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An investigation into the relationship of alveolar bone height and timing of canine retraction following premolar extraction

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SUMMARY

A study was undertaken, using Panorex radiographs, to examine the effect on alveolar bone of the time interval between the extraction of a tooth and the commencement of active tooth movement into the extraction site. There were 3 experimental groups of 25 subjects each, namely, no treatment; active canine retraction begun within 3 weeks of extraction of the first premolar; and active canine retraction begun not less than 20 weeks after extraction of the first configuration. No statistically significant differences were shown in the height of the interstitial alveolar bone supporting the mandibular canine in the 3 groups.

OPSOMMING

Met gebruik van Panorex röntgenfotos is 'n studie gemaak om die uitwerking van die tydsduur tussen die verwydering van 'n tand en die aanvang van aktiewe tandbeweing in die ekstraksie area te bepaal. Daar was 3 proefgroepe van 25 persone elk, naamlik, geen behandeling, aktiewe caninus retraksie wat binne 3 weke na ekstraksie van die eerste premolaar begin is en aktiewe caninus retraksie wat nie minder as 20 weke na ekstraksie van die eerste premolaar uitgevoer is nie. 'n Metingstegniek is ontwerp om alveolêrebeen konfigurasie op te teken. Geen statisties betekenisvolle verskille in die interstisieel alveolêre beenhoogtes om die mandibulêre caninus is waargeneem nie.

INTRODUCTION

A common problem in orthodontic practice is the treatment of patients from whom the first premolar teeth have already been extracted by the general dental practitioner. In many instances the extraction space has been only partially obliterated by drifting of adjacent teeth, often with a quite marked dipping of the alveolar bone where the premolar teeth have been removed (Fig. 1). Two questions arise from this observation.

(a) Would there be satisfactory restoration of the alveolar bone when the extraction site was eventually closed?

(b) What would be the effect on the restoration of the alveolar bone if the mechanical closure of the extraction site was commenced soon after extraction or was delayed until healing was complete?

Laboratory studies on rats (Furstman and Bernick, 1972) and monkeys (Mizutani and Ishihata, 1976) have shown that, following extractions, subsequent repair did not restore interproximal bone to its former height. In a clinical study of 25 patients who had had 4 first premolars extracted and had received full fixed appliance therapy and were out of retention, Libby (unpublished Master's thesis, University of Tennessee), cited by Weber (1971) used a periodontal probe to measure the depth of the gingival sulci at the disto- and mesiobuccal aspects of maxillary and mandibular second premolars and at the mesio- and distolabial aspects of maxillary and mandibular canines. He also used a standardized radiographic technique to measure the heights of the interproximal alveolar crests on the mesial and distal aspects of the maxillary and mandibular second premolars. Libby showed that there was no significant difference in the depths of the gingival sulci and heights of alveolar bone crests of the mandibular second premolars on the sides adjacent to the extracted first premolars and the sides of the teeth remote from the extraction site.

Like Libby, Kloehn and Pfeifer (1974) used a combination of direct measurement of gingival crevice depth and clinical examination of pre- and post-treatment radiographs to investigate effects of orthodontic treatment on the periodontium. They concluded that there were no adverse changes in the alveolar crests.

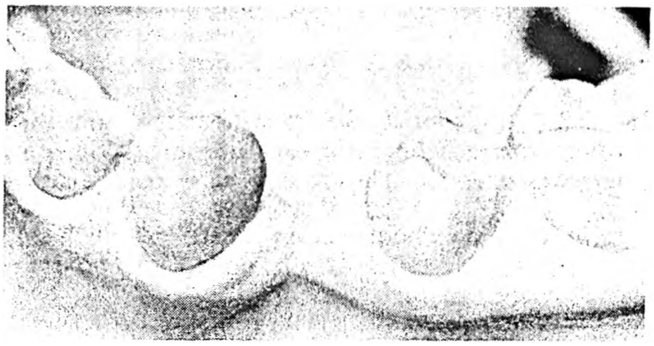

Fig. 1: Study model showing 'dipping' of alveolar bone at extraction site.

