Periodontal Condition in Orthodontically Treated and Untreated Individuals

I. Loss of Attachment, Gingival Pocket Depth and Clinical Crown Height

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A number of histologic studies in the 1930's by Schwartz,[27] Oppenheim,[16,17] Stuteville,[33] Skillen[29,30] and others revealed that various injuries in the teeth and supporting structures were caused by trauma from orthodontic forces. Although most defects were found to be reversible or underwent repair following removal of the forces, the restitution from other injuries was questioned. In particular, progression of gingivitis to the underlying tissues[29,30] and alveolar crest resportion[17,29,33] was emphasized. More recent clinical and histologic evaluations of the posttreatment condition of the supporting tissues in the marginal regions include assessments of pocket depths[11,36,37] and attachment levels, mostly in short-term experiments,[5,10,11,22] alveolar bone loss associated with various types of tooth movement[13,23] and extraction,[5,6] and gingival recession on mandibular incisors.[20,24] The most extensive studies in human beings of the regenerative period after orthodontic treatment were made by Rateitschak and coworkers.[22] In their analysis of the findings in premolars that had been tipped buccally for two months, and then retained for three months before extraction with removal of buccal plate and mucosa, generally no apical migration of the gingival pocket epithelium was found.

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The observations in these studies indicate that permanent damage does not arise in the healthy periodontium as a result of orthodontic treatment. On the other hand, several periodontists, mostly on the basis of clinical experience, have assumed that orthodontic intervention may provide the first stage in a chronic marginal periodontitis.[3,14,26] Due to the irreversible and progressive nature of periodontal disease, even a slight destruction associated with orthodontic therapy may become a factor of great clinical significance with advancing age. The differences in opinion and the uncertainty as to the ultimate periodontal health of orthodontic patients may be explained in part by the fact that the number of patients evaluated generally has been limited. Moreover, observations based on short-term experimental or animal investigations, like unsupported clinical evidence, are of limited value with regard to the assessment of the degree of persistent damage caused during a full course of orthodontic therapy.

The purpose of the present study was to use sensitive methods, introduced recently,[9] in an attempt to evaluate the periodontal conditions of young individuals subjected to orthodontic treatment by the edgewise technique.

MATERIAL

The treated group consisted of 51 patients, 18 boys and 33 girls, with a mean age of 16.2 years (S.D. 1.4). The participants were examined approximately two years after the removal of the fixed appliances. The group comprised all Class II, Division 1 four first premolar extraction cases that had been treated exclusively by a standard lightwire edgewise technique in the private practice of one of the authors (B.Z.) during the years 1967-69. The average period of treatment was 19.1 months (S.D. 2.9). The individuals had participated in a previous study on the gingival conditions associated with active treatment,[37] and all data obtained during the previous examination were available for reference purposes. In contrast to the situation during treatment, the participants had received no special attention with respect to oral hygiene care following discontinuation of active retention.

The untreated group was included for the purpose of studying the periodontal condition in individuals of corresponding age, who had not received orthodontic treatment. Fifty-four pupils of two local school classes, 24 boys and 30 girls, with a mean age of 16.3 years (S.D. 1.2) were selected to match the treated group as nearly as possible in all respects, particularly with regard to age, sex, caries experience and socioeconomic status. The untreated subjects had not been influenced in any way by the authors to change their usual behaviour with respect to oral hygiene procedures.

Methods

Pocket depth

The distance from the gingival margin to the bottom of the clinical pocket was assessed according to the method of Holm-Pedersen and Löe.[9] A thin steel strip was inserted to the bottom of the pocket parallel with the long axis of the tooth, and the level of the gingival margin was marked on the strip by means of a pointed probe (Fig. 1). Measurements on the strips were made to the last 0.1 mm by means of a calibrated magnifying glass (8x).

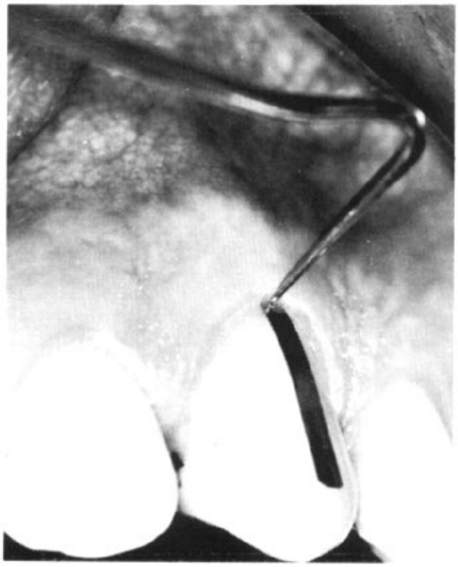

Fig. 1 Assessment of gingival pocket depth by the use of the steel strip inserted to the bottom of the clinical pocket.

