Long-term effect of root proximity on periodontal health after orthodontic treatment

Jon Årtun,* Vincent G. Kokich, and Stig K. Osterberg*****
Oslo, Norway, and Seattle, Wash.

The present investigation was done (1) to evaluate the incidence and distribution of root proximity after orthodontic treatment and (2) to test the hypothesis that interproximal areas with thin interdental bone provide less resistance against marginal periodontal breakdown than areas with normal width of bone between the roots. Only adult patients were examined at least 16 years after active orthodontic treatment. The distance between the roots was measured directly on periapical radiographs. Gingival health, level of connective tissue attachment, and clinical scores for bone levels in sites with thin interdental bone and neighboring or contralateral sites with normal width of bone between the roots were compared. Among the 400 patients studied, 25 had unilateral or bilateral areas with root proximity. Root proximity was diagnosed between maxillary central and lateral incisors in 18 patients, between mandibular central and lateral incisors in two patients, and between maxillary lateral incisor and canine, maxillary first and second molars, mandibular canine and first premolar, mandibular first and second premolars, or mandibular first and second molars in only one patient. No statistically significant differences in inflammation, level of attachment, and bone level were observed between root proximity sites and control sites. The results indicate that anterior teeth are not predisposed to more rapid periodontal breakdown when roots are in close proximity. Too few molar sites were included to draw conclusions regarding such areas. (AM J ORTHOD DENTOFAC ORTHOP 1987;91:125-30.)

Key words: Root proximity, orthodontic treatment, attachment level, bone level, gingival inflammation

It has been suggested that orthodontic treatment may have adverse effects on the gingival and periodontal tissues, which may hasten or promote periodontal breakdown later in life.[1,2] Furthermore, it has been speculated that an adequate space between the teeth at the level of crestal bone is necessary for maintenance of gingival health[1] and that malposed or rotated teeth may be predisposed to more rapid breakdown of the periodontium when roots are in close proximity, resulting in a thin interproximal septum.[1-4] Studies on the pathogenesis of periodontal disease indicate that alveolar bone resorption is only a secondary response to the apical spread of the inflammatory process and the loss of attachment.[5] However, the speculations above are based on the hypothesis that the destructive effect of the inflammation varies with the status of the alveolar bone.[6]

Few studies have documented the effects of orthodontic treatment on the periodontium.[7-10] None has disclosed any difference in the level of attachment between treated and untreated persons.[7,8] Furthermore, no difference in crestal alveolar bone levels has been found between study and control groups.[10] Within each group, differences in the amount of breakdown have been related to tooth type and surface location,[7,9] and attempts have been made to differentiate between extraction sites and other interdental areas.[8,10] However, no one has tried to correlate long-term periodontal health and tissue destruction with the thickness and configuration of the interproximal alveolar bone.

Improper angulation of teeth during orthodontic treatment decreases the interalveolar space between adjacent roots and may, depending upon the shape of the crown and the configuration of the cementoenamel junction, reduce the width of the interdental alveolar bone.[11] The purposes of the present study were (1) to analyze the frequency and distribution of root proximity after orthodontic treatment, and (2) to determine the effect of root proximity on long-term periodontal health after orthodontic treatment.

MATERIAL AND METHODS

Screening of subjects

Posttreatment plaster casts and radiographs completed a minimum of 16 years earlier on 400 orthodontic patients by faculty members and/or graduate students in the graduate orthodontic clinic at the University of

*Department of Orthodontics, University of Oslo.
**Department of Orthodontics, University of Washington.
***Department of Periodontics, University of Washington.

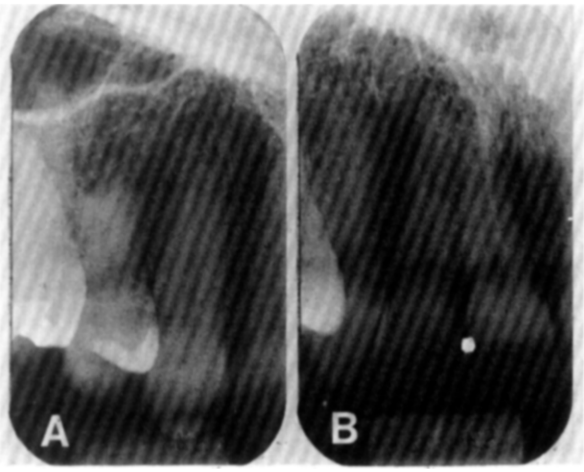

Fig. 1. Root proximity site **(B)** and neighboring control site **(A)**.

