontic

1. Fixed mechanotherapy- extraction & non-extraction
2. Relocating impacted teeth
3. Distal/mesialization of molars

4. Intrusion of posterior teeth in open bite cases
5. Closure of diastema
6. Uprighting and Derotation of teeth
7. Magnetic Brackets
8. Magnetic appliance for treatment of snoring in patients with and without sleep apnea
9. Extrusion of fractured teeth
10. Retainers (micro magnetic retainer)



**Magnetic Appliances-** Magnetic forces are used to bring about orthodontic tooth movement, Derived from magnets in attraction or repulsive mode

### 1.3.12. Advantages

1. Eliminates patient co-operation
2. Less pain and discomfort
3. Continuous force = reducing treatment time
4. Reduced periodontal disturbance, root resorption & caries
5. No friction & Better directional force control
6. Less chair side time

### 1.3.13. Disadvantages

1. Tarnish & corrosion
2. Cytotoxic effects
3. Bulk
4. Bitter Taste
5. Expensive

## 1.4. Appliances & other orthodontic uses of magnets

### 1.4.1. Active Vertical Corrector (AVC)

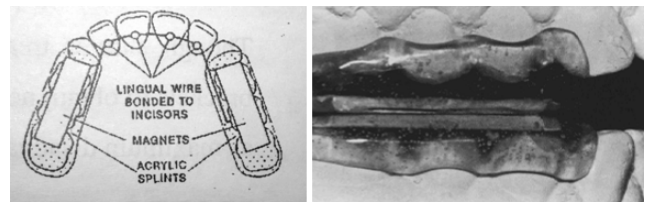
1. Developed by Dellinger in 1986, as a non surgical alternative treatment for Skeletal open bite
2. Can be fixed/removable and works as an energized bite block.
3. As it is energized only by the intermittent force from the muscles of mastication—electromagnetic field.
4. Superior to static bite block appliance
5. The energy system is obtained by the repelling force of **Sm -Co** magnets encased in a stainless steel capsule.
6. **Constant force** system results in rapid tooth movement than conventional appliances such as high-pull headgear, Activator bite block therapy.

1.4.1.1. Mechanism of Action. Reciprocal intrusion of maxillary and mandibular teeth resulting in autorotation of mandible and open bite correction

1.4.1.2. Activation. Intermittent force from the muscles of mastication leads to activation of electromagnetic field which leads to increase in remodeling and finally orthodontic tooth movement.

### 1.4.2. Fixed Magnetic Appliance

1. Introduced by **Varun Kalra & Charles Burstone** in 1989.
2. Used for Growth modulation.
3. Appliance has the repelling **SmCo** magnets embedded in the upper and lower acrylic splints.



### 1.4.3. Expansion

1. **Vardimon and Graber** (1987) demonstrated palatal expansion using two types of appliances

### 1.4.4. Advantages

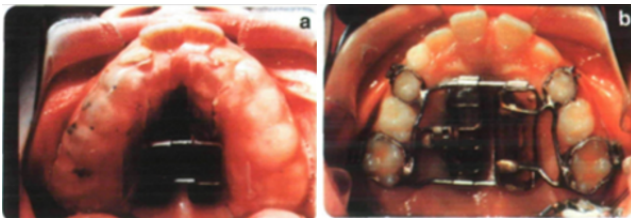
1. Physiologic forces
2. Avoids the rotation of maxilla

#### 1.4.4.1. Disadvantages .

1. Expansion is slower.
2. Bulky, needs stabilization

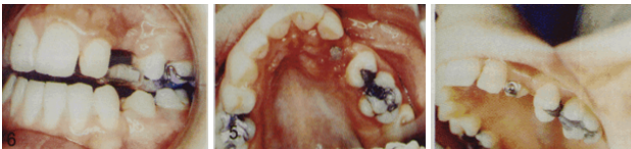
### 1.4.5. Tooth Impaction

1. **Vardimon, Graber, Drescher (1991)** used Nd2Fe14B magnets to assist eruption of an impacted canine.
2. Procedure:-A mucoperiosteal flap is raised uncover impacted canine — Vertical magnetic bracket/small magnet are bonded to the lingual crown surface.



