

Gingival Condition Associated with Orthodontic Treatment

II. Histologic Findings

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Recent clinical investigations have demonstrated the presence of generalized gingivitis when fixed orthodontic appliances are used.¹⁻⁶ The tissue response represents a reaction to the local irritation.³⁻⁵ However, clinical recordings involve inherent limitations in that they are subjective and therefore susceptible to examiner variability. The degree of correlation between clinical assessments of gingivitis and the microscopic appearance of the tissue generally is somewhat weak.⁷⁻⁹ Previous histologic reports on the pathologic changes in the gingivae derive from short term orthodontic experiments,^{5,10,11} case reports^{1,12,13} or data presented in abstracted form.¹⁴ Therefore, it was considered of interest to make a comprehensive histologic study on the type and extension of gingival inflammation at different intervals during a full period of orthodontic treatment including the retention period after removal of the fixed appliances. By this means more objective information might be obtained regarding the degree of inflammation. In addition, it would be possible to study the density and distribution of the cellular infiltrations, the type of inflammatory cells present, the topographic and chronologic appearance of the different cell forms, any epithelial changes, etc.

MATERIAL AND METHODS

Forty-eight 2 mm wide specimens comprising the tissue from the gingival margin to the alveolar crest were removed with minimal trauma from sixteen individuals (aged 11-15 years) at different intervals during the ortho-

dontic treatment period. All patients were treated with an edgewise-light wire technique⁶ for an average of nineteen months.

Prior to excision, a clinical assessment of the gingival condition was made according to the criteria of the Gingival Index system.¹⁵ The biopsy sites were the buccal aspects of the first molars or, in one case, the second premolar. In all cases healing occurred within a few days and the free gingiva regenerated approximately to the pre-operative levels according to the pattern described by Holm-Pedersen and Löe.¹⁶

The excised tissue specimens were fixed in Newcomer's fluid¹⁷ and embedded in paraffin. Serial sections cut at 6 μ were stained with hematoxylin-eosin, toluidine blue and astra blue-nuclear fast red.^{17,18}

RESULTS

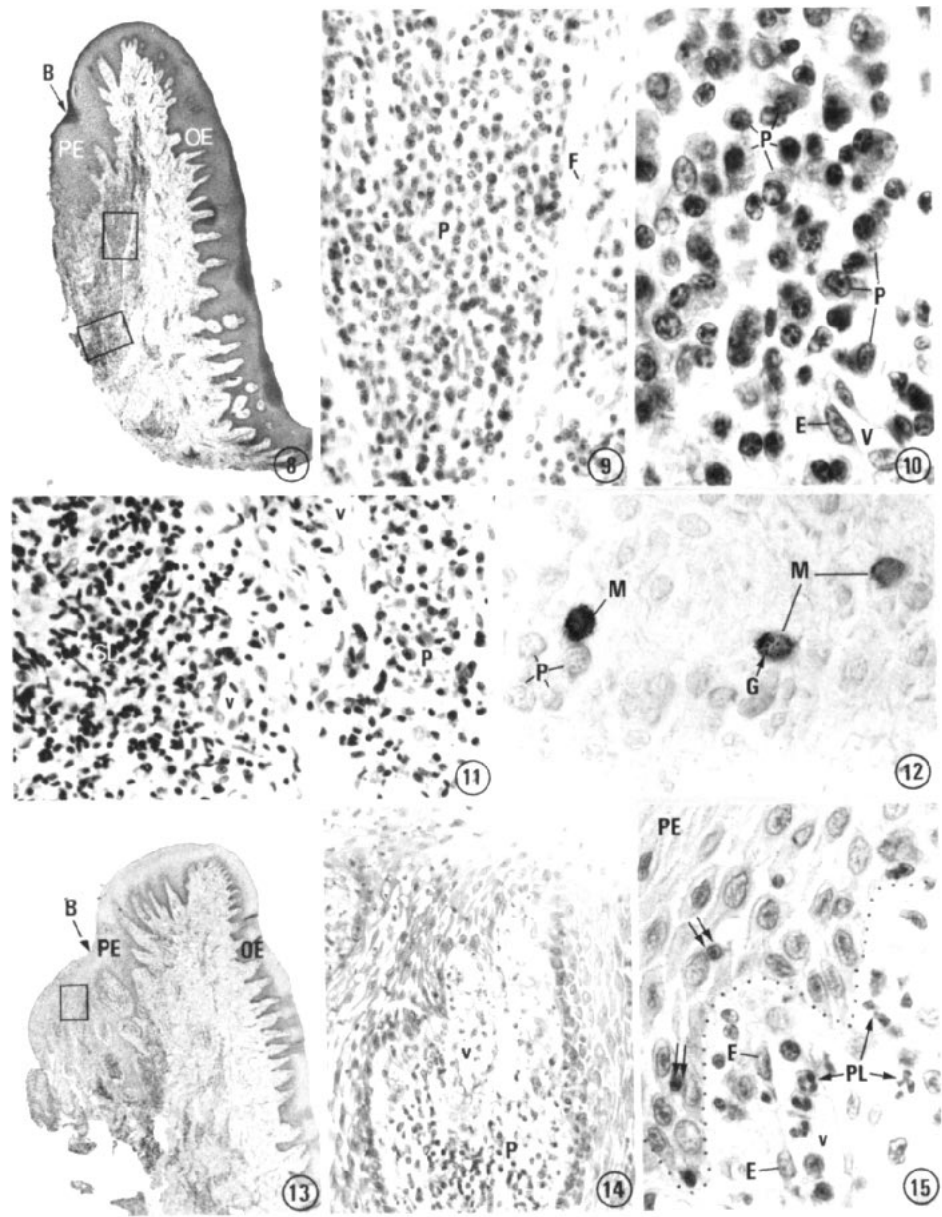
The biopsies obtained at the start of the orthodontic treatment invariably contained a few inflammatory cells, mostly lymphocytes, in the connective tissue along the gingival pocket epithelium (Figs. 1-3). The specimens excised at the later appointments always revealed increased mononuclear cell infiltrates with plasma cells and lymphocytes predominating.