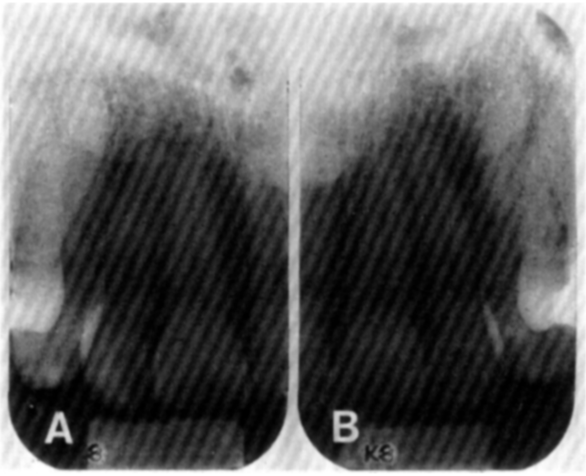

Fig. 2. Root proximity site **(A)** and contralateral control site **(B)**.

Washington were examined. All patients had been treated with a *fully banded* edgewise appliance with 0.022×0.028-inch bracket slots. The radiographs were judged subjectively. Those patients with (1) radiographic evidence of root proximity, (2) models showing well-aligned teeth, and (3) closed interproximal contacts were scheduled for reexamination. At the time of reexamination, study models were made, a full-mouth set of periapical radiographs was taken with the paralleling long-cone technique, and clinical examinations were performed.

Diagnosis of root proximity

Periapical radiographs taken at the time of reexamination were placed in slide mounts and projected onto a screen at magnification $\times 10$. The position of the cementoenamel junction (CEJ) was determined jointly by two of the authors. Helios calipers, graduated in tenths of a millimeter, and a transparent grid were used to measure the radiographic images. The calipers were oriented perpendicular to the long axes of the interdental septae at a level 2 mm apical to the line bisecting the distance between the CEJ of the adjacent teeth. The measurements were corrected to "normal." Root proximity was diagnosed when the roots were closer than 0.8 mm. Adjacent or contralateral interproximal areas with more than 1.0 mm between the roots were used as control sites. The mean distances between the roots were 0.4 mm (SD, 0.22) at the root proximity sites and 1.4 mm (SD, 0.99) at the control sites. The distance between root proximity and control sites in the same individual was always more than 0.4 mm (Figs. 1 and 2).

Selection of subjects

Based upon the results of the reexamination and the measurements of the radiographs taken at the time of reexamination, nine men and 16 women, aged 28 to 55 years (mean, 39.7; SD, 5.0), were included in the sample. The average posttreatment interval was 24.3 years (SD, 4.8) with a range of 16 to 32 years. In eight patients root proximity was diagnosed on both sides of the dental arch (bilateral). In 17 patients root proximity was diagnosed on only one side (unilateral). For all but three root proximity sites, unilateral or bilateral, an adjacent interproximal area served as a control. The contralateral interproximal area served as a control area for nine patients. None of the patients selected had gross malalignment,[12,13] overhanging restorations,[14] marginal ridge discrepancies, and/or tooth open contacts[15] in the root proximity sites or control areas.