Numerous radiographic studies have been carried out to determine the effects of orthodontic tooth movement on the interdental alveolar bone. Buchner (1949) observed the post-treatment intraoral radiographs of 100 consecutively treated patients and concluded that these patients showed alveolar bone loss. No measurements were made. Tirk, Guzman and Nalchajian (1967) developed a standardized technique for exposing films using the Panoramix machine. They traced the exposed films and established a plane which could be used for superimposition of subsequent films of the same individual. After qualitative assessment of the tracings they concluded that orthodontic treatment resulted in loss of interdental alveolar bone.

The distance from the alveolar crest to cementoenamel junction on intraoral bitewing radiographs taken immediately prior to and immediately after the treatment of 76 individuals was measured by Baxter (1967). He concluded that there was no significant difference in the height of the alveolar crest before and after treatment. In contrast, Sleichter (1971) examined the intraoral radiographs of patients who had undergone premolar extractions and noted a blunting of the interproximal alveolar crest in every case.

Zachrisson and Alnaes (1974), following a detailed study of 51 treated class II division I cases and 54 matched untreated cases, concluded that although the differences were small, orthodontically treated individuals showed significantly more alveolar bone loss than did untreated individuals. The greatest amount of bone loss occurred on the distal aspect of canines retracted into the site of an extracted first premolar.

All of the above studies were concerned with the effect of extractions and orthodontic tooth movement on the interdental alveolar bone. None, however, compared the height of the interdental alveolar bone of the canine tooth retracted into the first premolar extraction site where the only variable was the length of time elapsed between premolar extraction and the commencement of mechanical canine retraction.

This study was undertaken:

1. To develop a technique whereby the amount of alveolar bone supporting a mandibular canine tooth could be measured on a Panorex radiograph.
2. To investigate the effect of timelag between premolar extraction and commencement of canine retraction on the alveolar bone supporting a mandibular canine tooth at the completion of treatment.

MATERIALS AND METHODS

Standardized routine pre- and post-treatment radiographs taken with an S.A. White Panoramic x-ray machine fitted with an S.A. White Pancentric head positioner (Ryan, Rosenberg and Law, 1973) were used. The first 25 sequentially filed post-treatment films that satisfied criteria defined for each of the experimental groups were selected. Thus 75 subjects were subdivided into:

1. Those in whom there was excellent alignment of the mandibular teeth and in whom no treatment had been carried out.
2. Those in whom mechanical retraction of the mandibular canines was started within 3 weeks after the extraction of the first premolar teeth.
3. Those in whom mechanical retraction of the mandibular canines was started not less than 20 weeks after the extraction of the first premolars.

The following criteria were common to all 3 groups:

1. The age of the patient at the time the radiograph was taken was between 13 and 18 hr.
2. There was minimum overlap of the interproximal surfaces of the teeth in the area to be studied.
3. There were clearly visible interdental alveolar crests on the mesial and distal aspects of the mandibular canines.

The cases selected in the 'treated' groups were all treated within the same 5-yr period by the same operator using identical edgewise appliances and standardized treatment procedures. The post-treatment films were taken approximately 9 months after active treatment had ceased.

In order to facilitate the taking of measurements the radiographs were placed on an illuminated tracing box and the salient features required for this study were traced (Tirk et al, 1967) on Ozalid Reprolar D acetate tracing paper using a 6H lead pencil (Figs. 2, 3). Ten of the radiographs used in the study were traced and measured twice in a random order to establish the degree of intraexaminer tracing and recording precision. The Student's t-test for related samples was used on all the linear and angular measurements made of these 10 cases to test for intraexaminer variation in tracing and measuring precision.

There are no internationally accepted defined landmarks in use on Panorex radiograph tracings. For this study a series of landmarks was defined (Fig. 2).

1. *The intercrestal plane.* This was established by drawing a line connecting the highest points on the mesial and distal alveolar crests of the mandibular canine tooth.
2. *The canine long axis line.* The long axis line of the mandibular canine was established by connecting the cusp tip and apex tip. This line was extended inferiorly to cross the lower border of the mandible.
3. *The mandibular plane.* The midpoint on the gonial angle was connected to the point where the canine long axis line intersected the lower border of the mandible to establish the mandibular plane.
4. *The mandibular lateral incisor and second premolar long axis lines.* Lines were drawn through the long axes of the mandibular lateral incisor and second premolar teeth and extended to intersect the mandibular plane.

