Acta Odontológica Latinoamericana: (1984) 1, 25-30

Relapse measurements in experimental tooth movements

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Received: January 31, 1984.

Abstract:

An experiemental study of relapse after experimental orthodontic movements produced in rats with a specially designed appliance (López Otero et al (1973) J. Period. Res 8:327-333) is presented. The orthodontic device, which moved the upper first molars in a vestibular direction, was removed after 48 hours (Goup I) or 96 hours (Group II) of treatment. The animals in both groups were killed either 7 or 15 days after removal. The intermolar distance was measured to evaluate tooth movement on casts prepared from the upper jaw. Relapse was proved in every case, being greater in Group I than in Group II. The histometric evaluation of alveolar bone was performed on histologic sections. It revealed an increment in bone formation areas in the alveolar surface in detriment of bone resorption and an increment of bone volume. These results demonstrated the real increment of alveolar bone following appliance removal.

Resumen:

Se presenta un trabajo experimental sobre recidivas de movimientos ortodóncicos provocados en ratas por un aparato especialmente diseñado (López Otero et al. (1973) J. Period. Res. 8: 327-333) que provoca la separación de los primeros molares superiores hacia vestibular. Luego de ejercer su fuerza durante 48 horas (Grupo I) ó 96 horas (Grupo II) los aparatos fueron retirados, sacrificándose los animales de los dos grupos después de 7 ó de 15 días. La evaluación del movimiento producido se realizó midiendo la distancia intermolar sobre modelos de yeso, comprobándose la recidiva en todos los casos, siendo más pronunciada en el Grupo I que en el II. Además se realizó un estudio histométrico sobre los cortes histológicos que reveló el incremento de áreas de formación en la cortical ósea alveolar en detrimento de la reabsorción ósea y el aumento del volumen del hueso interradicular. Estos resultados demuestran el real incremento del tejido óseo alveolar luego de la remoción del aparato ortodóncico.

Introduction:

One of the main causes of failures in orthodontic treatments is the migration of the moved tooth back toward its original position. This "relapse" has been the subject of several studies as, despite the improvement of new techniques, this problem has not yet been solved.

The causes of relapse are varied (1-6) and several factors have been postulated for tretament failures (7-12). Among them are the persistence of the attachment of the gingival fibers (2,8-11), the stretching and rearrangement of periodontal fibers (3,8,12-14), the oxytalan fiber's recovery (3, 12, 15), and the increment in the amount og glycosaminoglycans in the gingiva (16-17).

In order to study the behaviour of bone tissue in relapse, a histologic and histometric study was made in an experimental model of proved efficacy developed by us (18-21).

Materials and Methods:

Forty-eight male Wistar rats weighing 250 g were fitted with an orthodontic device under sodium pentobarbital anesthesia. The appliance consists of two molar bands with a horizontal bracket welded to their palatal face through which the arms of a helicoidal spring are introduced. The spring was constructed with a 3 mm round section Cr-Ni satinless-steel wire (18). The force of the spring was measured with a Correx type dinamometer, activating the spring to the intertube distance of 4 mm. The force thus exerted is 75 gm ± 5 (18-21).

The animals were separated into two groups of 24 rats each. Group I wore the orthodontic device for 48 hours and Group II for 96 hours, at the end of which the appliances were removed.

Each group was subdivided into two subgroups and the animals were killed 1 week or 2 weeks after removal of the appliance.

Three silicone paste impressiones were taken of the upper jaw of each animal. The first was taken just before placing the appliance, the second immediatly after the appliance was removed and the third immediatly after killing the animal. Velmix stone casts were made from the impressions. The distance between left and right massial fossae was measured on the casts with a stereoscopic microscope with the aid of dividers. The initial distance was subtracted from the distance on removal of the device and from the distance measured after the animal was killed. The distance on killing was likewise subtracted from the distance found on removal of the device. This difference was considered to represent the degree of relapse.

A group of 10 non-treated animals of the same age and killed at the same time as treated animals, was used as controls.

The upper jaws were removed, fixed in formaline, decalcified in 10% EDTA and embedded in paraffin. Sections of the distal roots were made in a buccopalatal orientation and stained with H-E.

The most axial sections were projected at 10 X and drawn. The sections were observed under the microscope and zones of bone formation, bone resorption and rest of the alveolar bone surface marked with different colours on the drawings. The percentage of those zones was considered to determine bone activity as proposed to determine bone activity as proposed by Itoiz et al (22). Relative volume occupied by interradicular bone and the periotontal ligament was measured on the area limited by the interradicular space and the tangent to the apical roots, according to the procedure of López Otero et al. (23). These histometric studies were made with the aid of a semi-automatic analysing system (Kontron Massgerate MOP/AM 03 Karl Zeiss) following stereological principles (24).

