

Effect of biteblocks and repelling magnets on root formation of unerupted premolars in macaca monkeys

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The effect of repelling magnets on the root formation of unerupted teeth was studied in monkeys. Four controls, four monkeys with acrylic biteblocks and four monkeys with repelling samarium magnets embedded in biteblocks were observed for 12 weeks. After the monkeys were killed the teeth were examined histologically and the root formation evaluated. A clear influence on both the predentine formation and the Hertwig's root sheath was observed. The results clearly indicate the need for more long-term studies on the tissue reactions produced by repelling magnets. *Proc Finn Dent Soc 1991, 87: 109-14*

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Over the last few years, magnets have been incorporated into orthodontic appliances that are used in the orthodontic treatment of anterior open bite and excessive lower face height. They have also been advocated for intrusion of molars and for reduction of the vertical development of buccal segments. Dellinger (1986) reported intrusion of posterior teeth followed by an upward and forward rotation of the mandible. Later Kalra et al. (1989) suggested that the length of the mandible could also be increased by such appliances. Intrusion was, however, still an important component in their findings. According to Dellinger (1986) this type of treatment may be a valid alternative to a surgical superior repositioning of the maxilla in some cases.

To date, effects of magnetic orthodontic appliances have been studied with cephalometric methods. The tissue reactions related to in-

trusion have, however, received less attention. This type of tooth movement has previously been observed to result in a high degree of iatrogenic damage including vacuolization of the pulp, changes in the apical anatomy of roots during their formation and in root resorption (Stenvik and Mjör 1971). Since the effect of repelling magnetic appliances on root surfaces during intrusion has not been assessed this study evaluated the structure and direction of Hertwig's root sheath and the characteristics of the predentine following 24 weeks of intrusion produced by repelling magnets and/or posterior bite blocks.

Material and methods

Twelve male juvenile rhesus monkeys (*Macaca mulatta*) obtained from the Caribbean Pri-

mate Research Center in Puerto Rico were used in this study. The animals were divided into three groups. Bite opening appliances with magnetized disks in a repelling configuration were inserted in the animals of the first group. Four additional animals were given similar biteblocks with non-magnetized disks (sham appliances). The rest of the animals received no appliances and were used as controls.

The biteblock appliance consisted of bilateral acrylic blocks connected and reinforced by a 0.036 inch stainless steel wire framework. Samarium disks covered by a stainless steel case were embedded in each block. To produce repulsive forces the polarities of the maxillary and mandibular magnets were the same. No magnetic forces were present in the sham appliances.

The vertical height of the metal cases containing the magnets was 2 mm. Every effort was made to place the metal disks in positions that minimized the vertical opening produced. The magnets had a peak repulsive force of 358 g at 0 mm airgap. At 1 mm airgap, the force was 148 g and at a distance of 2 mm, the magnets were separated by 78 g of force.

Before bonding, the acrylic appliances were equilibrated to allow a balanced occlusion in the posterior region. The appliances were then bonded using Excel bonding resin (Reliance Orthodontic Products, Itasca, IL). Further details concerning management of the appliance can be found in Hoenie (1986).

The treatment effects of the appliance were followed by means of standardized lateral cephalograms before and after cementation and at 6, 12 and 24 weeks.

At 24 weeks, the appliance was removed, the final cephalogram taken and the animals killed. After decapitation the jaws were excised and placed in a solution of 10 % neutral buffered formalin.

Since the purpose of this study was to

evaluate the effect of treatment on erupted as well as on the unerupted developing teeth, tissue blocks were later trimmed, leaving the whole alveolar process which had been covered by the appliance. The tissue blocks were then decalcified in EDTA and 8-micron-thick parasagittal sections were stained with haematoxylin and eosin. Ten sections, all including the full extension of the pulp of at least two teeth, were evaluated.

The development of the permanent teeth was classified according to the orientation of the predentine and the Hertwig's root sheath in relation to the external root surface. Three categories were defined, namely (1) The Hertwig's root sheath extending in an apical direction, (2) the root sheath perpendicular $\pm 30^\circ$ to the root surface and (3) the root sheath directed into the pulp, indicating a shortening of the root.

According to the configuration of the predentine, the teeth were classified into two groups. In Group 1 there was no alteration in the predentine direction. Group 2 there was marked angulation between the predentine and the root surface.

The significance of differences in distributions were evaluated using the chi-squared test.