With these landmarks as a basis a series of measurements was made. Angular measurements were made to the nearest whole degree, on the tracings, using a protractor. Linear measurements to the nearest 0,1 mm were made using a Digiplan M.O.P. quantitative image analysing system (Kontron Massergeräte GMBH Germany).

The measurements studied are shown in Fig. 3. These were:

1. *Cusp tip to intercrestal plane.* This was taken as the distance in mm from the tip of the canine cusp to the point where the canine long axis line intersected the intercrestal plane.

2. *Intercrestal plane to mandibular plane.* This was taken as the distance in mm from the point where the canine long axis line intersected the intercrestal plane to the point where the canine long axis line intersected the mandibular plane.
3. *Angular measurements.* The distal angle which each of the long axis lines, that is, the lateral incisor, canine and second premolar, made with the mandibular plane was recorded.

The data were transferred to IBM coding forms and thence to computer punch cards for analysis in an IBM 370/158 computer using the Statistical Package for the Social Sciences (Nie et al, 1975). The analysis of the data concerning the variables in the 3 experimental groups, was carried out with the one-way analysis of variance and the Scheffé test for all possible comparisons (Roscoe, 1975). A probability value of $p < 0{,}05$ was selected as the level of statistical significance.

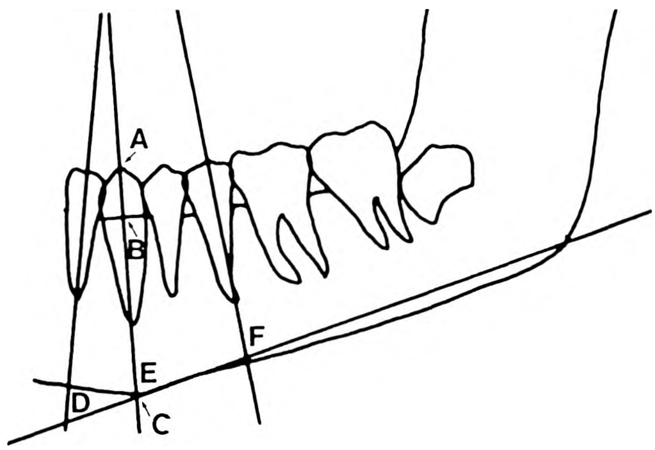

Fig. 2: Landmarks defined for the study.
1. Intercrestal plane
2. Canine long axis line
3. Mandibular plane
4. Mandibular lateral incisor long axis line
5. Second premolar long axis lines

RESULTS

No statistically significant intraexaminer variation in tracing and measuring precision was noted, which indicated that the measuring techniques were reproducible and reliable.

The linear and angular measurements are listed in Table 1 and the statistically significant one way analysis of variance between treatment groups are indicated. Where significant differences were seen, Scheffé's test for all possible comparisons was performed.

The mean values for the measurement cusp tip to intercrestal plane, indicate that this distance was significantly greater in the untreated control group than it was in both the early and the late retraction groups, for both left and right sides.

Intercrestal plane to mandibular plane measurement in the untreated cases was higher than in both the treated/untreated groups. The mean value for the early retraction was in turn higher than that of the late retraction group.

The one-way analysis of variance showed a significant difference between the groups for 43 but Scheffé's test for all possible comparisons failed to reveal any significant difference between the 3 groups.

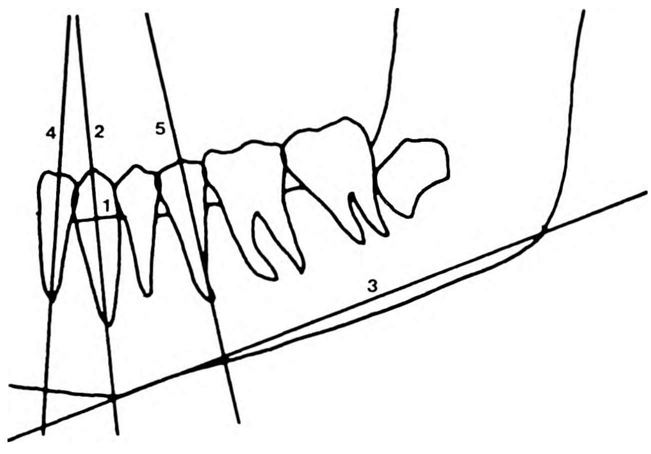

Fig. 3: Measurements studies.
1. Cusp tip to intercrestal plane A-B
2. Intercrestal plane to mandibular plane B-C
3. Angular measurements D, E, F.