Results.

The distance between the messial fossae of the first molar showed the relapse suffered by the treated teeth after removal of the orthodontic device in both gropus (Table I). Those animals in which force was exerted for 48 hours (Group I) suffered a 38% relapse 7 days after removal of the appliance and 68% after 15 days. The animals that wore the orthodontic device for 96 hours (Group II) showed a 50%postremoval relapse on day 7 and 75% on day 15 (Fig. 1).

Histologic study of samples 48 hours after placing the appliance revealed few osteoclasts and extensive erosive areas on the alveolar bone surface, whereas after 96 hours abundant osteoclasts closely associated to the resorptive areas could be observed. After removal of the appliance a clear incremental line covered by a thick band of faintly stained bone tissue appared on the alveolar bone in all cases (Fig. 2).

Histometric study of the state of bone activity on the alveolar bone surface in the animals of Group I showed a slight decrease in bone resorption areas on day 7 after removal of the appliance and was particularly evident on day 15. In both subgroups an increment in bone formation was detected (Table 2). In animals of Group II an evident decrease in bone resorption areas was observed on 7th day after removal of the orthodontic device. Similar values were obtained on the 15th day. A striking increment in bone formation areas, greater on the 7th day than on the 15th day after removal of the appliance, was found in the same group of animals (Table 3).

The ratio between volume of periodontal ligament and volume of bone in the interradicular space decreased after removal of the appliance, more noticeably after 7 days than after 15 days, for both groups (Fig. 3).

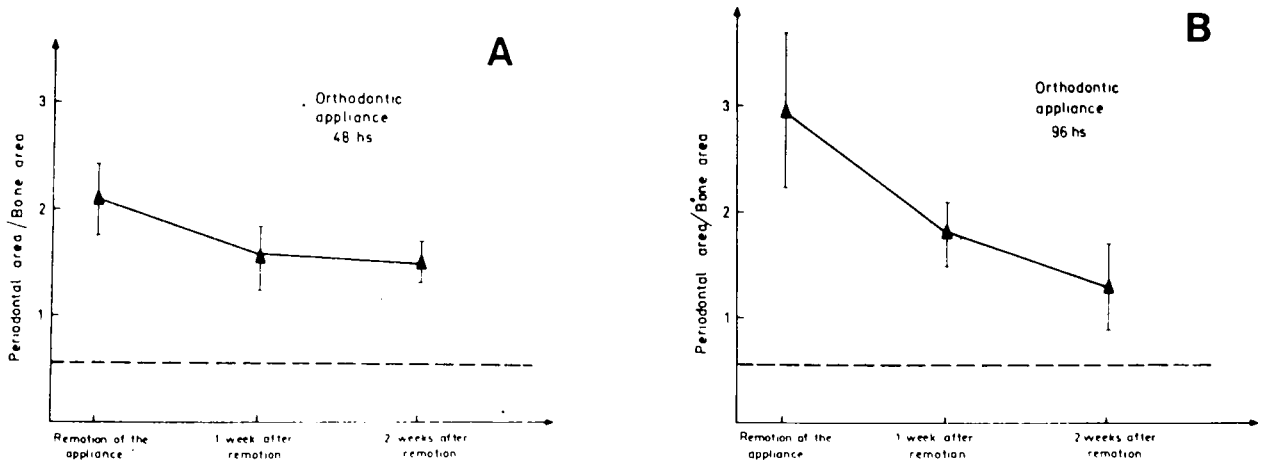

Figure 3: The graph shows the decrease in the ratio between periodontal area and bone area in animals which wore the orthodontic appliance for 48 hours (A) and for 96 hours (B). Dotted line reoresents control values.

Discussion:

This study affords new data on some aspects of relapse demonstrated by measurements on casts and the application of histometric methods to the corresponding sections.

Two different variable were considered; i.e. the time elapsed between placement and removal of the appliance and the time post-remotion. Previuos data (18,19) were taken into account for the choice of the experimental time-lapses: the highest proportion of resorptive areas appeared in the alveolar bone after 18 hours of orthodontic force and the highest proportion of bone formation areas after 96 hours.

The measurements of intermolar distances showed that relapse was greater in the first week than in the second week after removal of the appliance in both experimental groups and could be due to the stretching of the periodontal fibers. Moroever, relapse was greater in those animals which wore the appliance for 96 hours, probable because the mechanisms of bone formation had already been triggered when the device was removed (18-21).

