Gingival Condition Associated with Orthodontic Treatment

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Recent clinical and experimental studies have indicated that the most important etiological factor in periodontal disease is the bacterial plaque at the gingival margin.[1] The introduction of fixed orthodontic appliances into the mouth increases the number of retention areas, and thus the progression of a gingival reaction might result in increased periodontal involvement and damage.

A number of authors have reported pathological changes in the gingiva following the use of orthodontic appliances,[2-20] but only a few investigations related to the extent, frequency and severity of gingival alterations have been performed.[7] Some longitudinal studies utilizing index systems to classify the degree of gingival inflammation have been made,[11, 14, 17] but these studies are restricted to the initial phases of treatment. However, longitudinal assessments of the gingival changes during a full period of orthodontic treatment with fixed appliances, including the period following band removal, have not been reported. An evaluation of such patients will be reported in the present study.

MATERIAL

The experimental material consisted of forty-nine individuals, twenty-one boys and twenty-eight girls, treated with fixed appliances in both dental arches according to a standardized edgewise-light wire technique.[21] Most of the patients were from eleven to thirteen years of age at the start of the treatment with a mean of twelve and one-half years. The average period of treatment was 17.5 months (S.D. 3.1) in the maxillary arch, and 19.1 months (S.D. 2.9) in the mandibular arch. Bands on the upper anterior teeth were carried for an average of 14.2 months (S.D. 4.9) and those on the lower incisors for an average of 12.4 months (S.D. 2.9). Subsequent to band removal, Hawley retainers were placed in the upper dental arches. They were used three months for 24, 16 and 14 hours, respectively, and then at night for one year.

A *control* group was included for the purpose of studying plaque accumulation and gingival condition in individuals of corresponding age not treated orthodontically. The pupils of two local school classes were selected to match the experimental group as nearly as possible in all respects, particularly with regard to caries experience, social class, age and sex. The pupils comprised twenty-seven boys and twenty-six girls, with a mean age of thirteen and one-half years. They were given no toothbrushing instruction by the authors prior to the examination.

METHODS

Oral hygiene instruction. Two or three weeks before any orthodontic treatment was begun, patients and parents were thoroughly instructed according to an organized hygiene program.[21, 22] Conventional manual toothbrushing with a horizontal scrub technique[21] was used. Special attention was directed toward the areas between the bands and the gingival margins. No particular tooth-

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paste was recommended. The patients were instructed in no other form of cleaning than careful toothbrushing. All rinsed with 0.2 per cent sodium fluoride solutions twice a week throughout the observation period.

Scoring methods. Assessments of oral hygiene were performed according to the criteria of the Plaque Index (PlI) system.[23] Gingival condition was assessed according to the criteria of the Gingival Index (GI) system.[23] In addition, linear measurements were made from the bottom of the gingival pockets to stable reference points (see below). All examinations were made as partial recordings on the buccal and mesial surfaces of the upper right first molars, second premolars, cuspids and central incisors. The measurements included: (*a*) the distance from the bottom of the gingival pocket to the gingival edge of the distal part of the edgewise bracket (on molars to the mesioincisal edge of the buccal tubes); (*b*) the distance from the bottom of the gingival pocket to the incisal edge of the band material on the mesial tooth surfaces (from the buccal aspect and as close as possible to the contact points); (*c*) the gingival pocket depths (distance from gingival margin to bottom of clinical pocket). In order to obtain comparable values for banded and nonbanded teeth, the distances were also measured to the incisal edges before any band was cemented, recemented or removed. The recordings allowed the expression of the following characteristics: (1) accumulation of plaque (PlI); (2) prevalence and severity of gingivitis (GI); (3) degree of gingival hyperplasia, buccally [variations in differences between distances (*a*) and (*c*)] and interproximally [variations in differences between distances (*b*) and (*c*)].

The assessments were carried out in the order mentioned and hence the PlI always preceded the GI. Measurements were performed as described by Glavind and Löe[24] to the nearest mm with the aid of pocket probes marked at every second mm from 2 to 14 mm. All data collected were reported to an assistant, the investigator being unaware of previous records.