None of the analyses employed revealed any significant difference in the angulation of the mandibular lateral incisors and canines when the various groups were compared. All the analyses revealed the angulation of the lower right second premolar to be significantly greater in the late retraction group than in both the treated/untreated group and the early retraction group. The angulation of the lower left second premolar was significantly greater in the late retraction group than in the early retraction group.

DISCUSSION

Lack of stable landmarks

The measurement, even in one spatial plane, of the amount of bone supporting a lower canine tooth following its retraction into the site from which a first premolar tooth has been extracted is difficult. This is because there are no absolutely stable landmarks to use in making the measurements.

For example, a measurement taken from the alveolar crest to the apex of the tooth may vary, not only as the result of loss of alveolar marginal bone, but also as the result of root apex resorption (Phillips, 1955; Dougherty, 1968; and De Shields, 1969).

In an attempt to determine the effect of orthodontic tooth movement on the amount of bone supporting teeth at the end of treatment, numerous studies have been undertaken where the height of the interdental marginal alveolar bone was related to the cementoenamel junction (Buchner, 1949; Tirk et al, 1967; Baxter, 1967; Sleichter, 1971; Weber, 1971; Zachrisson and Alnaes, 1974). The cementoenamel junction was not used in this investigation as it is impossible to locate it on a Panorex film.

Sjölien and Zachrisson (1973) describe a method using intraoral periapical radiographs which are projected on to a graded scale. Their method allowed for determination of total periodontal bone support, the amount of apical root resorption and of marginal bone loss. As our study was retrospective and Panorex rather than periapical radiographs were available, the method of Sjölien and Zachrisson could not be used. Instead the total amount of bone support was ascertained by measuring from the alveolar crest to the lower border of the mandible.

TABLE 1: Linear and angular measurements for each group n = 25

Measurement	Treatment Group					
	Nil		Early		Late	
	x̄	sd	x̄	sd	x̄	sd
Cusp tip to intercrestal plane (mm)						
33 *	9,33	1,13	8,62	0,92	8,44	0,82
43 *	8,87	1,03	8,20	0,01	8,52	0,67
Intercrestal plane to mandibular plane (mm)						
33	35,72	3,64	35,70	3,27	34,18	2,54
43 *	36,05	3,70	35,73	3,16	33,74	2,71
Distal angle between mandibular plane and tooth long axis lines (°)						
32	67,28	4,11	66,38	6,41	67,22	3,99
33	69,08	4,97	70,85	4,97	68,80	4,45
35 *	75,48	7,09	73,92	5,99	78,88	5,90
42	66,92	4,68	66,31	5,92	66,81	5,26
43	67,94	5,56	70,29	5,92	68,13	3,27
45 *	72,58	6,38	69,48	5,56	77,70	6,29

The use of the panorex radiograph

Wicall and Swoope (1974) cite Ainamo and Tommisalo (1967) and Westerholm (1966) as having shown that panoramic radiographs can be used to measure alveolar bone loss in periodontal disease. Panorex radiographs have been used extensively for diagnostic and record purposes in orthodontic practice and were therefore chosen for use in this study (Graber, 1966 and Manson-Hing, 1976).

Whether intraoral radiographs or extraoral panoramic radiographs are used, difficulties exist with respect to the accuracy of the radiographs. Reagan and Mitchell (1963) tested the accuracy of radiographic interpretation of alveolar crest height and found the amount of error to be least in the lower posterior quadrant. The alveolar crest examined in this study were at the junction of the anterior and posterior segments of the arch. Even accurate paralleling long cone techniques such as that described by Eggen and cited by Sjölen and Zachrisson (1973) resulted in some image distortion. With this technique a length increase of some 5,6 per cent was reported to occur.

Many workers, including Kite et al (1962), Graber (1966), Christen and Segreto (1968), have described and measured the distortion encountered in Panorex radiography. Christen and Segreto (1968) reported the vertical length distortion to be of the order of 15 per cent.

In spite of the known distortion factor the study was carried out. The radiographic technique was standardized and applied as accurately as possible by one operator. The distortion factor was therefore likely to be common to all the cases studied.