**Fig. 1:** A: The bonded MED. B: The bonded MED.

3. The Force acts through a bigger intra oral magnet placed in removable appliance.
4. Advantage: simple, frictionless, short treatment time



#### 1.4.6. Magnets for diastemas (Muller (1984))

1. Rectangular SmCo magnets
2. Light continuous forces
3. Direct bonding to the labial aspect of the tooth.

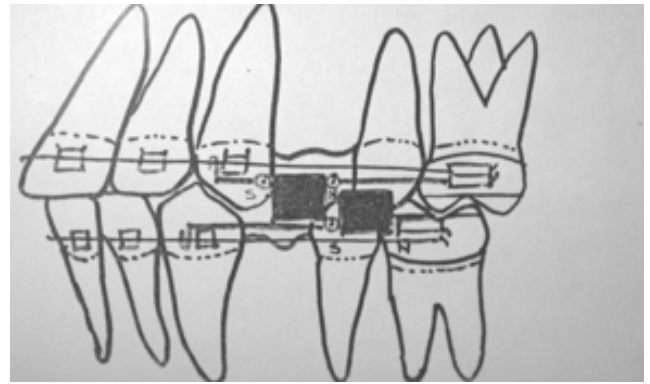
##### 1.4.6.1. Advantages.

1. No archwires
2. Less Chair side time
3. Position of teeth can be controlled by position of magnets



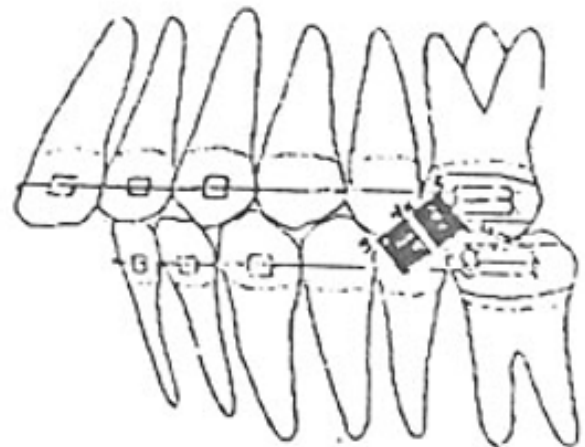
#### 1.4.7. CL-II mechanics in extraction cases

1. Upper magnet - attached to the upper sectional arch & ligated to mesial aspect of canine
2. Lower magnet- attached to lower sectional arch
3. Upper & lower magnetic poles in attraction result in tooth movement



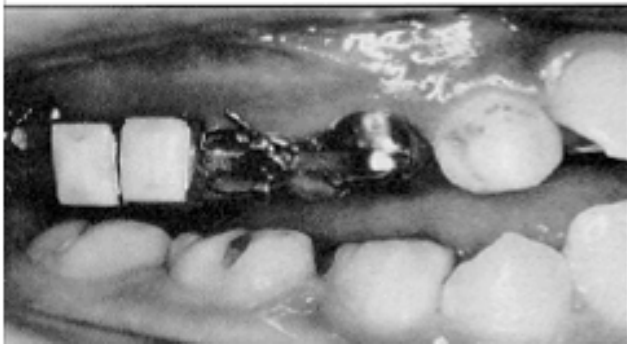
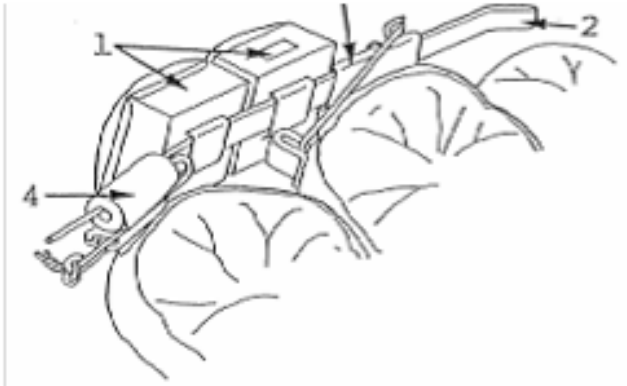
#### 1.4.8. CL-II mechanics in non-extraction cases

