Periodontal Condition in Orthodontically Treated and Untreated Individuals
II. Alveolar Bone Loss: Radiographic Findings

BJØRN U. ZACHRISSON, D.D.S., lic.odont., Odont.Dr.
LARS ALNÆS, D.D.S.

Few investigations have been performed on the posttreatment condition of the dentition following routine orthodontic treatment, and uncertainty still exists as to whether or not, and to what extent, the periodontal tissues become permanently damaged after such therapy.[19,24,34] Due to the progressive nature of periodontitis, even little damage to the supporting tissues associated with orthodontic treatment may be of great clinical importance.[10,15,24] Some attempts to assess the degree of persistent damage, if any, by means of radiography have been reported[1,5,11,13,22,28,33,34] However, previous radiographic studies on alveolar bone loss associated with orthodontic intervention[1,13,33,34] have mostly been performed on limited and inhomogeneous material, and have lacked adequate reference groups of untreated individuals. Moreover, the criteria for the localization of the reference point on the alveolar bone and the measured distances have not been unequivocally defined. The examinations have been made either at the time of removal of the appliances, thus not taking into consideration the regenerative ability of the tissues, or at varying periods afterwards. In the present study, therefore, strictly standardized material and technical procedures were used to estimate the interdental alveolar crest heights in orthodontically treated and untreated individuals.

From the Department of Orthodontics and the Dental Institute of Experimental Research, Dental Faculty, University of Oslo, Oslo, Norway.

MATERIAL

The group of patients selected for follow-up was described in detail in the previous part of the study.[37] A total of 108 Norwegian teenagers of both sexes were included, with a mean age of 16.2 years (S.D.1.4). The *treated group* consisted of 51 individuals having completed the orthodontic treatment approximately two years prior to the present examination. All patients had had Class II, Division 1 malocclusion, and all four first premolars were extracted as part of the orthodontic treatment. A continuous arch light-wire edgewise technique was used for a mean period of 19.1 months (S.D. 2.9). The *untreated group* included 54 individuals selected to match the others as nearly as possible in all respects. Serial extraction carried out in some of the reference individuals, either in one (3 subjects) or in both (10 subjects) dental arches, served a useful purpose in the interpretation of the effect of solitary extractions unrelated to active orthodontic tooth movement.

METHODS

Radiographic technique

Two posterior bite-wing radiographs were taken using the Twix device to ensure consistent film positioning. The projections were standardized with a

vertical angle of 10 degrees and the central ray parallel with the mesial surface of the maxillary first molar. Standard size ultraspeed periapical films were used. The x-ray dental unit operating at 50 KV and 7 MA was employed with fixed exposure time. The radiographs were developed, fixed and rinsed by the same assistant according to standardized procedures.

Measurement procedures

Following repeated standardization sessions,[3] the same person made all measurements within a limited period of time (one week). This was a blind test, and the radiographs of the treated and untreated groups were intermixed during the examination sessions. The mesial and distal aspects of the maxillary and mandibular first molars and second premolars and the distal aspects of the canines were selected for study. The mesial surfaces of the canines were rejected because of inadequate reproduction in many cases. Hence twenty measurements were obtained from each patient.

The radiographs were placed onto an illuminator and two reference points, i.e., cemento-enamel junction (CEJ) and the crest of the interdental alveolar bone approximating the tooth surface, were located under a magnifying glass and marked by a fine needle.[8] The most coronal level where the periodontal space still retained its normal width was considered as the alveolar crest.[3] Infrabony craters were measured to the point of the most apically advanced radiolucency,[31] but marginal thickening[9] was not recorded as alveolar bone loss as long as an evident oblique resorption was not present. The distance between the CEJ and the projection of the alveolar crest on a line parallel to the long axis of the tooth through the CEJ will be referred to as the *CEJ-AC* (Cemento-Enamel Junction to Alveolar Crest) *distance*