Loss of attachment

The distance from the cemento-enamel junction (CEJ) to the bottom of the clinical pocket (i.e., the part of the root that no longer has periodontal fibers attached to the cementum)[7] was recorded according to the same method. Following the recognition of the CEJ,[21] the steel strip was inserted and the location of the junction was marked with a dot. Measurements were made to the nearest 0.5 mm. When the CEJ could not be located by the probe, it was assumed to be established at the bottom of the pocket.

Crown height

Measurements of clinical crown height were made on plaster models using a Mauser slide gauge with sharpened points. Impressions were taken in alginate material and cast in stone. Measurements were made to the last 0.1 mm from the deepest curvature of the buccogingival margin to the middle of the crown's incisal edge on the incisors, to the top of the buccal cusp on canines and premolars, and to a thin steel blade placed over the mesio- and distobuccal cusps on the molars.

The buccal areas of the maxillary right first molar, second premolar, canine and central incisor were selected for examination. The buccal areas were preferred, because they give the most consistent readings of loss of attachment and a high degree of accuracy with regard to the insertion of the strips. The buccal regions are thought to be the most susceptible to damage because of the limited thickness of the buccal bony plate.[16,17,23] All clinical registrations were made by the same investigator (L.A.). Plaster models and strips were then collectively handed over to the other investigator (B.Z.), who made all measurements as blind test, not knowing to which group of patients the individuals belonged.

Method errors

To determine the reliability of the methods, duplicate registrations and measurements of loss of attachment, pocket depth, and crown height were made on eleven orthodontic patients showing evidence of loss of attachment. The time interval for the duplicate registration with strips and for the two series of impressions was 30-60 minutes. The time lapse between any two sets of measurements was 1-2 hours. When 0.1 mm units were used, the method errors were 0.12 mm for pocket depths, 0.21 mm for loss of attachment, and 0.14 mm for clinical crown height. On the basis of these errors, it was considered appropriate to measure loss of attachment to the nearest 0.5 mm.[7]

Statistical analyses

The distribution of measured loss of attachment in both the treated and untreated group was discrete. Therefore, there were many tied ranks. In such instances the use of the Wilcoxon, or any other rank test, is not quite appropriate.[28] The significance probabilities, therefore, were calculated by a stepwise procedure for testing homogeneity against one-sided alternatives in a 2 x r contingency table. The operation was performed with the same level of significance in each partial test. The test procedure is described in detail by Schweder.[28]

Correlation coefficients and probabilities were calculated between individual mean loss of attachment and various factors, including sex, age, caries experience and degree of overjet at start of treatment, mean gingival and plaque index scores during active treatment, duration of treatment, time needed for retraction of canines and caries incidence at time of band removal.

Differences in mean pocket depth and mean crown height were tested by student's *t*-test.

Results

Loss of attachment

Mean losses of attachment for the selected *teeth* in the treated and the untreated groups are shown in Figure 2. None of the mean figures exceeded 0.50 mm. The bottom of the gingival pockets for the different teeth on an average were situated from 0.20 to 0.37 mm (mean 0.30) more apically in the individuals who had received orthodontic treatment. The paired differences between the treated and the untreated groups according to the nonparametric method used were statistically significant for the incisors and the second premolars ($P<0.001$), for the canines ($P<0.01$), but not for the first molars.

