Thyroid function and root resorption

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Apical root resorption is a common complication of orthodontic treatment. The great variation between individuals subjected to similar types and durations of orthodontic treatment, and the reports of a "high risk" group with a frequency of 10%, indicates that other factors may be involved in addition to force.[1,2,3]

A number of studies have shown that the occurrence of hyaline zones and the degradative activity which follows the development of necrotic tissue are related to the amount of force applied during orthodontic treatment.[4-8] However, in studies by Becks and Cowden[9] and others, factors regulating general metabolism have been suggested. The regulation of degradive activities, such as phagocytosis and bone resorption in the periodontal region, is greatly influenced by factors controlling general bone modeling.[10-14]

In addition to applied force, tooth movement seems to depend on calcium metabolism in alveolar bone.[15,16] A study by Midgetts et al.[15] indicated that animals with hyperparathyroidism had significantly decreased bone density, as well as increased bone remodeling changes. Goldie and King[17] have shown that lactation, coupled with a calcium-deficient diet, will produce decreased bone density and increased tooth movement. Engström et al.[14,16] demonstrated that although the level of PTH in serum plays an important role in the regulation of the resorptive activity in bone, a change in serum calcium level is a determining factor for root resorption. This indicates that force-induced root resorption is dependent on more

Abstract

The regulation of degradative activity such as phagocytosis and bone resorption in the periodontal region is greatly influenced by factors controlling general bone modeling. The purpose of this study was to determine if thyroxine has any influence on the occurrence of force-induced root resorption. Young male rats were divided into three groups: a group of normal rats, a control group in which appliances were placed, and an experimental group in which appliances were placed and l-thyroxine was administered (5 micrograms/kg bw for 12 days).

Root resorptions were induced by orthodontic force on the maxillary incisors. Fewer force-induced root resorption lesions occurred in the thyroxine group than in the control group. Alkaline phosphatase activity in the thyroxine group was significantly different from the normal and control groups. Thus, the decrease of resorptive lesions in the thyroxine group seemed correlated to a change in the bone modeling process, especially as related to the resorption activity.

Key Words

Alkaline phosphatase • Bone metabolism • L-thyroxine • Modeling • Remodeling • Root resorption • Thyroid

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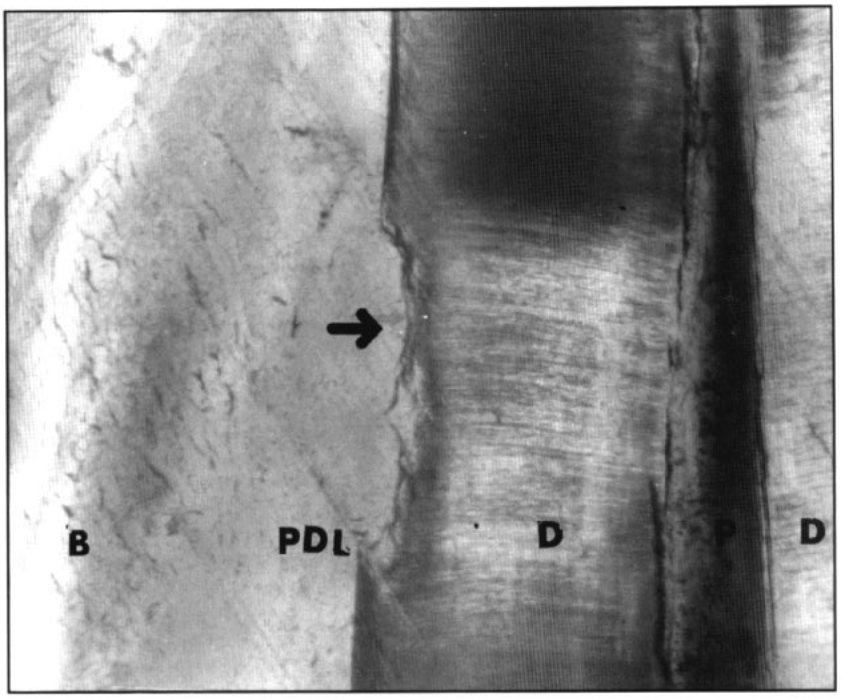

Figure 1
Undecalcified section showing alveolar bone and root of maxillary incisor as viewed in a light microscope [X40]. Note root surface lesion (arrow) B: bone; PDL: periodontal ligament; D: dentin; P: pulp.

than one endocrine system.