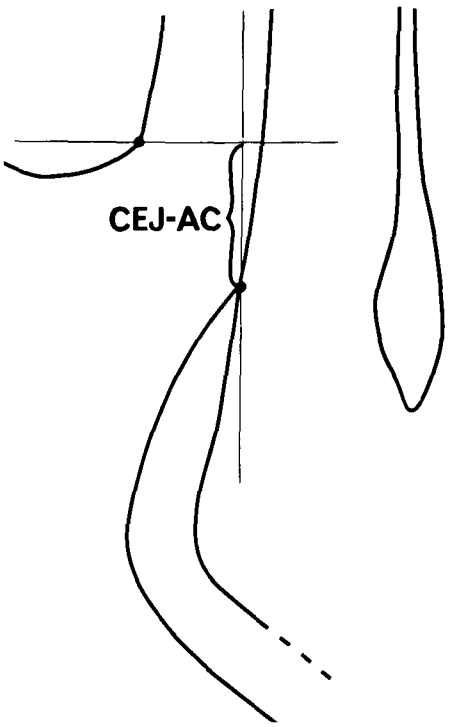

Fig. 1 Schematic drawing indicating the measured CEJ-AC (cemento-enamel) junction to alveolar crest) distance.

(Fig. 1). Differences in the CEJ-AC distance between any two distributions presumably reflect different degrees of alveolar bone loss. All measurements were made to the nearest 0.5 mm by means of a calibrated magnifying glass (8 x) marked at every 0.1 mm.

The CEJ-AC distance was measured only when there was no hesitation as to the measurability of the area in question. Teeth containing restorations with overhanging margins were excluded, as such fillings may induce excessive alveolar bone loss.[4]

Method error

To determine the reliability of the method, duplicate measurements (time interval 1-2 hours) were made on duplicate exposures (time interval 30 - 60 minutes) of 220 tooth surfaces of 11 randomly selected patients. When meas-

TABLE I

Frequency (per cent) and distribution of nonmeasurable alveolar crest heights (cemento-enamel junction to alveolar crest) on bite-wing radiographs

	MAXILLARY TEETH					
	First molar		Second premolar		Canine	
	Distal	Mesial	Distal	Mesial	Distal	Mean
Treated group	12.8	12.8	0.0	1.0	0.0	5.3
Untreated group	27.8	18.5	5.6	2.8	1.9	11.3

	MANDIBULAR TEETH					
	First molar		Second premolar		Canine	
	Distal	Mesial	Distal	Mesial	Distal	Mean
Treated group	12.8	9.8	3.0	7.9	12.8	9.3
Untreated group	16.7	10.2	10.2	13.0	25.8	15.2

ured in 0.1 mm units, the method error was 0.24 mm. Therefore, measurements to the nearest 0.5 mm were considered pertinent.[31]

Statistical analysis

In comparisons of two distributions, systematic differences were revealed by Student's *t*-test. Correlation coefficients and probabilities were calculated between the means for the individual, and for the distal aspect of the canines, and various factors, including sex, age, caries experience and degree of overjet at the start of treatment, mean gingival and plaque index scores during active treatment, duration of treatment, time needed for retraction of canines, caries index at time of band removal and loss of attachment.[37]

Results

Nonmeasurability

Difficulties with regard to the recognition of either or both reference points hampered measurements of alveolar crest heights in about ten per cent of all surfaces examined (Table I). Nonmeasurability varied greatly from one type of tooth to another, and the percentages were consistently higher in the untreated than in the treated group (Table I). Of 219 surfaces where no measurement was made, 65% were due to projection inadequacies. The remaining surfaces were not measurable because of indistinct bone contours (14%), tipped or rotated teeth (7%), amalgam fillings covering the CEJ (7%), bone heights adjacent to overhanging margins of restorations (6%), or neighboring teeth under eruption (1%).