During the first few months mainly subchronic changes were registered with domination of lymphocytes (Fig. 6) and only few plasma cells in central regions (Fig. 7). Such changes persisted throughout the treatment period in some patients with particularly good oral hygiene. In most subjects, how-



Figs. 1-7 Clinically normal buccal marginal gingiva from the first molar region prior to orthodontic therapy. E:endothelial cell, ML:medium large lymphocyte, OE:oral epithelium, PE:pocket epithelium, SL:small lymphocyte, V:vessel lumen. HE stain. Fig. 1. Slight infiltration of inflammatory cells in the connective tissue adjacent to the pocket epithelium and about some vessels. The pocket epithelium has an even boundary toward the connective tissue with but small indications of rete pegs. $\times 40$. Fig. 2. Part of Fig. 1. $\times 400$. Fig. 3. Part of Fig. 2. The majority of the inflammatory cells are small and medium large lymphocytes. $\times 1000$.

Buccal marginal gingiva from first molar region during the first months after placement of orthodontic appliances. B:band impression, F:fibroblast, P:plasma cell, and E, ML, OE, PE, SL and V as above. Fig. 4. A mild inflammatory reaction prevails in the connective tissue of the pocket area. Pronounced epithelial projections of irregular appearance protrude from the pocket epithelium. Note the impression by the orthodontic band. $\times 60$. Fig. 5. Part of Fig. 4. $\times 400$. Fig. 6, part of Fig. 5, area adjacent to pocket epithelium. Small and medium large lymphocytes predominate. Fig. 7, central part of Fig. 5. The dominating cell type is the plasma cell. Double arrow: binucleated variant of plasma cell.



ever, the cellular picture shifted toward chronic inflammation of mild to moderate severity characterized by plasma cell dominated cellular infiltration, hyperplasia and proliferation of the pocket epithelium (Figs. 8-15).

In spite of considerable individual variation in gingival appearance during the experimental period with cellular infiltrations ranging from a sparse distribution in the pocket area (Fig. 4) to dense accumulations covering about half the width of the connective tissue (Fig. 13), some general tendencies were observed. The predominating cell types, plasma and lymphocytes, occupied different positions within the tissues. Plasma cells appeared throughout the connective tissue but invariably dominated in the central regions (Figs. 7, 9-11), while the different lymphocyte variants were more common adjacent to the pocket epithelium than along the middle of the sections (Fig. 11). Particularly in the region about the bottom of the gingival pocket, many small and strongly basophilic lymphocytes could be observed (Fig. 11). Significant numbers of polymorphonuclear

leukocytes were only seen close to and within the pocket epithelium (Figs. 14, 15). Many mast cells were also present (Fig. 12).

After removal of the orthodontic appliances the cellular and vascular alterations subsided within a few months. The gingivae returned gradually toward "normal" conditions, although some acanthosis of the pocket epithelium might remain.

DISCUSSION

The main emphasis of the present study was directed toward the gingivitis associated with orthodontic therapy. The biopsies were collected from the buccal aspects of the first molars which, during treatment, moved little if at all. Therefore, the material was hardly suited for supplementation of earlier studies on gingival reactions to tooth movements like rotation^{19, 20} and retraction.²¹⁻²³

The histologic observations generally confirmed the clinical demonstration of gingivitis.⁶ However, in agreement with earlier findings in orthodontic¹ and nonorthodontic^{7, 9, 24} patients, the de-