The distribution of mean loss of attachment for the *individuals* is indicated in Figure 3. Both the treated and the untreated groups showed charac-

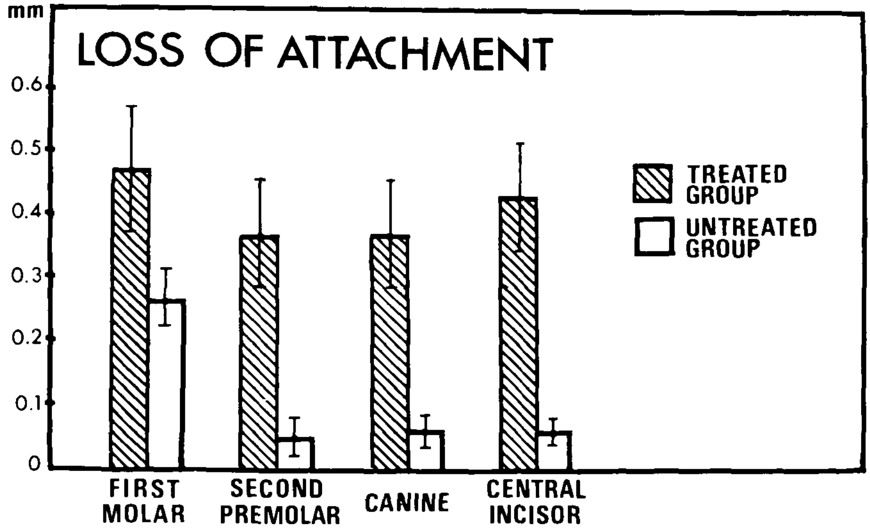

Fig. 2 Mean loss of attachment for maxillary teeth, with standard errors (inserted), in 51 orthodontically treated and 54 untreated young individuals.

teristics of logarithmic distributions. As revealed by the step-down homogeneity test, the differences in loss of attachment between the orthodontically treated and untreated individuals was statistically significant ($P<0.001$). Mean loss of attachment was 0.41 mm (S.D. 0.52) in the treated group and 0.11 mm (S.D. 0.16) in the untreated group. No participants in the untreated group had mean scores exceeding 1.0 mm, but five orthodontic patients showed mean figures from 1.0 to 1.5 mm, one between 1.5 and 2.0, and one

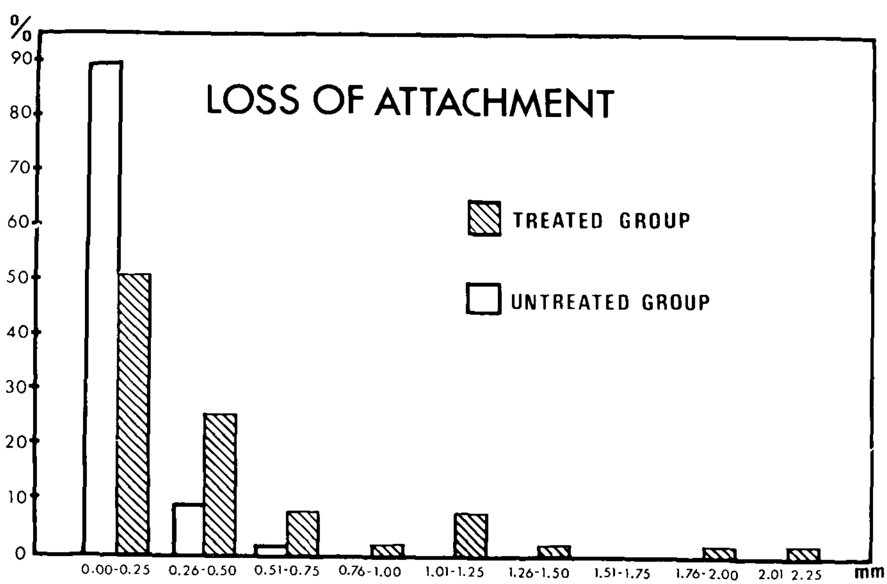

Fig. 3 Distribution of individual mean loss of attachment in 51 orthodontically treated and 54 untreated young individuals.