Scoring periods. Regular assessments were made in all patients: (I) at the start, (II) two to five times during the period of active treatment, (III) at the removal of the appliances, (IV) at each of four monthly appointments after the removal of the appliances.

Separate indices were calculated in the usual manner[23] for the areas, for the tooth, and for the individual at each examination. Indices for the individual during the treatment period were calculated by adding the separate indices for the individual and dividing by the number of examinations.

Method errors. The reproducibility in measuring pocket depth and loss of attachment was assessed by analyzing statistically[24] the difference between measurements of pocket depth and distance from the bottom of the clinical pocket to incisal tooth edges with an interval of one hour on thirteen individuals selected at random. The method error for single measurements of pocket depth was ± 0.22 mm and for distances from gingival pocket to incisal tooth edges ± 0.39 mm. The difference between double measurements did not exceed 1 mm, irrespective of variations in distances measured. In general, measurements on interproximal surfaces showed the larger, and those on buccal surfaces, the smaller errors.

Statistical analyses. Student's *t*-test was used for assessment of significance with regard to the linear measurements. Statistical analyses with regard to the clinical index systems will not be presented, since the criterial stages are not absolute and proportional, and no clear-

cut tests are available for evaluating the variability in assessment throughout an experimental period.[25]

Results

Gingival changes during treatment. In spite of good oral hygiene with low average PlI scores (Tables I-III), the majority of the patients usually developed generalized moderate gingivitis within one to two months after the placement of the appliances. Once established, however, the gingival changes did not vary considerably during the further course of treatment.

The GI scores for the experimental group were considerably higher than those of the control group, although the PlI scores were lower. The mean GI score was 1.55 and the mean PlI was 0.43. The corresponding figures in the control material were 1.07 and 0.69. The mean pocket depths in the experimental patients were 3.36 mm on the mesial surfaces and 2.55 mm on the buccal surfaces. The corresponding figures in the control material were 2.86 and 2.13 mm. Both differences between the experimental and the control subjects as well as the differences between the interproximal and the buccal surfaces in both groups were statistically significant ($P < 0.001$).

Even patients with perfect tooth cleansing showed evidence of mild inflammatory gingival changes during treatment having mean GI scores around 0.75. Patients with poor oral hygiene usually had average interproximal GI scores close to, but only in one case exceeding, 2.00 and buccal scores about 1.75. Gingival pockets in such patients measured up to, but seldom over 5 mm.

The distances from the bottom of the gingival pockets to the stable reference points showed little variation and any differences were within the limit of 1 mm.

	At start	During treatment	At removal of bands	Months after band removal 1	2	3	4	Control group
GI interproximal	0.91±0.36	1.78±0.28	1.84±0.24	1.40±0.44	1.09±0.54	0.79±0.53	0.75±0.45	1.23±0.36
GI buccal	0.49±0.38	1.33±0.37	1.42±0.36	0.74±0.40	0.54±0.41	0.42±0.41	0.36±0.37	0.92±0.49
PlI	0.49±0.41	0.43±0.34	0.51±0.41	0.30±0.30	0.41±0.38	0.39±0.40	0.45±0.46	0.68±0.61
Pocket depth interproximal (mm)	2.71±0.31	3.36±0.41	3.61±0.29	2.89±0.40	2.70±0.38	2.56±0.32	2.59±0.33	2.86±0.40
Pocket depth buccal (mm)	2.02±0.29	2.55±0.46	2.46±0.45	2.08±0.35	1.98±0.35	1.93±0.31	1.93±0.33	2.13±0.37

Table I. Mean scores for gingival condition, plaque accumulation and gingival pocket depth ± standard deviation) throughout orthodontic treatment with fixed appliances (GI: gingival index, PlI: plaque index). Note the small standard deviations with regard to gingival condition during active treatment.

Tooth	Cingival index		Plaque index	Pocket depth (mm)	
	Interproximal	Buccal		Interproximal	Buccal
First molar	1.80±0.34	1.72±0.51	0.68±0.52	3.74±0.76	2.47±0.51
Second premolar	1.84±0.32	1.46±0.57	0.40±0.44	3.46±0.56	2.42±0.50
Cuspid	1.81±0.30	1.08±0.48	0.30±0.37	3.24±0.50	2.82±0.89
Central incisor	1.66±0.43	1.05±0.20	0.33±0.37	2.98±0.59	2.47±0.82

Table II. Mean scores for the individual teeth during active treatment with fixed orthodontic appliances.