In addition to parathyroid hormone, bone resorptive activity is also regulated by l-thyroxine.[18-23] Patients with untreated hyperthyroidism show increased bone resorption.[21] The administration of high doses of thyroxine in rats has been shown to increase bone resorption,[22,24] in contrast to low dose administration, which was found to reduce periosteal resorption.[25]

The purpose of this study was to determine if thyroxine has any effect on root resorption. There are clinical reports which suggest that the administration of a low dosage of thyroxine decreases the extent of force-induced root resorption. (See the case reports following this article.)

Material and methods

Forty-eight male albino rats of the Sprague Dawley strain with a body weight of 140 gm (42 days old) were obtained from Simonsen Laboratories, Gilroy, Calif. The rats were randomly divided into three groups with 16 animals in each group: a group of untreated rats was designated the normal group; a group of rats in which appliances were placed was designated the control group; and a group of rats in which appliances were placed and thyroxine was administered was designated the thyroxine group.

The rats were fed a standard diet of ground rat pellets and water ad lib., and were checked daily for distress. One animal in the control group died. The rats were weighed twice a week. The experimental period for all groups was 10 days.

The thyroxine group was given 5 micrograms/kg bw l-thyroxine (3,3',5,5' tetraiode-L-Thyronine, obtained from ICN Biochemicals, Costa Mesa, Calif) per day, administered over 24 hours by infusion from miniosmotic pumps (ALZET, model 2002, Alza Laboratories, Palo Alto, Calif). This dose is the equivalent of 1/2 grain of thyroxine in humans.

The pumps were surgically implanted subcutaneously in the dorsal part of the neck under anesthesia 48 hours before the appliances were placed.

In the control and thyroxine groups, orthodontic appliances were placed as previously described by Engström et al.[14,16] The appliances were preformed and constructed on dry skulls to fit the maxillary incisors. Orthodontic bands were placed on the right and left maxillary incisors. Vertical tubes were welded to the lateral sides of the bands. The bands were cemented with glass-ionomer cement under anesthesia and active springs (0.45 mm of Australian regular type wire, TP, LaPorte, Ind) were inserted into the tubes. Each spring exerted a lateral force over the incisors of 50gm. This force value was chosen since previous studies have found that root resorption occurs within 7 days after applying this amount of force.[14,16] The force was measured with a Correx gauge when the spring was placed, and at the termination of the experiment.

On Day 0 and Day 10 of the experimental period occlusal radiograms (Kodak high resolution Occlusal Film S0-343, 4x5) of the maxillary incisor region were taken under anesthesia on all rats. The skulls were fixated in a specially constructed craniostat, according to the method developed for rats and described by Engström et al.[25]

The distance between the maxillary incisors was measured using a Boley gauge. The distance measured on the occlusal radiograms was enlarged 4X when projected on a screen.

The rats were anesthetized with Ketamine (44 mg/kg, b.w.) and Xylazine (130 mg/kg, b.w.) i.m. when the occlusal radiograms were taken, when pumps were implanted, and when appliances were placed.

At the end of the experimental period (Day 10) blood was drawn by intracardiac puncture and the serum was analyzed for alkaline phosphatase activity and levels of thyroid hormone (T4) at the Clinical Biochemical Laboratories, UCLA Medical Center, Los Angeles, Calif.