Alveolar bone loss

Mean radiographic measurements of the interdental alveolar crest heights per tooth surface of the treated and untreated groups are shown in Figure 2. The CEJ-AC distance averaged 1.11 mm (S.D. 0.20) in the orthodontic patients and 0.88 mm (S.D. 0.12) in the reference group. This difference is statistically significant ($P<0.001$). The highest figures for the CEJ-AC distance were noted in closed extraction spaces and, particularly, on the pressure side of the retracted canines. Paired comparisons between homologous tooth surfaces in the treated and untreated groups revealed consistently more alveolar bone loss for all the teeth in the treated group (Fig. 2). The differences were statistically significant for the distal aspects of the maxillary and mandibular canines ($P<0.001$), the mandibular second premolar ($P<0.001$) and the maxillary ($P<0.05$) and man-

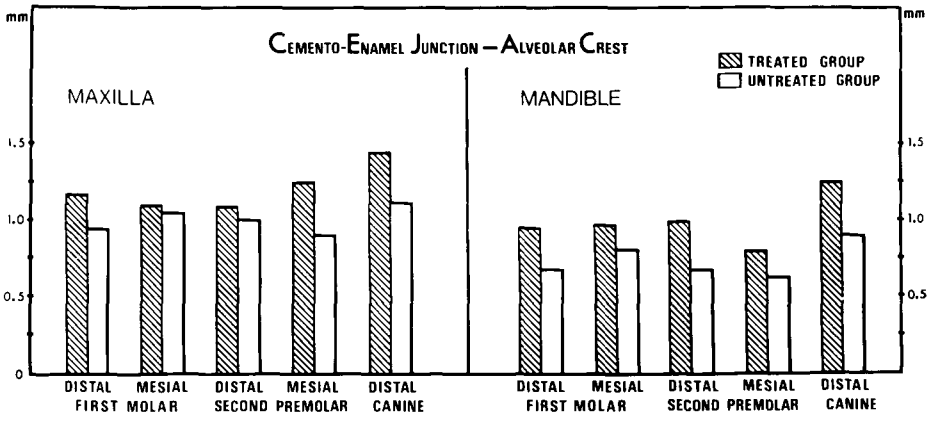

Fig. 2 Mean radiographic measurements of distance from cemento-enamel junction to alveolar crest in bilaterally pooled tooth surfaces of 51 orthodontically treated and 54 untreated young individuals. (Standard deviations for the different surfaces ranged between 0.41 and 0.54 mm in the treated group, and between 0.35 and 0.44 mm in the untreated group).

dibular ($P<0.01$) first molars, and for the mesial aspects of the maxillary ($P<0.001$) and mandibular ($P<0.05$) second premolars.

The distribution of mean CEJ-AC distance both for the individual and for the distal aspect of the canines indicated that considerable individual variation was present (Fig. 3). None of the correlation coefficients between the CEJ-AC distance and the different factors tested was significant at the five per cent level.

When the untreated group was subdivided into serial extraction and nonextraction cases, no significant differences in mean CEJ-AC distances were recorded in the premolar and canine region, but in some individuals subjected to serial extraction, tendencies toward increased alveolar bone loss were noted. No significant sex or age differences in alveolar crest height were noted in the untreated group.

Discussion

Recent studies have indicated that radiographic measurements of interdental alveolar bone loss may be as accurate as periodontal probe measurements.[30] In addition, radiography may yield information that cannot at all, or not as easily and/or objectively, be obtained by clinical methods.[2] Assessment of alveolar bone loss from radiographs should be restricted to the evaluation of interdental bone because of difficulties in obtaining satisfactory views of buccal and lingual bone levels.[32]

The results of the present study demonstrated that the orthodontic patients showed significantly more alveolar bone loss radiographically than did the reference subjects. However, the differences were small. The general pat-

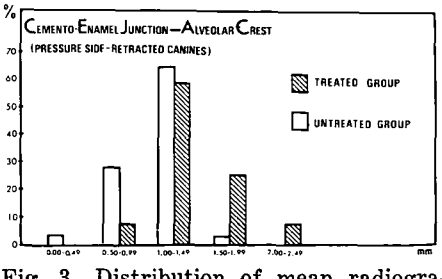

Fig. 3 Distribution of mean radiographic measurements of distance from cemento-enamel junction to alveolar crest in bilaterally and bimaxillary pooled distal surfaces of the canines of 51 orthodontically treated and 54 untreated young individuals.