1. Upper magnet - mesial to molar tube
2. Lower magnet -mesial to the upper magnet
3. At  $70^{\circ}$  from the horizontal plane
4. 0% air gap for Maximum force
5. Magnets in attraction or repulsion can be used to drive upper buccal segment distally.

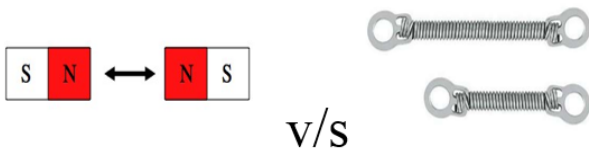


#### 1.4.9. Molar distalization (Gianelly(1988))

1. Two repelling magnets for each maxillary quadrant.
2. Nance appliance is placed to reinforce the anchorage.
3. Constant force = 80z



1.4.10. Bondemark & Kurol (1994)



**Results:** Coil are most comfortable & forces were more constant than magnet forces.

1.4.10.1. Disadvantage of magnets .

1. Difficulty in correctly positioning
2. Risk of swallowing if dislodged

1.4.11. Magnetic edgewise brackets

1. Introduced by Kawata (1987),
2. Shorter treatment time & good biocompatibility.
3. But of lab procedure is complex
4. Chromium plated SmCo magnets soldered to base of edgewise brackets which were directly bonded to the teeth

1.4.12. Functional Orthopedic Magnetic Appliances (FOMA)

1.4.12.1. (Vardimon et al (1989)).

1. Developed FOMA for correction of Class II & III malocclusions
2. It had shown positive treatment effects in monkeys

1.4.12.2. FOMA II (NeFeBo).

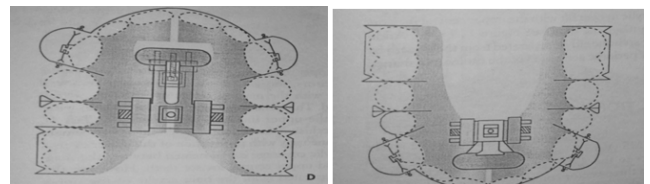
1. It has upper and lower attracting magnets.
2. Active appliance, directs its inherent magnetic forces to the jaws, thereby keeping the jaw in an advanced posture.

1.4.12.3. FOMA III (Ne-Fe-Bo)-.

1. The upper magnet is attached to a retraction screw, the lower magnetic housing is attached near the lingual surface of the central incisors.
2. The upper magnet is retracted periodically to stimulate maxillary advancement and mandibular retraction.

1.4.12.4. FOMA III has a biphasic action-

1. Immediate rapid sutural Expansion
2. Slow and delayed cartilaginous suppression.



1.4.13. Magnetic activator device

1. Developed by **Darendilier** (1993)
2. **MAD I** – used for correction of mandibular deviation
3. **MAD II** – for CI II corrections
4. This removable appliance postures the mandible forward.
5. Attractive force was about - 600 gms.
6. CI-II malocclusion corrected by posterior movement of upper jaw and forward movement of mandible.
7. First 6 months – full time.

8. Next 2 months – night time only.
9. It consists of an upper and lower Hawley's framework carrying a rectangular magnet in premolar region.