At the end of the experiment (Day 10), the

animals were killed by an overdose of sodium barbital s.c. (Nembutal 100 mg/kg of b.w.) and decapitated. The premaxilla/maxillae were dissected out and treated with ethyl alcohol (90%) for 1 week. The specimens were then embedded in methyl-methacrylate, (MMA product, Aldrich Inc., Milwaukee, Wisc).

The embedded specimens were serially sectioned in the transverse plane (frontal) at a thickness of 1 mm with a specially constructed metallurgic saw.

Sections were viewed in a light microscope fitted with a camera lucida (40x). The root surface perimeter, as well as the extent of root surface resorptive lesions, were determined using grid squares 5x5 mm projected in the viewing field at a magnification of 40x. The root perimeter was measured by counting the number of grid squares covering the root outline. The amount of root resorption was determined by counting the number of squares with root surface lesions (Figure 1) and comparing that number to the number of squares of the total root surface.

The error of method for determination of the amount of root resorption was calculated from duplicate measurements using the Dahlberg formula.[26] Descriptive statistics were calculated. ANOVA calculations were used to determine differences between the three groups for tooth movement, serum alkaline phosphatase activity and levels of circulating thyroid hormone in serum.

Table I
Serum alkaline phosphatase activity (U/L) and amount of circulating l-thyroxine (T4) from normal, control and thyroxine groups. (Mean ± standard deviation, n=10). P value shows significant differences between the three groups.

	Normal	Control with appliance	Thyroxine with appliance	<p
Alkaline	205±48.07	109.5±25.02		0.01
Phosphatase		109.5±25.02	281.2±41.3	0.02
activity (U/L)	205±48.07		281.2±41.3	0.0001
T4 (mcg/dL)	4.84±0.9	2.87±0.58		0.001
	4.84±0.9		3.2±0.57	0.01

Table II
Root surface lesions (percentage). Mean value=percentage of total root perimeter ± standard deviation, n=16. P value shows significant difference between the control and thyroxine groups.

	Normal	Control with appliance	Thyroxine with appliance	<p
Root surface lesions	None	7.61+4.26	4.34+4.4	0.05

Results

The measuring error of the root resorption was small (0.14%). The error for tooth movement measurement was 0.05 mm. Thus, the measurements were sufficiently reproducible and the values obtained as shown in Tables I and II were reliable.

The total alkaline phosphatase activity in serum was statistically different among the three groups (Table I). In the control group, the activity was less than in the normal group. The highest activity occurred in the thyroxine group (Table I).

The level of circulating l-thyroxine (T4) in serum was significantly greater in the normal group than in the two groups with appliances (Figure 2). There was a slight increase in the level of T4 of the thyroxine group from the control group with appliances (Table I).

Lateral movement of the maxillary incisors in the control group and in the thyroxine group differed significantly from the normal group with no appliances. The amount of expansion in the two experimental groups was similar; no statistically significant difference was found. (Figure 3, control group with appliances: mean 2.6 mm, SD 0.6; thyroxine group: mean 2.8 mm, SD 0.9).)

No root surface lesions were found in the normal group. In the control group, marked lesions on the root surface were observed in 14 out of 15 rats. Lesions were found on 7.6% of the root surfaces in the control group (Table II).

In the thyroxine group 10 out of 16 rats showed root surface lesions. The percentage of root surfaces with lesions in this group was 4.3%. The extent of the surface lesions was significantly less in the thyroxine group than in the control group (Table II).

Discussion

Root resorption was induced in the maxillary incisors of rats in the normal and thyroxine groups when the teeth were subjected to an orthodontic force. The amount of force-in-

Figure 2
Bar graph of the mean value and standard deviation of serum thyroxine in normal, control and thyroxine groups.

Figure 3
Bar graph of the mean value and standard deviation of the amount of tooth movement in the normal, control and thyroxine groups.