tern was similar to that observed in previous investigations and confirmed the ability of the periodontal tissues in the majority of patients to resist the orthodontic treatment. The greatest alveolar bone loss was noted in the closed extraction spaces; the pressure side of the retracted canines disclosed large CEJ-AC distances. This finding confirms the observations of Buchner,[5] Tirk and co-workers,[33] Maushardt[13] and Sleichter,[26] but it contradicts statements made by Baxter[1] and Libby.[34] In Baxter's study, however, a similar tendency was found in the first premolar extraction cases treated with the edgewise technique. The fact that almost seventy per cent of these cases were Class I malocclusions might explain the differences.

The periodontal status of the closed extraction spaces is of particular clinical interest because removal of teeth is frequently a part of orthodontic treatment. Some recent histological evidence from animal experiments indicates that the alveolar crest will not return to its former height adjacent to extraction sites.[6] It is possible that the extractions *per se* had contributed to the alveolar bone loss in the treated group, inasmuch as a tendency toward more loss was noted in some of the serial extraction cases in the untreated group. However, several other factors were probably important, including the orthodontic forces used, the gingival condition associated with the treatment, pressure from the transseptal fibers,[17] and individual predisposition to increased resorptive activity.[12,15] There is also a possibility that part of the differences between the untreated and treated groups were present prior to, or otherwise unrelated to, treatment. Further studies are needed to clarify the relative importance of the etiologic factors.

With regard to the orthodontic treatment procedures, emphasis should be placed on the type of force used. Many authors have stated that tooth movements providing a high load at the alveolar crest, such as torque and rapid tipping, may result in reduction of the alveolar crest height.[16,20,21,26,29] In spite of attempts to move the canines bodily in the present study, some degree of uprighting generally was necessary after space closure. On the other hand, available data do not indicate that significant alveolar bone loss takes place following tipping and uprighting by the Begg technique.[1,34]

The presence of gingival inflammation during orthodontic tooth movement may augment alveolar crest resorption.[25,29] The maintenance of optimal oral hygiene in adults retards the rate of alveolar bone loss.[31] The generalized gingivitis present during active treatment, therefore, should receive attention. The insignificant correlation between the CEJ-AC distance and the GI scores in the present study might be explained by the small variability in gingival condition when the fixed appliances were in place.[35]

The figures on bone height given in the present study cannot be claimed to represent absolute values, and a number of precautions must be taken. 1) Assessments could not be made on all bone septa. However, mainly due to the standardized radiographic technique used and the age of the participants, nonmeasurability was considerably lower than in previous reports.[2,23] The high degree of nonmeasurability in the untreated group (Table I) was partly a consequence of the presence of the first premolars; 2) radiographic assessments generally cause an underestimation of interdental alveolar bone loss;[30,32] 3) infrabony pockets are difficult to detect on radiographs. The alveolar crest may not be uniformly resorbed over a single tooth surface in response to orthodontic forces,[16] and the frequency of undetect-

ed bone craters may be higher in the treated than in the untreated group; 4) any single measurement cannot provide an accurate picture of bone loss for tooth surfaces presenting alternate crest heights.

Evaluations of the clinical significance of the present results are difficult due to the widely divergent opinions concerning the maximal or optimal heights of the alveolar crest. On the basis of histologic observations, Schei and co-workers[23] considered bone loss to have taken place when the alveolar crest was found more than one millimeter from the CEJ. This distance conforms to the mean figures in the untreated group (Fig. 1). Consequently, the average degree of alveolar bone loss in the treated group may lie within an acceptable range to be compensated for by the achievement of an adequate and stable treatment goal. It should be kept in mind, however, that because the retentive apparatus of the tooth is largely restricted to the coronal two thirds of the root, the loss of even a small degree of alveolar crest height may be of great clinical significance.[7,10,18]