Clinical examination

For each study area, information was recorded from the mesiofacial and mesiolingual aspects of one tooth and the distofacial and distolingual aspects of the adjacent tooth. All measurements were made with a University of Michigan no. 0 probe. Hygiene condition and gingival condition were scored according to the Plaque Index (Pl I) and the Gingival Index (GI) systems,[16] respectively. The periodontal condition was evaluated by measuring pocket depth, attachment level (distance between CEJ and bottom of clinical pocket),[17] and alveolar bone height (distance between CEJ and alveolar bone).[17] Transgingival probing was used to assess the level of crestal bone.[18] The protocol for making the periodontal measurements began by locating the CEJ

Table I. Distribution of root proximity sites and control sites among 25 patients after orthodontic treatment (measured for long-term effect)

<table>
<tr><th colspan="2">Root proximity sites</th><th colspan="2">Control sites</th><th colspan="2">Control sites</th></tr>
<tr><th>Site</th><th>N</th><th>Site</th><th>N</th><th>Site</th><th>N</th></tr>
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Table II. Mean differences in clinical measurements between root proximity sites and neighboring control sites (N = 22)

	Root proximity site ($\bar{X} \pm SD$)	*Control site* ($\bar{X} \pm SD$)	*Difference* ($\bar{X} \pm SD$)	*Significance*
Pl I	0.89 ± 0.59	0.91 ± 0.62	−0.02 ± 0.28	NS
GI	1.23 ± 0.61	1.26 ± 0.65	−0.03 ± 0.31	NS
CEJ-BP	1.88 ± 1.27	1.76 ± 0.94	0.12 ± 0.71	NS
CEJ-AB	2.93 ± 1.25	2.80 ± 0.95	0.13 ± 0.76	NS

Pl I = Plaque Index.
GI = Gingival Index.
CEJ-BP = Distance between cementoenamel junction and bottom of pocket.
CEJ-AB = Distance between cementoenamel junction and alveolar bone.

and then recording the distance from the gingival margin (GM) to the CEJ. A negative value indicated a more apical position of GM relative to CEJ. The proble was then moved apically with a nonstandardized light force to locate the connective tissue attachment. The distance from GM to bottom of the pocket (BP) was recorded. If the CEJ could not be identified, it was assumed to be at the bottom of the pocket.[17] Finally, the tip of the probe was forced through the soft tissue until definite resistance was met and the distance from the GM to the alveolar bone (AB) was recorded. All measurements were rounded to the nearest millimeter. Any measurement that was close to 0.5 mm was always rounded to the lower whole number.[17] The level of attachment was calculated by subtracting the distance GM-CEJ from the distance GM-BP. The bone level was calculated by subtracting the distance GM-CEJ from the distance GM-AB.

Error of the method

The reproducibility of the clinical measurements was assessed by analyzing the statistical difference between two measurements made an hour apart on ten patients selected at random. The error of the method was calculated using the following equation:

$$S_X = \sqrt{\frac{\Sigma D^2}{2N}}$$

where D is the difference between duplicate measurements and N is the number of double measurements.[19] The errors for averaged measurements in each interproximal site were 0.09 for the distance GM-CEJ, 0.14 for the distance GM-BP, and 0.15 for the distance GM-AB. The errors for single measurements were 0.16 for the distance GM-CEJ, 0.32 for the distance GM-BP, and 0.29 for the distance GM-AB. The difference be-

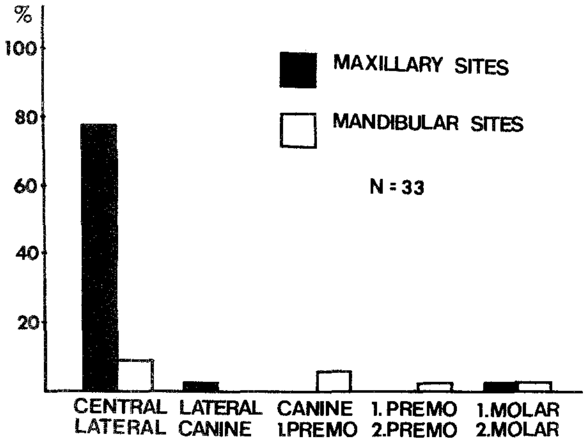

Fig. 3. Distribution of 33 root proximity sites according to frequency of occurrence between sites.

tween the two measurements did not exceed 1 mm, irrespective of variations in distances measured. To test the reproducibility of the direct measurements on the radiographs, duplicate measurements were performed on the radiographs of ten subjects 3 weeks after the first assessment. The error of the method was calculated as before. The error was 0.19 for the distance between the roots.