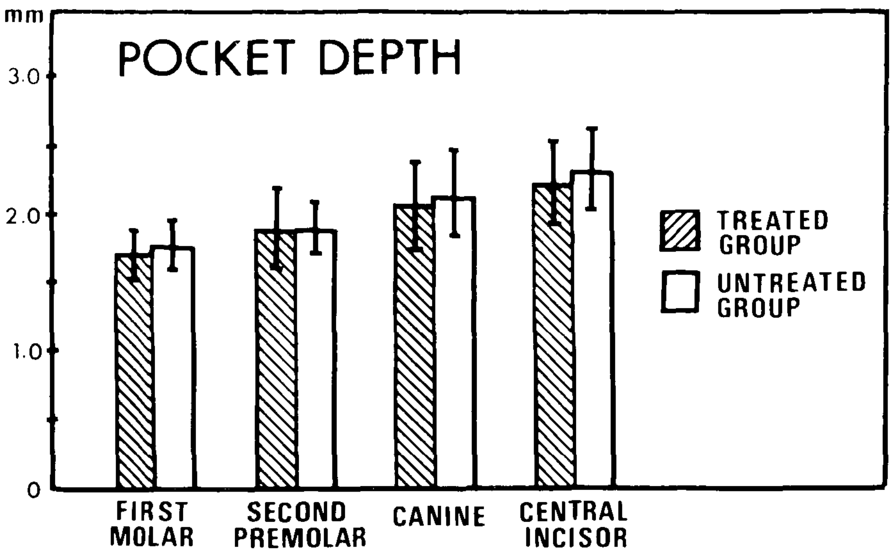

Fig. 4 Mean gingival pocket depth for maxillary teeth, with standard deviations (inserted), in 51 orthodontically treated and 54 untreated individuals.

girl had a mean score of 2.25 mm. Measurements on the pretreatment casts indicated that these defects were not prominent before treatment. The differences between the treated and the untreated groups were evident also in the score ranges below 1.0 mm (Fig. 3). The differences with regard to sex (Table I) and age were not statistically significant. The individual mean loss of attachment was not significantly correlated to any single factor tested.

Pocket depth and crown height

Mean pocket depths for the selected teeth in the treated and the untreated groups are given in Figure 4. Corresponding figures for crown height appear in Figure 5. For both parameters the differences revealed between homologous teeth in the two groups were small and not statistically significant. However, the individual variation was large (Figs. 4, 5). No statistically significant differences with regard to sex (Table I) or age were registrated in either group, except that in the reference group mean pocket depth for boys was significantly ($P<0.05$) higher than for girls.

Discussion

Besides reduction in alveolar crest height, the essential changes during periodontal destruction are loss of fiber attachment and proliferation of pocket epithelium beyond the cemento-enamel junction.[7] A limited and continuous increase in the distance between the CEJ and the alveolar crest with age might be considered physiologic, but the rate of migration of the connective tissue attachment level is significantly related to the efficiency of oral hygiene.[25,35] In clinical practice both radiographic and clinical pocket measurements may be used for information about the extent of damage, but with regard to the buccal areas, radiographs are unreliable.[34]

The clinical assessments of loss of attachment in the present study indicated that a slight damage of the periodontium had occurred concomitantly with the orthodontic intervention, at least in some of the individuals. This deduction may be based upon several

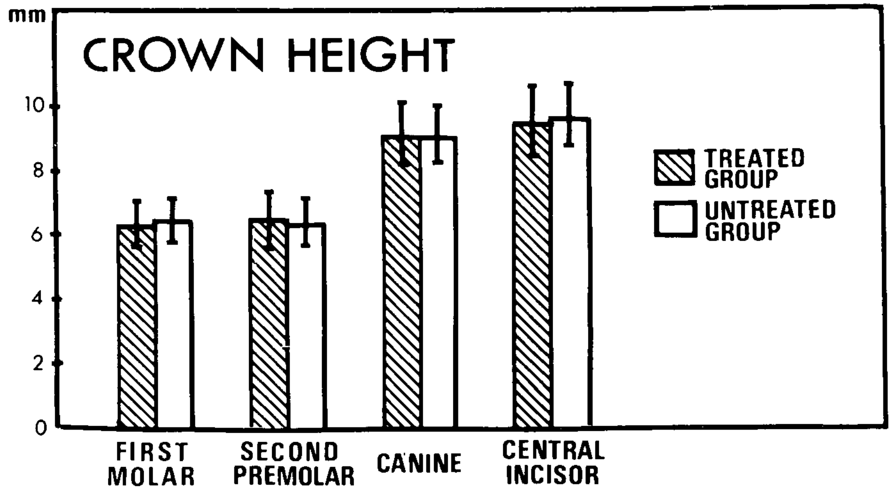

Fig. 5 Mean clinical crown height for maxillary teeth, with standard deviations (inserted), in 51 orthodontically treated and 54 untreated individuals.