Results

Changes in root development were observed in both experimental groups. Although there was much variation, there were significantly more roots that exhibited a folding of the Hertwig's root sheath and an orientation of the predentine toward the central axes of the tooth in the biteblock and on the magnet group than in the control group (Table 1 and 2; Figs. 1—3). The direction of the root sheath was changed from being slightly bent toward the centre of the root in an apical direction to a flattening and folding into the pulp. Within the two experimental groups, no

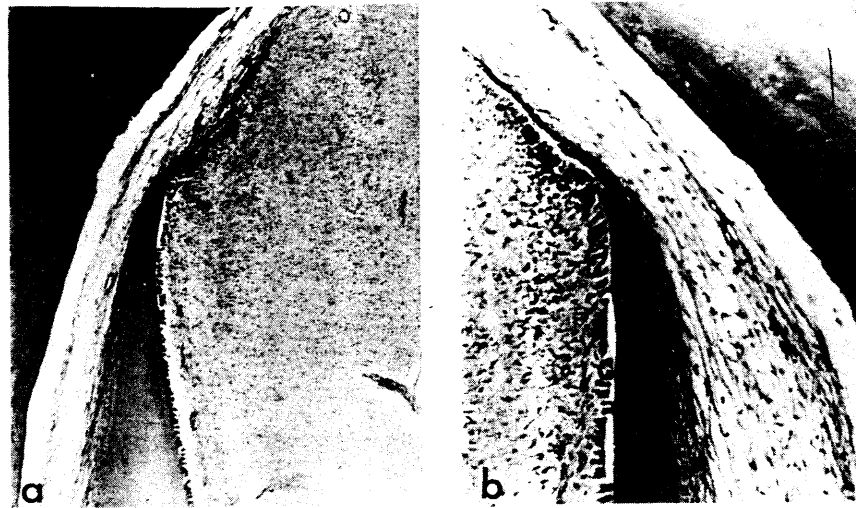


Fig. 1. Photomicrograph showing the predentine (a) and the Hertwig's root sheath (b) in an unerupted premolar from a control monkey. Original magnification a: x16, b: x64.

difference was noted with regard to predentine but significantly more teeth exhibited an inverted Hertwig root sheath in the animals wearing magnetic appliances.

No difference was observable between erupted first molars and unerupted premolars. No differentiation was done in the calculations.

Discussion

Intrusion performed as a part of fixed appliance treatment has been perceived as a risk factor with regard to root resorption (DeSchiels 1969, Linge and Linge 1983, Dermant and DeMunck 1986). These authors evaluated root resorption in maxillary incisors radiographically. Stenvik and Mjör (1970) and Dellinger (1967), on the other hand, intruded premolars and followed the reactions histologically. Both authors found that increased force resulted in increased risk of root resorption.

In the study reported here, all roots studied were in course of formation and no api-

cal root resorption was observed. Since the biteblocks were bonded to the erupted teeth, deciduous and permanent molars, forces on the unerupted premolars must have been transferred via pressure on the deciduous

TABLE 1. Distribution of the roots according to the angulation of the Hertwig's root sheath. The distributions in the three groups differed significantly

	> 120°	90° ± 30°	< 60°
Control	22	7	6
Biteblock	0	16	20
Biteblock + magnets	2	4	21

$p < 0.01$

TABLE 2. Distribution of teeth according to morphology of predentine

	No change	Angulated process
Control	29	6
Biteblock	5	15
Biteblock + /magnets	5	23

$p < 0.01$

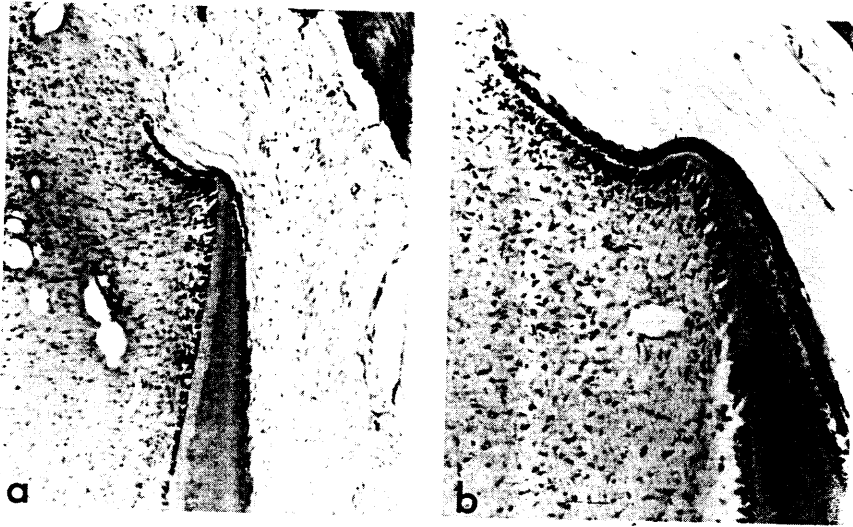


Fig. 2. Photomicrograph showing the angulated pre dentine (a) and the bend Hertwig's root sheath (b) of an unerupted premolar from a monkey treated with biteblock only. Original magnification a: x16, b: x64.

teeth. Because of the marked variation it was, however, not possible to quantify the effect of the magnets alone.