Data analysis

From each study area, the data for the clinical measurements (Plaque Index, Gingival Index, level of attachment, and bone level) were averaged into one value. For bilateral areas, the means of the averaged values for the root proximity sites and the two control sites were used. Differences between root proximity sites and control sites in each person were calculated. In addition, a separate statistical analysis was performed for those unilateral root proximity sites having contralateral control sites with parallel roots. Student's t tests for dependent means were evaluated to determine any statistically significant differences. The $P < 0.05$ level was considered as statistically significant.

RESULTS

Frequency and distribution of root proximity

Among the 400 patients analyzed, 6% had one or more interproximal areas with root proximity. Thirty-three root proximity sites were identified among these 25 patients (Table I). The majority (72%) of the areas with root proximity was found between maxillary central and lateral incisors. Only 15% of the root proximity sites were in posterior segments (Fig. 3).

Hygiene and inflammation

No statistically significant differences were observed in the hygiene and gingival health between sites with thin interdental alveolar bone and sites with normal width of the interproximal septae (Tables II and III).

Level of attachment and bone level

No statistically significant differences in attachment level and bone level were found between experimental and control sites (Tables II and III).

DISCUSSION

In the present investigation, the prevalence of root proximity in the overall sample was low. Extraction sites with overparalleled adjacent teeth and apices actually touching have been studied with regard to relapse tendency.[4] However, no one has previously evaluated the incidence and distribution of areas with root proximity either in patients after orthodontic therapy or in untreated controls. In the present investigation, the majority of the root proximity sites were found between maxillary central and lateral incisors. The most likely reason for the high incidence in this particular area is the common difficulty associated with proper crown angulation or the "artistic" aspect of the maxillary lateral incisors encountered during the finishing stages of orthodontic treatment.

The patients in the present study received orthodontic treatment nearly 25 years ago. Therefore, all were treated with a banded rather than a bonded appliance. Clinicians who routinely use multibonded appliances appreciate the difficulty of properly placing bonded attachments to achieve ideal root position. It is especially difficult to relate the bonded brackets to the marginal ridges or occlusal planes of premolars. For that reason, a study of postorthodontic patients with bonded appliances may show not only a high incidence of root proximity, but also a higher predilection for root proximity in posterior segments. In addition, use of preangulated canine brackets in nonextraction cases may increase the prevalence of root proximity between canines and premolars.

For years anecdotal comments have been made in the literature about a theoretical association between root proximity after orthodontic treatment and the potential for subsequent periodontal breakdown.[1-4] However, the present authors disagree with this hypothesis. Our findings indicate that anterior teeth are not predisposed to more rapid periodontal breakdown when the roots are in close proximity. These results corroborate a recent investigation in the dog,[20] suggesting that even

Table III. Mean differences in clinical measurement between root proximity sites and contralateral control sites (N = 9)

	Root proximity site ($\bar{X} \pm SD$)	*Control site* ($\bar{X} \pm SD$)	*Difference* ($\bar{X} \pm SD$)	*Significance*
Pl I	0.61 ± 0.42	0.86 ± 0.82	−0.25 ± 0.68	NS
GI	0.17 ± 0.65	1.22 ± 0.75	−0.05 ± 0.41	NS
CEJ-BP	1.31 ± 0.39	1.53 ± 0.48	−0.22 ± 0.51	NS
CEJ-AB	2.39 ± 0.40	2.61 ± 0.56	−0.22 ± 0.48	NS

Pl I = Plaque Index.
GI = Gingival Index.
CEJ-BP = Distance between cementoenamel junction and bottom of pocket.
CEJ-AB = Distance between cementoenamel junction and alveolar bone.

absence of the bony component does not imply less resistance against progression of periodontal disease. Interestingly, some of the patients in our sample had periodontal disease with loss of periodontal support in several areas. However, even in these patients, the periodontal breakdown was not worse in the root proximity site.