Tooth	Gingival index		Plaque Index	Pocket depth (mm)	
	Interproximal	Buccal		Interproximal	Buccal
First molar	1.98±0.25	1.79±0.54	0.69±0.63	4.00±0.70	2.34±0.45
Second premolar	1.92±0.26	1.60±0.64	0.57±0.60	3.72±0.60	2.19±0.44
Cuspid	1.84±0.34	1.22±0.55	0.37±0.54	3.65±0.56	2.97±1.02
Central Incisor	1.61±0.56	1.06±0.24	0.39±0.48	3.05±0.60	2.35±0.76

Table III. Mean scores for the individual teeth at the time of removal of the appliances.

Tooth	Gingival index		Plaque index	Pocket depth (mm)	
	Interproximal	Buccal		Interproximal	Buccal
First molar	1.42±0.54	0.78±0.74	0.88±0.83	3.04±0.54	1.94±0.51
Second premolar	1.18±0.42	0.78±0.59	0.52±0.67	3.10±0.63	2.06±0.44
Cuspid	1.25±0.60	0.91±0.79	0.72±0.70	2.77±0.47	2.20±0.67
Central incisor	1.05±0.53	1.20±0.55	0.60±0.69	2.49±0.61	2.30±0.60

Table IV. Mean scores for the individual teeth in the control group of individuals not treated orthodontically.

With regard to the individual teeth investigated (Table II), the first molars were generally the most, and the central incisors the least, affected. The second premolars normally were more affected than the cuspids. One constant exception was that the buccal gingival pockets of the cuspids, due to the tissue accumulation during distal driving, were deeper than the other buccal pockets. Only first molars (five cases) and second premolars (one case) showed mean GI scores above 2.00. As evidenced in Table IV, a different distribution pattern of changes was noted in the control material.

Gingival status at the time of removal of the appliances. The mean GI and PlI scores were higher at the time of band removal than at any other time during the experimental period, while the pattern of changes was similar to that during treatment.

All individual tooth surfaces, except the buccal surface of the central incisors, showed consistently higher GI scores than in the control material (Tables III, IV). The PlI scores were of the same order or lower than those of the control group. The interproximal pocket depths were significantly ($P< 0.001$) larger than in the control group, but the differences in buccal pocket depth were smaller and significant ($P< 0.001$) only for cuspids and first molars.

Gingival changes after removal of the appliances. As indicated in Figure 1, a rapid improvement in gingival condition was observed subsequent to the removal of the bands. At the appointment one month later, the different scores in the experimental and the control patients were essentially the same (Table I). At the subsequent appointments the scores in the experimental group continued to fall below the values of the control group, and a stabilization occurred at about four to five months after removal of the appliances. Still, a mild gingivitis persisted in the majority of the subjects, particularly interproximally (Fig. 1), but the GI scores were considerably lower than those of the control group. The standard deviations were generally large, and there were considerable differences in gingival condition for patients with good and poor oral hygiene. The PlI scores at the time of band removal were slightly lower than those of the control group. The scores reached a minimum one month later, but rose slowly again and stabilized themselves at values corresponding to those during treatment.

The average pocket depths in the experimental individuals four months after band removal (Table I, Fig. 1) were significantly smaller than those in the control material, both for interproximal ($P<0.001$) and buccal surfaces ($P<0.01$). The interproximal pockets were significantly ($P<0.001$) deeper than the buccal pockets. The reductions in pocket depths were not accompanied by any significant concomitant reduction in the distances between the bottom of the gingival pockets and the incisal edges of the actual teeth. With regard to the individual teeth investigated, a pattern similar to that during treatment was observed.