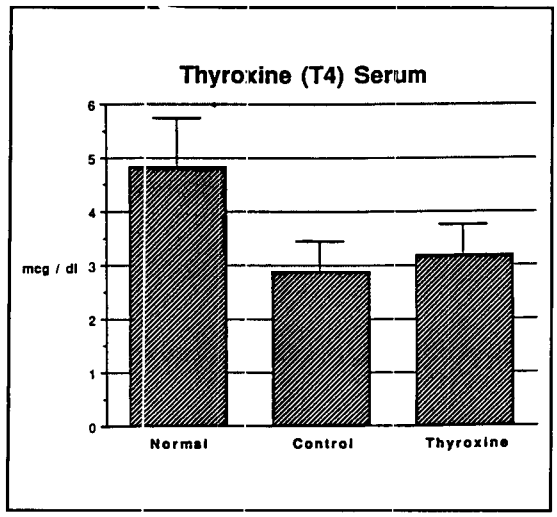

Figure 2

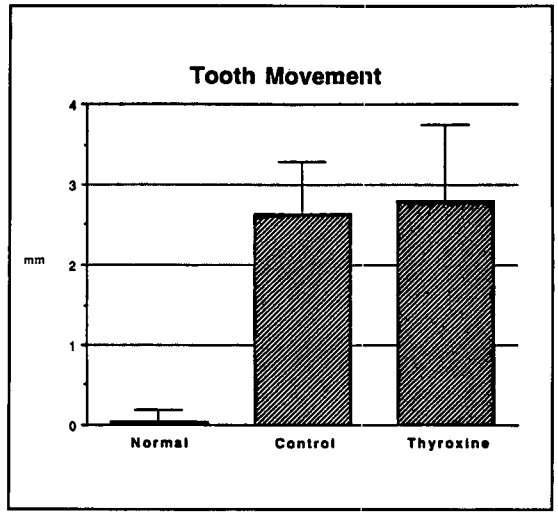

Figure 3

duced root resorption lesions was less in the thyroxine group than in the control group. Since the alkaline phosphatase activity in serum was significantly different in the normal and control groups, the results indicate that thyroxine administration might affect bone metabolism. Further, the decrease of resorptive lesions in the thyroxine group may be correlated to a change in the bone modeling process, especially resorption activity.

In order to assess a possible change in bone metabolism, a biochemical determination of alkaline phosphatase activity in serum was performed. Alkaline phosphatase activity is considered to show the metabolic state of bone cells.[27,28] Since a significant increase in APase activity was found in the thyroxine group it appears that the l-thyroxine administration changed the bone metabolism.

The level of circulating l-thyroxine in serum was less in the two groups with appliances than in the normal group. This decreased level was slightly affected by the administration of l-thyroxine. This may indicate that, during tooth movement, cells that are involved in the degradative activity are using thyroxine at some stage of their cycle. However, the most reasonable causative factor could be the stress induced by the manipulation and insertion of the orthodontic appliances. It is well established from experimental animal studies, and from studies in normal human subjects that the pituitary-thyroid axis is reactive to physical and psychologically-perceived stress.[29]

The force-induced resorptive lesions, which were significantly less in the thyroxine group compared to the control group, are perhaps due to a decrease in root resorptive activity resulting from a low dose of thyroxine. Some reports show that the administration of thyroxine in low doses reduces bone resorption.[20,22] The decrease in root resorption found in this study might indicate that thyroxine administration leads to a more efficient (less root degradative) force-induced remodeling process.

Conclusions

In conclusion, the present study found that thyroxine administration seems to lower the frequency of root resorption in the maxillary incisors of rats. It is suggested that thyroid function is an important clinical factor in the etiology of force-induced root resorption. Administration of thyroxine should be considered in some patients, especially in those who show beginning root resorption, or those who have low thyroid function.

Further research is needed to evaluate the nature of the thyroxine-effect on cells involved in force-induced periodontal tissue remodeling.

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