different observations including (1) the distance *per se* from the CEJ to the fiber attachment level (Fig. 2, Table 1); (2) the significant differences in mean loss of attachment between the treated and the untreated groups (Fig. 2); and (3) the evident distribution differences between the two groups with regard to individual mean scores (Fig. 3). Admittedly, the assumption that unsuccessful attempts to locate the CEJ by the probe in young individuals corresponds to no loss of attachment[21] is a weak point which necessitates caution in the interpretation of the results. On the other hand, the mean loss of attachment in the reference group conformed with figures for adolescents reported recently by other authors.[1,31]

The attempts to measure attachment loss indirectly failed to provide further evidence. In individual teeth, loss of attachment may manifest itself as increased pocket depth and/or clinical crown height.[7] Pocket depths alone do not necessarily express the degree of severity of periodontal destruction, as the gingivae may be subject to recession and hyperplasia. In cross-sectional group comparisons, minor differences in attachment levels relative to the CEJ may be concealed by large individual variations in pocket depth and crown height. This would explain why the differences with regard to these two

	Loss of attachment				Pocket depth				Crown height			
	Treated group		Untreated group		Treated group		Untreated group		Treated group		Untreated group	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Male	0.33	0.44	0.09	0.16	2.19	0.55	2.28	0.39	7.94	0.92	8.06	0.74
Female	0.46	0.55	0.14	0.15	1.98	0.42	2.06	0.27	7.91	0.70	7.80	0.57

TABLE I

Mean loss of attachment, gingival pocket depth and clinical crown height according to sex in 51 orthodontically treated and 54 untreated young individuals.

parameters between the orthodontically treated and untreated individuals in the present study were insignificant. The present study design was cross-sectional because (1) assessments of periodontal condition are most accurately performed on fully erupted teeth[21] (the canines and/or second premolars generally had not attained contact with their opposing teeth at the start of treatment) and (2) the interpretation of cross-sectional data on loss of attachment is feasible in young persons, as such loss is absent or minimal in orthodontically untreated teen-agers (Fig. 3).

Mean loss of attachment in the 16-year-old orthodontic patients approached the order of magnitude reported by others[7,35] for individuals aged 20-30 years. Suomi and coworkers[35] recently demonstrated that in adults, who had received no instruction to change their usual patterns of oral hygiene, an average apical migration of the attachment level of 0.10 mm per year took place over a three-year period. In another group, where the oral hygiene condition was kept at the highest possible level, the mean loss of attachment was only 0.08 mm during the whole three-year period. Hence, provided reasonably good levels of oral hygiene are maintained, further progression of periodontal breakdown in the subjects of the present study may be kept at minimum levels. However, the high mean loss of attachment in a small percentage of the treated cases (Fig. 3) must be viewed with particular concern because of the accompanying bone loss and decreased support for the teeth. On the other hand, recessions to the extent that the bone failed to cover most of the buccal root surfaces were not registered. Such recessions, or breaks in the continuity of the alveolar bone, are thought to arise when roots are forced into contact with the cortical plate of the alveolar process, particularly when the cortical bone is thin.[17,23] The high mean loss of attachment on the maxillary first molars in the untreated individuals (Fig. 2) is in agreement with the findings of O'Leary et al.[18] and might in part be explained by a thin bony plate in these areas, by pre-existing fenestrations and dehiscences,[18] or possibly by imperfect habitual toothbrushing.[1,35] The present findings also corroborate the observations of Pearson,[20] who found that severe gingival recession buccally on lower central incisors occurred in only a small percentage of treated cases. In order to completely resolve questions regarding the clinical implications of the present results, further investigations are needed.

The etiology of the attachment loss in the orthodontically treated patients remains ambiguous and apparently individual proneness differences tended to veil the correlation trials. In addition to variations in gingival condition, probably different treatment procedures, traumatic effects from increased thoroughness of toothbrushing, and other factors may have contributed. Moreover, although care was taken to place the orthodontic bands properly on the anatomical crowns of the teeth, some cutting of fiber attachment on posterior teeth during the banding procedures cannot be ruled out. On the other hand, the mean loss of attachment on the different types of teeth varied little (Fig. 2). Particular emphasis therefore should be placed on the presence of gingivitis during the treatment period, which supposedly would influence the periodontal condition. It may be mentioned that in the study of Rateitschak et al. some few cases with evident gingivitis revealed beginning apical migration of the pocket epithelium. The observation period of five months in that study may thus have been too short to show the full extent of damage during routine orthodontic therapy.