Discussion

Most children in the present study developed moderate generalized gingivitis during the orthodontic therapy. The changes were observed within one or two months after the placement of the appliances, which substantiates the findings of others.[14, 17] A slight increase by time was noted at the subsequent appointments. These gingival alterations occurred in spite of the repeated motivation and instruction in toothbrushing given prior to and during the treatment with particular attention directed toward the gingival tooth areas. The horizontal scrub technique has recently

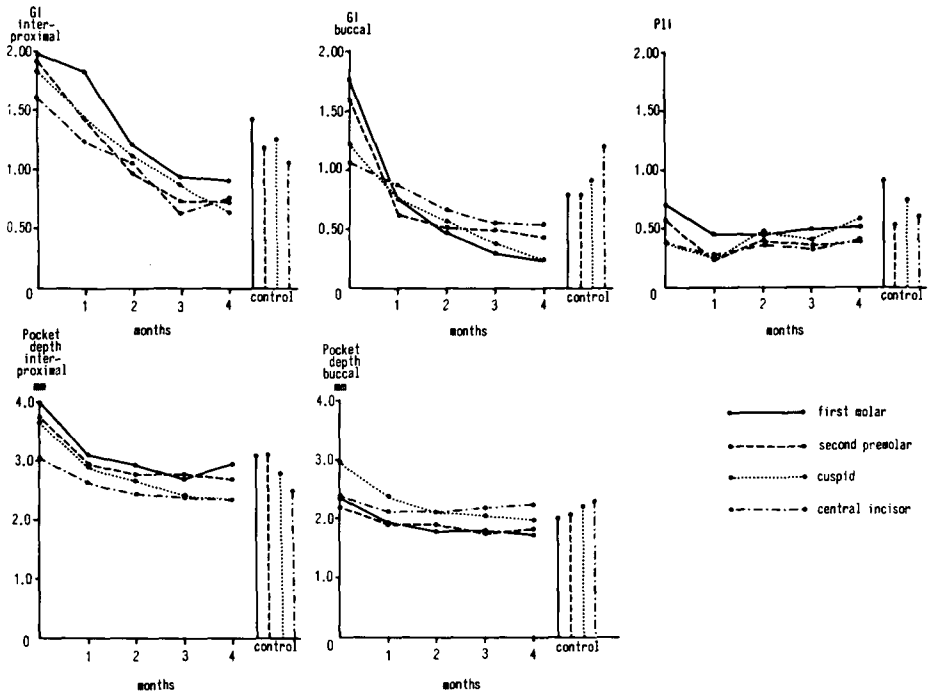

Fig. 1 Mean scores for gingival condition, plaque accumulation and gingival pocket depth for the individual teeth at each of four monthly appointments after the removal of the orthodontic appliances (GI: gingival index, PII: plaque index). The corresponding scores in the control group of patients not treated orthodontically are indicated at right in each figure. Note the improvement in gingival health during the first month after band removal.

been reported to have equally good or better plaque removing effects than a number of other toothbrushing techniques.[26] As reflected in the low mean PII scores, the cleaning habits of the children were satisfactory. Even patients with perfect tooth cleaning developed mild inflammatory changes, particularly interdentally, and such changes appeared inevitable with the methods used. However, severe inflammation was not observed as frequently as reported by others,[7] and this may be explained by the regular recording and supervision of the hygiene status.

Other explanations for the low PII scores may be that subgingival plaque along the band margins below the gingival crest had remained unregistered[27] and the regular fluoride mouth rinsing used. Koch and Lindhe[28] observed that methodical rinsing, plus regular attention, stimulated the children's interest in oral hygiene to a great extent. This might also explain why the mean PII scores of the experimental subjects were lower than that of the control group. In another report Koch and Lindhe[29] found reasons to presume that fluoride from rinsing solutions might be retained in dental plaques over prolonged periods and induce or aggravate inflammatory processes. Although low mean PII scores would tend to minimize the retention of fluoride, a similar detrimental effect cannot be ruled out in the present study. It should be noted, however, that more recent studies indicate an insignificant effect of fluoride rinses on the fluoride concentration in the plaque.[30] An interesting and consistent finding was that the PII scores reached

minimum levels during the first month after removal of the appliances. Evidently, this finding represented a novelty effect. The elimination of the orthodontic bands stimulated the children to look after their teeth unusually well at that time. As would be expected, the effect was transient and the scores soon reached their usual figures (Table I).