In the present study, only two root proximity sites were located between posterior teeth. It is therefore impossible to make any strong statement about the lack of association between root proximity and periodontal breakdown for such areas. The bony architecture, crown form, root morphology, and shape of the interproximal contact are different between anterior and posterior teeth. In addition, difficulty in curetting the root surfaces of molars in close proximity[1,4] may result in a poor prognosis when periodontitis is involved. Further investigation of posterior root proximity in a larger sample is necessary to confirm or disprove the findings of the present study.

One potential problem with this study was the inability to accurately measure the amount of bone between the roots. A two-dimensional radiographic projection was used to estimate a three-dimensional structure. For that reason, differences in labiolingual malposition of the roots could not be explained. Therefore, only persons with well-aligned teeth in root proximity sites and control sites were included in the study. Another problem in measurement can occur because of distortion of the image of the interdental alveolar crest on the radiograph. This diagnostic discrepancy was realized during the screening procedure. To minimize error, the central ray was always oriented directly through the root proximity sites and at a right angle to the dental arch. However, due to the curvature of the palatal vault, axial overinclination and inclination from the mesial aspect are inevitable in the area between maxillary canine and lateral incisors. The axial overinclination will foreshorten the radiographic distance between CEJ and AB. The inclination from the mesial aspect will accentuate this further because buccal areas of the CEJ from the lateral incisor and palatal areas of the CEJ from the canine will be superimposed on the radiograph. For this reason, the bone level was measured clinically in the present study.

The selection of control sites in the present study may be questioned. Instead, averaged measurements from all interproximal areas in the mouth with normal width of bone between the roots could have been used. However, it has been shown that considerable variation in the occurrence of periodontal disease exists in the different regions of the mouth.[21,22] Accordingly, mean values from individual patients seldom represent relevant parameters for evaluation of potential correlations among different intraoral variables.[22] For that reason, the contralateral area served as control in the present study. To increase the material, the interproximal area adjacent to the root proximity site served as an additional control.

There are inherent disadvantages with the split-mouth design used in part of the study. Since any changes at one side of the mouth are likely to affect the other side, the split-mouth design tends to underestimate the effect of the variable under study. In addition, differences in oral hygiene between sides may bias the results. More bone loss has been found between maxillary right central and lateral incisors than on the left side.[23] A likely explanation is that the right incisors are not brushed as well because the toothbrush orientation is changed in this area. Five of the nine unilateral root proximity sites with a contralateral control site were between maxillary right central and lateral incisors, and one was between maxillary left central and lateral incisors. This fact may overestimate the effect of the variable under study. In addition, it may be argued that the inclination of the teeth adjacent to the root proximity sites may lead to some degree of tipping of the teeth adjacent to the neighboring site. Accordingly, this site may not be regarded as a valid control. However, the results of a recent study[24] indicate that there is neither more inflammation nor more periodontal breakdown in sites where the adjacent teeth are tipped together, provided there is no open tooth contact. In this investigation, all persons with open tooth contact in any experimental site were excluded from the study. With the chosen design, each person could serve as their own control, thus eliminating the need for matching criteria. These advantages were considered to outweigh the disadvantages.

The evidence from this investigation should not be used to legitimize or condone poor orthodontic treatment. In spite of the finding that root proximity does not predispose the interproximal area to more rapid periodontal destruction, other good reasons exist for aligning the roots of the teeth during orthodontic therapy. In most situations, the crown and the root are oriented in such a way that a properly aligned crown and a properly fitting occlusion have well-aligned roots. In some situations, however, it is impossible to avoid root proximity during orthodontic therapy. In patients with mild incisor irregularity or with anterior tooth size discrepancies, interproximal enamel is removed during orthodontic treatment and the roots are brought into closer proximity. In other patients with unusual crown/root morphology, root proximity is inevitable to produce alignment of the crown. Based upon the results of the present study, the clinician may not be overly concerned as these situations do not seem to result in a higher predilection for periodontal breakdown.

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Reprint requests to:
Dr. Jon Årtun
Department of Orthodontics
Geitmyrsvn. 71
Oslo 4, Norway