Factors influencing the values obtained

In this study 2 measurements were taken, each with the intercostal plane as a common point from which the measurements were made. The other two points were the cusp tip of the canine tooth and the point of intersection of the long axis line of the canine with the lower border of the mandible. The values obtained for the 2 measurements could therefore have been influenced by attrition of the canine cusp tip, alteration in the height of the alveolar bone interdental crests, deposition or resorption of bone on the lower border of the mandible and canine eruption.

Mandibular canine cusp tip attrition

The results showed that the left canine tip underwent attrition in both the treated groups and that there was a significant reduction in the right canine tip in those cases where retraction was started soon after extraction of the first premolar. Certain imbalances in cusp tip positions exist in cases of malocclusion and are bound to occur during orthodontic movement of the teeth. The measurability of significant canine cusp tip attrition in this study focuses attention on the importance of establishing correct intercuspation during treatment.

Supporting alveolar bone

The measurements taken from the intercrestal plane to the lower border of the mandible showed a significant difference for 43 between the 3 groups when subjected to the one way analysis of variance. However, this was not confirmed when multiple comparisons were done. This would indicate that there was no significant loss of the bone supporting the mandibular canine tooth when it was retracted by means of an edgewise orthodontic appliance into the site from which the first premolar tooth had been extracted.

Mandibular lower border remodelling

Remodelling of the lower border of the mandible could influence the vertical measurements made in this study. No definitive evidence applicable to this, was however found in published works other than a general opinion that the area is remarkably stable (Brodie, 1941).

Mandibular canine eruption

The radiographs for the treated groups were taken approximately nine months after the removal of the appliances. Post-treatment "recovery" in terms of further eruption was not reflected in the results (Horowitz and

Hixon, 1969).

In a study on the time sequence of tissue regeneration in extraction sachets Amler (1969) demonstrated that 40 days after an extraction, the oral epithelium was again intact, there was still some corrective tissue below the epithelium but most of the sachet was filled with bone.

In the early treatment group of this investigation, retraction of canines was started within 21 days following premolar extraction and was therefore taken as demonstrating teeth movement into a healing socket. At 140 days the sockets of the late treatment group were taken as healed.

It would also appear that there was no significant difference in the amount of supporting bone whether the canine was retracted into a healing socket or into an already healed socket.

In broad principle these findings supported those of Baxter (1967) and Billy (1971) (quoted by Weber, 1971) but contradicted those of Buchner (1949), Tirk et al (1967), Sleichter (1971) and Zachrisson and Alnaes (1974).

This study demonstrated the ability of the alveolar bone to recover from the effects of orthodontic tooth movement and to become reestablished around a mandibular canine retracted into a premolar extraction site, whether the retraction was into a healing or long since healed extraction site.

Tooth angulation and alveolar crest height

Zachrisson and Alnaes (1974) found that the greatest amount of alveolar bone loss occurred on the distal aspect of canines retracted into a first premolar extraction site. Where a tooth has tipped in a mesial or a distal direction the height of the alveolar interdental crest tends to be less on the side to which the tooth has tipped. As teeth left in a tipped situation after treatment may have influenced the results obtained in this study, angular measurements, relating the long axis line of the mandibular lateral incisors, canines and second premolars to the mandibular plane, were made. The results indicated that there was no significant difference between the angulations of the right and left lateral incisors and the right and left canines in all 3 groups. However, the angulation of the lower second premolar teeth, both the right and the left, seemed to indicate that these teeth were not in as upright a position in the late retraction cases as in the early ones. As the treatment technique used in both groups was identical it would seem that there was increased resistance to mesial root movement in those instances where the bone had already healed in the extraction site.

CONCLUSIONS

A technique for the measurement of alveolar bone height in the mandibular canine region using Panorex radiographs has been described. This proved to be reproducible. Statistical analysis showed that the measurement techniques were precise so that the measurements could be accepted with confidence.

This technique was used to investigate the significance of the time interval between the extraction of premolar teeth and the commencement of canine retraction into the extraction site upon the supporting alveolar bone. The results of this study uphold the null hypothesis, that is, that the height of alveolar bone supporting a canine tooth retracted into a premolar extraction site is not affected by the length of time which elapses between the extraction of the premolar and the commencement of the canine retraction.

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