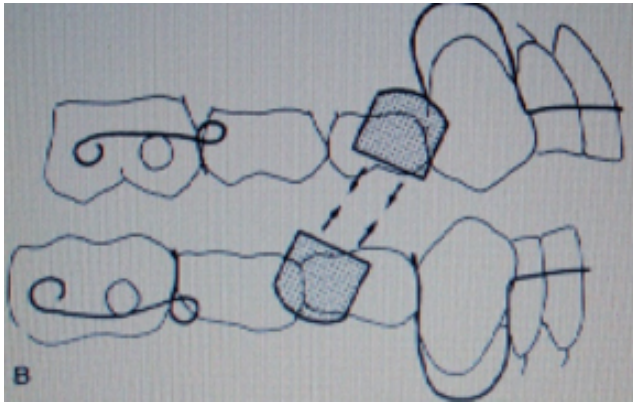
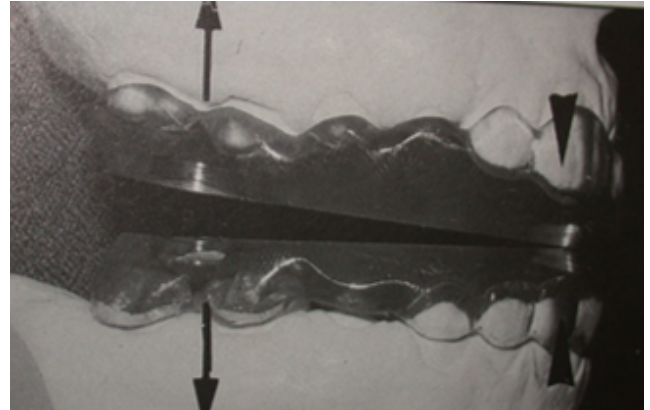


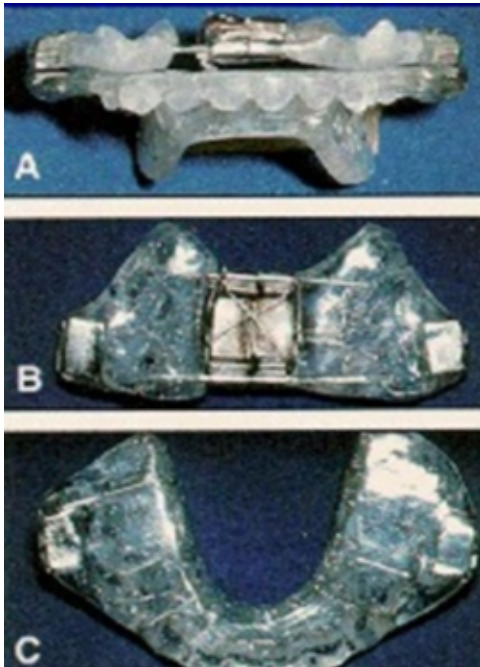
Fig. 2:

3. Anterior magnets guides mandible into a centered midline position and enhance anterior rotation of mandible.



## 1.4.13.1. Mad III.

1. MED + MAD III for early treatment of Class III malocclusion.
2. Maxillary expansion and stimulation of forward maxillary growth, to obtain dental and skeletal correction



## 1.4.13.2. MAD IV - open bite correction.

1. It consists of anterior attracting magnets and posterior repelling NeFeBo magnets.
2. The repelling magnets generate a force of 300g.

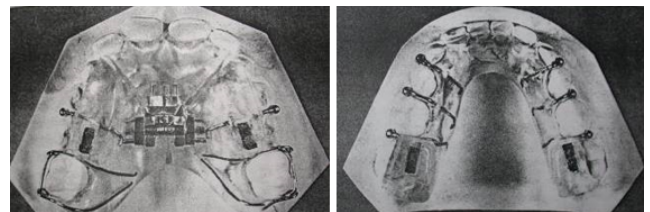
## 1.4.14. The Propellant Unilateral Magnetic Appliance (PUMA)

1. Treatment of hemifacial microsomia by Chafe (1995)
2. Repelling SmCo magnets in U/L acrylic bite blocks
3. Simulates autogenous costochondral graft
4. In these individuals there is underdevelopment of one half of the facial structures and muscles on the affected side.