Many periodontists have found reasons to assume that the penalties of orthodontic treatment may be paid for ten and fifteen years after the termination of therapy.[14,24,33] Particular concern, therefore, should be given to the more definite bone loss in some ten per cent of the orthodontic patients. Corresponding experiences were made in the clinical assessments of loss of attachment, but the degree of damage apparently was greater on the buccal surfaces, as might be expected. The considerable interindividual variability should be remembered during evaluations of the need for orthodontic treatment in individual cases. At present, it seems difficult to predict which individual may have a stronger predisposition for alveolar bone loss than others.

Summary

Fifty-one Class II, Division 1, four first premolar extraction cases treated by a light-wire edgewise technique were re-examined two years after removal of the fixed appliances. Measurements of the interdental alveolar crest heights relative to the cemento-enamel junction (CEJ-AC distance) were performed on standardized posterior bitewing radiographs. Fifty-four matching individuals who had not received orthodontic treatment served as a reference group.

The orthodontic patients showed significantly more alveolar bone loss radiographically than did the untreated subjects. Mean CEJ-AC distance was 1.11 mm in the treated group and 0.88 mm in the untreated group. Paired comparison of homologous tooth surfaces in the two groups revealed consistently higher figures for the CEJ-AC distance in the orthodontic patients. The greatest alveolar bone loss was noted in the closed extraction spaces, particularly on the pressure side of the retracted canines. The distribution pattern demonstrated considerable individual variation, and a small portion of patients showed more definite alveolar bone loss than others.

Dental faculty,
Geitmyrsvn. 71,
Oslo 4, *Norway*

Acknowledgment

The technical assistance of stud. odont. K. Løken is appreciated.

References

1. Baxter, D. H.: The effect of orthodontic treatment on alveolar bone adjacent to the cemento-enamel junction. *Angle Orthodont.*, 37:35-47, 1967.
2. Björn, H.: Radiographic assessment of periodontal disease. *Int. Dent. J.*, 18:611-619, 1968.
3. Björn, H., Halling, A. and Thyberg, H.: Radiographic assessment of mar-