The possibility also exists that the periodontal condition of the treated cases had been influenced by factors irrelevant to the orthodontic treatment, both prior to and afterwards. Decisive factors in this respect are the relationship of periodontal disease to (1) malocclusion and to (2) trauma from occlusion. Contradictory results appear in the literature as to whether crowding of teeth, or any other aspect of malocclusion, initiates or accelerates periodontal breakdown. The prevailing view is that malalignment of teeth does not in itself enhance tissue degradation, but that it decreases the efficacy of mechanical tooth-cleansing.[1] However, in spite of the resultant gingivitis in individuals with average oral hygiene measures, tooth retention seems to be little influenced in young individuals. Hence, mean loss of attachment around the malalignment anterior teeth in 20-year-old recruits with mediocre oral hygiene was recently[1] reported to be of the same order of magnitude as that for the untreated subjects in the present study. In addition, there is little evidence that the degree of anterior overbite and overjet has any significant effect, neither on the prevalence nor on the extent of gingivitis.[2] With regard to the etiological importance of trauma from occlusion, it seems established that occlusal, as well as orthodontic, trauma may manifest itself as a reversible increase in tooth mobility.[15] But information as to whether or not and to what extent excessive forces may act to accelerate and spread inflammation and possibly cause infrabony pockets[4,8] is very meager, and additional research including experiments of sufficiently long duration is required.

SUMMARY

Fifty-one individuals, representing Class II, Division 1 four first premolar extraction cases subjected to full orthodontic treatment by a light-wire edgewise technique, were reinvestigated two years after removal of the fixed appliances. Fifty-four matching young adults who had not had any orthodontic treatment served as a reference group. Clinical measurements of loss of attachment (distance from cemento-enamel junction to bottom of clinical pocket), pocket depth (distance from gingival margin to bottom of clinical pocket) and crown height were performed on the buccal surfaces of maxillary teeth. Loss of attachment and pocket depth were recorded on small steel strips inserted into the pockets; crown height was measured on casts.

The orthodontic patients demonstrated slightly, but significantly, more loss of attachment clinically than did the reference subjects. Mean loss of attachment was 0.41 mm in the orthodontic group and 0.11 mm in the reference group, but the individual variation was large. Paired comparison for corresponding tooth surfaces in the treated and untreated groups revealed consistently higher figures for loss of attachment in the orthodontic patients. Attempts to measure loss of attachment indirectly failed to furnish additional information, as the mean figures for pocket depth and crown height were virtually the same for orthodontically treated and untreated individuals.

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REFERENCES

1. Ainamo, J.: Relationship between malalignment of the teeth and periodontal disease. *Scand. J. Dent. Res.*, 80:104-110, 1972.
2. Alexander, A. G. and Tipnis, A. K.: The effect of irregularity of teeth