Root formation depends on Hertwig's root

sheath, the orientation of which is also related to the direction of the unmineralized pre dentine (Melsen et al. 1977). The orientation of the pre dentine varies throughout the

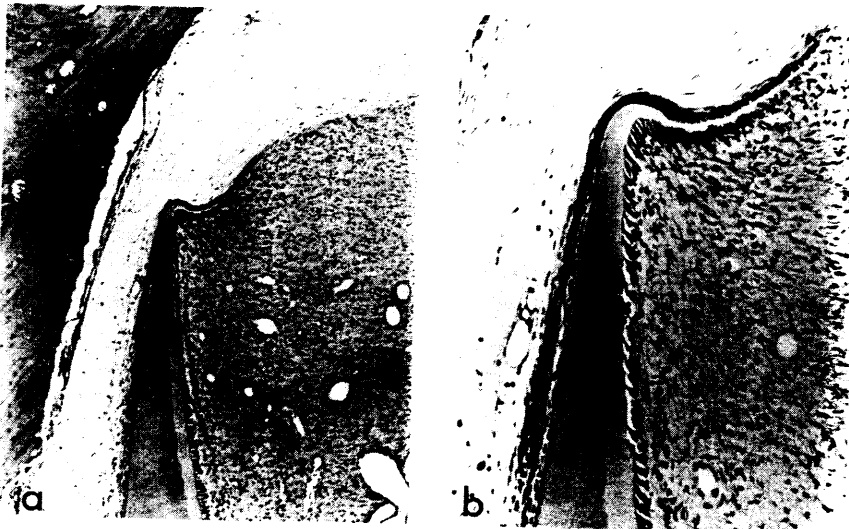


Fig. 3. Photomicrograph showing the angulated pre dentine (a) and the bend Hertwig's root sheath (b) of an unerupted premolar from a monkey treated with biteblocks with embedded repelling samarium magnets. Original magnification a: x16, b: x64.

different stages of root formation. The orientation of the calcification front becomes gradually more oblique in relation to the long axis of the tooth approaching the apex. This may in a radiographic image give an impression of differences in formation rate of formation the root (Melsen et al. 1977).

A change in orientation of both predentine and the Hertwig root sheath was found in both experimental groups, although there was a tendency toward a more pronounced effect in monkeys who had been wearing the magnetized appliance. It is known that root formation can be influenced by external factors such as hindered eruption trauma (Ohman 1965, Andreasen et al. 1988), or intrusional forces from orthodontic appliances (Stenvik 1969). Such stimuli generate alterations in the normal direction of the preden-

tine formation. These alterations may be temporary and can be followed by redirection of root formation, leaving only a steplike scar. However, this change in force direction cause the remaining part of the root to be formed at an angle to the long axis of the coronal part of the root (Stenvik 1969). In the study reported here it was, however, not possible to predict the degree of permanent change in the final root formation. The degree of permanent change will probably depend on both the timing and the duration of the stimulus.

The study reported here was limited to assessment of the temporary influence of repulsive magnets on root formation in unerupted teeth without commenting the degree of permanent influence. The findings do, however, indicate the importance of long-term studies in the future.

References

- Andreasen J O, Kristensen I, Andreasen F M. Damage of the Hertwig's epithelial root sheath: effect upon growth after autotransplantation of teeth in monkeys. *Endod Dent Traumatol* 1988, 4: 145—51
- Dellinger E L. A histological and cephalometric investigation of premolar intrusion in the *Macaca speciosa* monkey. *Am J Orthod* 1967, 53: 325—55
- Dellinger E L. A clinical assessment of the active vertical corrector: A nonsurgical alternative for skeletal open bite treatment. *Am J Orthod* 1986, 89: 251—63
- Dermaut L R, De Munck A. Apical root resorption of upper incisors caused by intrusive tooth movement. A radiographic study. *Am J Orthod* 1986, 90: 321—6
- DeSchiels R W. A study of root resorption in treated class II Division I malocclusions. *Angle Orthod* 1969, 39: 231—45
- Hoenie D C. The effect of interocclusal repelling magnets in a bite opening splint on the growth of the craniofacial complex on juvenile *Macaca mulatta*. Masters of Science in Orthodontics. University of Michigan, Ann Arbor, MI 1986
- Kalra V, Burstone C J, Nanda R. Effect of a fixed magnetic appliance on the dentofacial complex. *Am J Orthod* 1969, 95: 467—78
- Linge B O, Linge L. Apical root resorption in upper anterior teeth. *Eur J Orthod* 1983, 5: 173—83
- Melsen F, Melsen B, Rølling I. Dentin formation rate in human teeth (Poster presentation). *Calcif Tiss Res* 1977, Suppl 24
- Ohman H: Healing and sensitivity to pain in young replanted human teeth. An experimental clinical and histological study. *Odont* 1965, 73: 166—227
- Stenvik A. Pulp and dentine reactions to experimental tooth intrusion (A histologic study — long-term effects). *Eur Orthod Soc Rep Congr* 1969: 449—64
- Stenvik A, Mjör I A. Pulp and dentine reactions to

experimental tooth intrusion. A histological study of the initial changes. *Am J Orthod* 1970, 57: 370—85

Stenvik A, Mjör I A. The effect of experimental tooth intrusion on pulp and dentine. *Oral Surg* 1971, 32: 639—48

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