ginal bone loss. *Odont. Revy.*, 20: 165-179, 1969.
4. Björn, A. L., Björn, H. and Grkovic, B.: Marginal fit of restorations and its relation to periodontal bone level. Part I: Metal fillings., *Odont. Revy*, 20:311-321, 1969.
5. Buchner, H. J.: An answer to some criticism of treatment following bicuspid extractions. *Amer. J. Orthodont.*, 19:23-47, 1949.
6. Furstman, L. and Bernick, S.: Clinical considerations of the periodontium. *Amer. J. Orthodont.*, 61: 138-155, 1972.
7. Goldman, H. M., Schluger, S. and Fox, L.: *Periodontal Therapy.* C. V. Mosby Co., St. Louis, 1956.
8. Herulf, G.: Roentgenographic measurement of the height of the alveolar ridge in adolescents. *Svensk Tandläk.-T.*, 43:42-82, 1953.
9. Hollender, L., Lindhe, J. and Koch, G.: A roentgenographic study of clinically healthy and inflamed periodontal tissues in children. *J. Periodont. Res.*, 1:146-151, 1966.
10. Jacobson, O.: Clinical significance of root resorption. *Amer. J. Orthodont.*, 38:687-696, 1952.
11. Massler, M.: Changes in the lamina dura during tooth movement. *Amer. J. Orthodont.*, 40:364-372, 1954.
12. Massler, M. and Perreault, J. G.: Root resorption in the permanent teeth of young adults. *J. Dent. Child.*, 21:158-164, 1954.
13. Maushardt, R.: Untersuchung über die parodontalen Verhaltnisse nach Prämolarenextraktion und kieferorthopädischem Lückenschluss. *Fortschr. Kieferorthop.*, 29:219-224, 1968.
14. Moskow, B. S. and Baden, E.: Unusual gingival characteristics having a familial tendency: A case report. *Periodontics*, 5:259-264, 1967.
15. Morse, P. H.: Resorption of upper incisors following orthodontic treatment. *Dent. Pract.*, 22:21-35, 1971.
16. Oppenheim, A.: Human tissue response to orthodontic intervention of short and long duration. *Amer. J. Orthodont.*, 28:263-301, 1942.
17. Parker, G. R.: Transseptal fibers and relapse following bodily retraction of teeth: A histologic study. *Amer. J. Orthodont.*, 61:331-344, 1972.
18. Phillips, J. R.: Apical root resorption under orthodontic therapy. *Angle Orthodont.*, 25:1-22, 1955.
19. Rateitshak, K. H.: Orthodontics and periodontology. *Int. Dent. J.*, 18: 108-120, 1968.
20. Reitan, K.: Some factors determining the evaluation of forces in orthodontics. *Amer. J. Orthodont.*, 43: 32-45, 1957.
21. ————: Clinical and histologic observation on tooth movement during and after orthodontic treatment. *Amer. J. Orthodont.*, 53:721-745, 1967.
22. Rehak, R.: Die Veränderung der Gewebe im Röntgenbild nach orthodontischer Beansprunchung der Zähne. *Ztschr. f. Stomatol.*, 33:1424-1440, 1935.
23. Schei, O., Wærhaug, J., Lövdal, A. and Arnö, A.: Alveolar bone loss as related to oral hygiene and age. *J. Periodont.*, 30:7-16, 1959.
24. Schluger, S.: Periodontal aspects of orthodontic treatment. *J. Pract. Orthodont.*, 2:111-117, 1968.
25. Skillen, W. G.: Tissue changes the result of artificial stimuli and injury. *J.A.D.A.*, 27:1554-1563, 1940.
26. Sleichter, C. G.: A clinical assessment of light and heavy forces in the closure of extraction spaces. *Angle Orthodont.*, 41:66-75, 1971.
27. Solow, B.: The pattern of craniofacial associations. *Acta Odont. Scand.*, 24: suppl. 46, 1966.
28. Storey, E.: Bone changes associated with tooth movement. A radiographic study. *Austral. J. Dent.*, 57: 57-64, 1953.
29. Stuteville, O. H.: Injuries to the teeth and supporting structures caused by various orthodontic appliances, and methods of preventing these injuries. *J.A.D.A.*, 24:1494-1507, 1937.
30. Suomi, J. D., Plumbo, J. and Barbano, J. P.: A comparative study of radiographs and pocket measurements in periodontal disease evaluation. *J. Periodont.*, 39:311-315, 1968.
31. Suomi, J. D., West, T. D., Chang, J. J. and McClendon, B. J.: The effect of controlled oral hygiene procedures on the progression of periodontal disease in adults: Radiographic findings. *J. Periodont.*, 42:562-564, 1971.
32. Theilade, J.: An evaluation of the reliability of radiographs in the measurements of bone loss in periodontal disease. *J. Periodont.*, 31:143-153, 1960.
33. Tirk, T .M., Guzman, C. A. and Nalchajian, R.: Periodontal tissue response to orthodontic treatment studied by panoramix. *Angle Orthodont.*, 37:94-103, 1967.
34. Weber, F. N.: Clinical investigations related to use of the Begg technique at the University of Tennessee. *Amer. J. Orthodont.*, 59:24-36, 1971.
35. Zachrisson, S. and Zachrisson, B. U.: Gingival condition associated

with orthodontic treatment. *Angle Orthodont.*, 42:26-34, 1972.
36. Zachrisson, B. U.: Gingival condition associated with orthodontic treatment. II. Histologic findings. *Angle Orthodont.*, 42:352-357, 1972.
37. Zachrisson, B. U. and Alnaes, L.: Periodontal condition in orthodontically treated and untreated individuals. I. Loss of attachment, gingival pocket depth and clinical crown height, *Angle Orthodont.*, 43: 402-411, 1973.