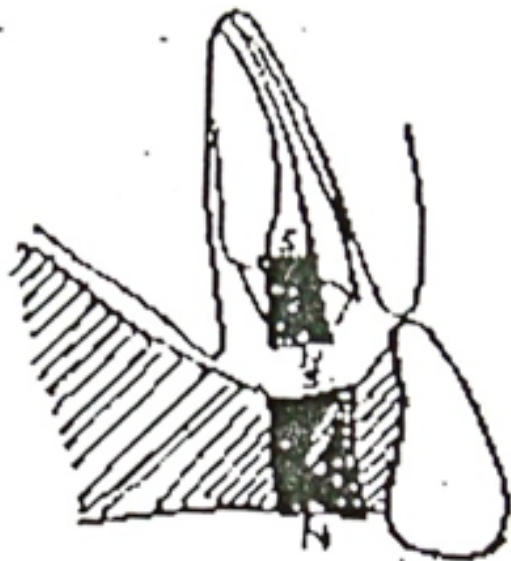
## 1.4.15. Magnetic twin block (Clark (1996))

- SmCo magnets are embedded in the inclined surface of the twin block in attraction mode.



#### 1.4.16. Extrusion of fractured teeth

1. **McCord & Harvie** (1984) & **Bondemark & Kurol** (1997) used magnets to extrude teeth with fractured roots.
2. Attractive magnets - one at root fragment & other in removable appliance.
3. After the desired extrusion the tooth can be restored



#### 1.4.17. Micro Magnetic Retainers

1. Springate & Sandler(1991)
2. Micro magnets made of Ne-Fe-Bo can be used as fixed retainer in patients with midline diastema.
3. More physiologic tooth movement and better oral hygiene



##### 1.4.17.1. Recycling of magnets.

1. Bondemark & Kurol conducted extensive studies on recycling (autoclaving) of rare earth magnets.
2. Biocompatibility, force & stability is not effected
3. Darendililer - magnets should not be recycled for ethical reasons & also to prevent demagnetization

## 2. Discussion

Early attempts at using magnets for intraoral uses were unsuccessful, mainly because of the large size of magnets at that time and the inadequate forces that they provided. However, since the introduction of rare earth magnets, such as samarium-cobalt and neodymium-iron-boron, it has become possible to produce magnets with small enough dimensions to be used in dental applications and still provide the necessary force. Introduction of rare earth magnets into orthodontics for various therapeutic uses is very recent. Within 10 years, magnetic forces have gained good acceptance in correction of skeletal and dental defects. The main advantage with magnets is operator controlled. It eliminates patient cooperation. Conceivable risks of harmful biological effects are negligible with magnets. It is easy to maintain oral hygiene. Compared with other conventional orthodontic methods of force delivery systems magnets are cost effective. Their high cost can overcome by reusing it after sterilization and recycling. These magnets after recycling have not shown much change in their force system. Magnets suffer from tarnish and corrosion. Tarnish and corrosion products are cytotoxic. Tarnish and corrosive nature is prevented by casing them in stainless steel jackets (or) giving parylene coat. Magnets exert continuous forces with less friction, compared to other conventional orthodontic appliances. Teeth movement are bodily in nature and treatment time is shorter. They can be associated along with fixed, removable and functional appliances. Uses of extraoral forces are minimized and anchorage control with them is very precise. Magnets can be used to give predictable forces in either attraction or repelling mode. The orthodontic stimuli provided by the magnetic appliance have reduced the systemic stress reaction seen with conventional orthodontic mechanotherapy. The incidence of periodontal disturbances, root resorption and caries are considerably low and foremost no discomfort.

## 3. Conclusion

Superiority of results with magnetic appliances as compared to those of conventional orthodontic appliances is still in dispute. The evidence currently suggests that the risk of harmful biological effects are negligible. High cost can be overcome by reusing after sterilization & recycling.

## 4. Source of Funding

None.

## 5. Conflict of Interest

None.

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