The histometric study revealed two important facts. Measurements of the bone periodontal surface showed a great increment in bone formation areas with detriment to bone resorption in both groups, indicating active bone formation. In agreement with these findings the ratio between periodontal area and bone area in the interradicular space decreases after removal of the appliance. As the interradicular space constitutes a closed compartment limited by the roots and a tangent to the apex, this diminished ratio can be considered a real increment in bone volume. Although the rearrangement and the stretching of periodontal fibers may contribute to relapse in the post-remotion period (14), marked new bone formation is evident. These data also revealed that relapse increases with the degree of tooth migration on removal of the appliance as demonstrated by measurements of the intermolar distance. It is well known that the failure rate decreases with retention (14, 16, 27). These data and ours would indicate that the stability of tooth movement is achieved when bone remodelling reaches its normal rate.

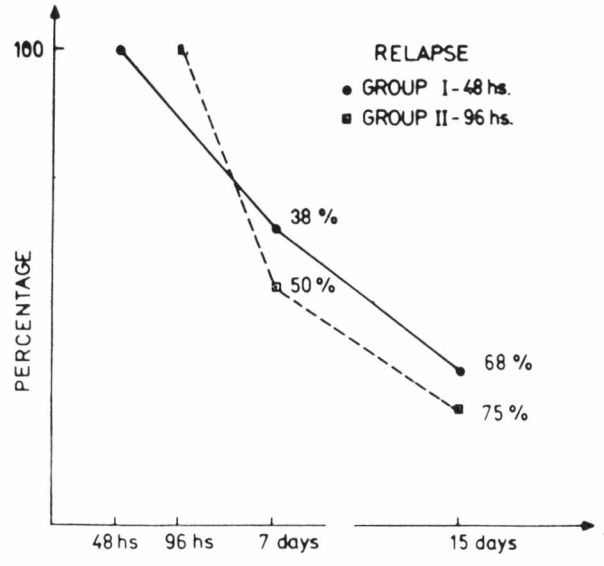

Figure 1: The graph shows the relapse in teeth which had the orthodontic appliance for 48 hours (Group I) and for 96 hours (Group II). 100% represents the intermolar distance on removal of the device. The percentage of recovery of the initial tooth position was calculated after 7 days for each group.

Figure 2: Portion of the interradicular bone showing an incremental line covered by more faintly stained bone tissue (arrow). 300 X.

TABLE 1. INTERMOLAR DISTANCE IN mm.

	Difference between final and initial distance			Relapse	
	on removal of the appliance*	1 week after removal	2 weeks after removal	in mm	%
Group I	0.62 ± 0.05	0.38 ± 0.06		0.24 ± 0.01	38
(Appliance 48 hs.)	0.59 ± 0.05		0.19 ± 0.02	0.40 ± 0.05	68
Group II	0.91 ± 0.07	0.45 ± 0.07		0.46 ± 0.07	50
(Appliance 96 hs.)	0.92 ± 0.05		0.25 ± 0.07	0.68 ± 0.07	75

* The intermolar distance on removal of the appliance was taken as 100%.
± Standard error.

TABLE 2. HISTOMETRIC MEASUREMENT OF BONE PERIODONTAL SURFACE IN ANIMALS WHICH WORE THE ORTHODONTIC APPLIANCE 48 HOURS.

	% of bone formation	% of bone resorption	% of bone rest
Control values on removal	10.40 ± 1.97	15.55 ± 1.46	73.53 ± 2.86
	14.19 ± 3.67	57.28 ± 4.99	28.52 ± 3.58
1 week after removal	24.35 ± 6.39	32.25 ± 7.19	39.11 ± 5.00
2 weeks after removal	34.10 ± 0.75	22.13 ± 7.20	51.37 ± 6.15

± Standard error.

TABLE 3. HISTOMETRIC MEASUREMENT OF BONE PERIODONTAL SURFACE IN ANIMALS WHICH WORE THE ORTHODONTIC APPLIANCE 96 HOURS.

	% of bone formation	% of bone resorption	% of bone rest
Control values on removal	10.40 ± 1.97	15.33 ± 1.46	73.53 ± 2.86
	16.35 ± 1.42	52.37 ± 5.56	31.93 ± 5.29
1 week after removal	47.34 ± 7.34	17.98 ± 8.05	33.82 ± 6.85
2 weeks after removal	35.04 ± 6.48	16.38 ± 6.47	48.69 ± 10.78

± Standard error.

Acknowledgments

This work was supported in part by Grant N° 8461 e/83of the Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina.

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