and the degree of overbite and overjet on the gingival health. *Brit. Dent. J.*, 128:539-544, 1970.
3. Burket, L. W.: The effects of orthodontic treatment on the soft periodontal tissues. *Amer. J. Orthodont.*, 49:660-671, 1963.
4. Comar, M. D., Kollar, J. A., and Gargiulo, A. W.: Local irritation and occlusal trauma as co-factors in the periodontal disease process. *J. Periodont.*, 40:193-200, 1969.
5. Dreyer, C. J.: The stability of the dentition and the integrity of its supporting structures. *Amer. J. Orthodont.*, 58-433-447, 1970.
6. Furstman, L. and Bernick, S.: Clinical considerations of the periodontium. *Amer. J. Orthodont.*, 61:138-155, 1972.
7. Glavind, L. and Löe, H.: Errors in the clinical assessment of periodontal destruction. *J. Periodont. Res.*, 21:180-184, 1967.
8. Glickman, I. and Smulow, J. B.: The combined effect of inflammation and trauma from occlusion in periodontitis. *Int. Dent. J.*, 19:393-407, 1969.
9. Holm-Pedersen, P. and Löe, H.: Wound healing in the gingiva of young and old individuals. *Scand. J. Dent. Res.*, 79:40-53, 1971.
10. Huettner, R. J.: Experimental histologic study of the effects of orthodontic movement on the gingiva and periodontal membrane in the Macaca rhesus monkey. *Amer. J. Orthodont.*, 46:929, 1960.
11. Jancosek, G. T.: The clinical effects of orthodontic treatment on periodontal soft tissues. *Amer. J. Orthodont.*, 51:305, 1965.
12. Kemper, W. W., Johnson, J. F., and Van Huysen, B.: Periodontal tissue changes in response to high artificial crowns. *J. Prosth. Dent.*, 20:160-164, 1968.
13. Kronman, J. H.: Tissue reaction and recovery following experimental tooth movement. *Angle Orthodont.*, 41:125-132, 1971.
14. Moskow, B. S. and Baden, E.: Unusual gingival characteristics having a familial tendency. A case report. *Periodontics*, 5:259-264, 1967.
15. Mühlemann, H. R., Herzog, H., and Vogel, A.: Occlusal trauma and tooth mobility. *Schweiz. Mschr. Zahnheilk.*, 66:527-544, 1956.
16. Oppenheim, A.: Biologic orthodontic therapy and reality. *Angle Orthodont.*, 6:5-183, 1936.
17. ————: Human tissue response to orthodontic intervention of short and long duration. *Amer. J. Orthodont.*, 28:263-301, 1942.
18. O'Leary, T. J., Drake, R. B., Crump, P. P. and Allen, M. F.: The incidence of recession in young males: A further study. *J. Periodont.*, 42: 264-267, 1971.
19. Parfitt, G. J. and Mjör, I. A.: A clinical evaluation of local gingival recession in children. *J. Dent. Child.*, 31:257-262, 1964.
20. Pearson, L. E.: Gingival height of lower central incisors, orthodontically treated and untreated. *Angle Orthodont.*, 38:337-339, 1968.
21. Ramfjord, S. P.: Indices for prevalence and incidence of periodontal disease. *J. Periodont.*, 30:51-59, 1959.
22. Rateitschak, K. H., Herzog-Specht, F., and Hotz, R.: Reaktion und Regeneration des Parodonts auf Behandlung mit festsitzenden Apparaten und abnehmbaren Platten. *Fortschr. Kieferorthop.*, 29:415-435, 1968.
23. Reitan, K.: Clinical and histologic observations on tooth movement during and after orthodontic treatment. *Amer. J. Orthodont.*, 53:721-745, 1967.
24. Rose, G. J.: Receding mandibular labial gingiva on children. *Angle Orthodont.*, 37:147-150, 1967.
25. Schei, Waerhaug, J., Lovdal, A., and Arnö, A.: Alveolar bone loss as related to oral hygiene and age. *J. Periodont.*, 30:7-16, 1959.
26. Schluger, S.: Periodontal aspects of orthodontic treatment. *J. Pract. Orthodont.*, 2:111-117, 1968.
27. Schwartz, A. M.: Tissue changes incidental to tooth movement. *Int. J. Orthodont.*, 18:331-352, 1932.
28. Schweder, T.: Multiple comparison of the failure rates of two discrete populations. *Statistical Research Report.* University of Oslo, 1972.
29. Skillen, W. G.: Tissue changes the result of artificial stimuli and injury. *J.A.D.A.*, 27:1554-1563, 1940.
30. Skillen, W. G. and Krivanek, F. J.: Effects of orthodontic appliances on gingival tissues. *Northw. Univ. Bull.*, 38:18-22, 1938.
31. Smith, L. W., Suomi, J. D., Greene, J. C. and Barbano, J. P.: A study of intra-examiner variation in scoring oral hygiene status, gingival inflammation and epithelial attachment level. *J. Periodont.*, 41:671-674, 1970.
32. Stahl, S. S.: The role of occlusion in the etiology and therapy of periodontal disease. *Angle Orthodont.*, 40:347-352, 1970.
33. 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.

34. 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.
35. Suomi, J. D., Greene, J. C., Vermillion, J. R., Doyle, J., Chang, J. J. and Leatherwood, E. C.: The effect of controlled oral hygiene procedures on the progression of periodontal disease in adults: results after third and final year. *J. Periodont.*, 42:152-160, 1971.
36. Weber, F. N.: Clinical investigations related to use of the Begg technique at the University of Tennessee. *Amer. J. Orthodont.*, 59:24-36, 1971.
37. Zachrisson, S. and Zachrisson, B. U.: Gingival condition associated with orthodontic treatment. *Angle Orthodont.*, 42:26-34, 1972.
38. Zachrisson, B. U.: Gingival condition associated with orthodontic treatment. II. Histologic findings. *Angle Orthodont.*, 42:352-357, 1972.