Prior to the placement of the orthodontic appliances, the subjects were not on a systematic periodic prophylaxis program, and the initial GI and PII scores may seem high. On the other hand, the criteria for GI = 0 are hard to fulfil. By means of daily supervised toothbrushing, scores between 0.30 and 0.50 may be obtained.[28] However, to get the individual scores to approach zero levels, meticulous toothbrushing and interdental cleaning is required.[31]

The GI scores were consistently higher and the pockets deeper at the interproximal surfaces than at the buccal surfaces (Tables I-III). These findings are in accordance with previous observations[13] and suggest that other methods of interdental cleaning[32] should supplement careful toothbrushing during orthodontic therapy. With regard to severity, the gingival changes in the present study showed a distribution pattern which differed from that of the control material and of patients not subjected to orthodontic treatment in other investigations.[33,34] The appliances most evidently influenced the posterior regions. Bands cemented on central parts of teeth in anterior regions tended to influence the gingival condition little, particularly buccally (Tables II-IV). This distribution corroborates earlier observations[3,10] and is probably due to the increased retention abilities introduced along the gingival margin and mechanical irritation of the band material. The general tendency to develop gingivitis in the age group is known to be large.[34,35]

The mean GI score four months after band removal was 0.55. Usually the buccal areas were free from inflammatory signs and the interproximal areas were slightly affected. As remarked by Russel,[36] however, disagreement may easily occur at the point of deciding whether a given area of free gingiva is normal or slightly inflamed. Even though zero levels were not approached, the present study has clearly shown that inflammatory changes during the period of active therapy rapidly decline by the removal of the appliances, despite removable retainers worn at night. Similar findings were reported by Spence.[7] The improvement in gingival condition may to some extent be influenced by the increased age of the patients. The prevalence of gingivitis has been observed to fall slightly between the ages of eleven and seventeen years, and a marked decrease in severity occurs after the age of thirteen years.[34,35]

The reductions in pocket depths following termination of active treatment were not accompanied by concomitant reductions in the distances to the stable reference points. This indicates that the increased pocket depths during treatment were due to edematous swelling and tissue accumulation during tooth movement, and not to apical movement of the gingival pockets. Similar experiences were made by Baer and Coccaro,[13] Rateitschak et al.[17] and Urbye.[37] Pearson[16] recently demonstrated that significant gingival recession occurred in only a small percentage of orthodontically treated cases, and was unable to correlate the recession to different types of tooth movement. This finding directs the attention to other factors including oral hygiene and gingival condition during treatment. However, the clinical recording methods used are crude, and

refined histologic and radiographic investigations may be required before the question about a premature aging of the dentition through orthodontic therapy[4,38] can be definitely settled.

Summary

A longitudinal clinical study was made on gingival conditions of forty-nine patients treated with fixed orthodontic appliances by an edgewise-light wire technique for an average of 19.1 months. Repeated motivation and instruction in toothbrushing with a horizontal scrub technique was given, and emphasis was directed toward the gingival areas. Sodium fluoride mouth rinsing was performed twice weekly throughout the observation period. Plaque accumulation and gingival status were assessed by partial recordings with the Plaque (PlI) and Gingival (GI) Index systems. Gingival hyperplasia was recorded through linear measurements from the bottom of the clinical pockets to the gingival margin and to stable reference points. A control group received no orthodontic treatment, no toothbrushing instruction or mouth rinsings.

The results demonstrated that, in spite of good cleaning with low PlI scores, most children developed generalized moderate hyperplastic gingivitis within one to two months after the placement of the appliances. These changes persisted throughout the period of active treatment with slight increase at subsequent appointments. Severe gingivitis was noted only in exceptional cases of patients with poor oral hygiene. Even patients with perfect tooth cleaning developed mild inflammatory changes. The interproximal areas were constantly more affected than the buccal areas and posterior teeth more than anterior teeth. The main improvements in gingival health occurred during the first month after band removal. The reduction in pocket depths after treatment was due mainly to shrinkage of hyperplastic gingivae. Hence the gingival changes were transient and no permanent damage to the periodontal tissues could be demonstrated with the methods used.

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