Figs. 8-15 Appearance of buccal marginal gingiva from the first molar region during major part of orthodontic therapy. B:band impression, E:endothelial cell, F:fibroblast, G:granule of mast cell, M:mast cell, OE:oral epithelium, P:plasma cell, PE:pocket epithelium, PL:polymorphonuclear leukocyte, SL:small lymphocyte, V:vessel lumen, HE stain (except Fig. 12). Fig. 8. A dense infiltrate of inflammatory cells has accumulated in the connective tissue of the pocket area. The oral area is comparatively free from inflammatory cells. The pocket epithelium in the band impression area is acanthotic. $\times 25$. Figs. 9, 10, central area of Fig. 8. There is an abundance of mature plasma cells. $\times 400$ and $\times 1000$, respectively. Fig. 11, apical area of Fig. 8. Note the topographical distribution difference between lymphocytes and plasma cells. The former predominate subjacent to the pocket epithelium, while plasma cells are most numerous more centrally. $\times 400$. Fig. 12, same region as in Fig. 10 stained for mast cells with the astra blue-NFR technique. Three typical mast cells appear intermingled between the plasma cells. Their large cytoplasmic granules stain darkly in contrast to the plasma cells $\times 1000$. Fig. 13, more pronounced gingivitis during orthodontic therapy than in Fig. 8. Almost the entire pocket area of the connective tissue is occupied by irregular hyperplastic epithelial pegs enclosing dense accumulations of inflammatory cells. In the oral area inflammatory cells are few but there is marked edema. $\times 25$. Fig. 14, part of Fig. 13. Polymorphonuclear leukocytes appear inside a vessel close to the pocket epithelium. Note intercellular edema in basal epithelial layers. In the connective tissue plasma cells predominate. $\times 400$. Fig. 15, part of Fig. 14. Epithelium-connective tissue boundary dotted. Some PMN leukocytes are seen inside the vessel. Others have emigrated into the connective tissue or into the pocket epithelium where they appear intercellularly (double arrows). $\times 1000$.

gree of correlation between the clinical assessment and the histologic observations on individual specimens was moderate. This may be partly explained by the distinct regional topographic limitation of the inflammatory changes.⁷ It should be remembered, however, that not only clinical but also microscopic appraisals imply inherent limitations in assessing the degree of inflammation. The inflammatory reaction is a dynamic process involving a series of ultrastructural changes and chemical events in addition to those seen in fixed and stained histologic specimens.⁸ Therefore, the microscopic appearance need not represent the clinical characteristics of gingivitis adequately. So far, it has not been established which measure gives the best representation of the degree of gingival inflammation. By implication, however, microscopic specimens provide information regarding the type of inflammation that cannot be obtained by clinical inspection.

According to the usual histologic parameters, the sections revealed hyperplastic chronic inflammatory changes of mild to moderate severity. This finding partly corroborates previous observations in short-term experiments by Skillen and Krivanek,¹⁰ Skillen¹¹ and Rateitschak et al.,⁵ but opposes the statement of Spence¹ that inflammatory cells are sparse in the gingiva when clinical gingivitis symptoms occur during treatment. The latter author, however, studied few biopsies. The biopsies in the present study were taken from the first molar area which exhibits higher GI scores than the other teeth.⁶ Huettner¹⁴ similarly noted that hyperplasia and inflammatory reactions were found most often adjacent to molar bands, while anterior bands tended to keep the gingival involvements on a minimum level.

With regard to localization of the inflammatory cell infiltrates within the sections and to distribution of the dif-

ferent cell types within the exudates, the present results confirm previous histologic observations on chronic gingivitis in nontreated individuals.^{7, 24} The findings therefore supplement the clinical experience by Rateitschak et al. that the gingival changes represent a reaction to the bacterial plaque products rather than to the orthodontic forces.

After band removal the gingival tissue gradually returned toward its "normal" histologic appearance within a short time thus corroborating recent clinical findings.^{6, 25} However, because of the manner in which the biopsies were obtained, part of the epithelial lining might remain on the tooth surface. It was not possible with the present technique to assess the degree of apical positioning of the epithelial attachment.

SUMMARY

Forty-eight 2 mm wide gingival biopsies were removed from the buccal aspects of the first molar in sixteen individuals at different intervals during a nineteen month period of orthodontic treatment or during the retention period after removal of the fixed appliances.

The results demonstrated that, although the biopsies taken prior to treatment invariably contained slight numbers of inflammatory cells, the specimens excised at later appointments always revealed increased mononuclear cell infiltrates, hyperplasia and proliferation of the pocket epithelium.

Throughout the period of active treatment most cases presented dense accumulations of chronic inflammatory cells occupying large portions within the pocket area of the connective tissue. The oral aspects of the gingivae were comparatively free from inflammatory cells. The predominating cell types, plasma and lymphocytes, showed different topographical localization patterns. Many mast cells were also pres-

ent, while polymorphonuclear leukocytes were found only within or near the pocket epithelium. After removal of the orthodontic appliances the cellular and vascular changes declined, and the tissue returned gradually toward "normal" conditions.

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