Prioritization of risk factors of gingival hyperplasia during orthodontic treatment: the role of biofilm

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Abstract

Background: The mechanism of gingival growth that may occur during fixed orthodontic treatment is not yet fully understood and the amount of dental plaque is often incriminated. The objective of this study was to evaluate the prevalence of gingival growth during multi-attachment orthodontic treatment and to prioritize its risk factors.

Methods: This comprehensive cross-sectional descriptive study was conducted on 193 orthodontic patients in good general health, treated by a fixed appliance. Periodontal clinical parameters such as plaque index, gingival index, probing pocket depth, periodontal phenotype and gingival enhancement index were recorded. Likewise, the brushing habits and the date of the last scaling were noted. The orthodontic parameters studied were the duration of the treatment, the type of attachment, the alloys used for the arches and the type of ligatures. Descriptive statistics were carried out, then univariate analyses were achieved thanks to cross sectional tables and lastly, a multivariate analysis allowed a hierarchization of the risk factors.

Results: Gingival growth occurred for 49.7% of patients included. The risk factors for this pathology during fixed orthodontic treatment were conventional metal brackets (OR = 3.5), oral ventilation (OR = 3), male gender (OR = 2.2), thick periodontium (OR = 2) and elastomeric ligations (OR = 2). After achievement of the logistic regression, the amount of plaque would not be directly related to the development of this gingival increase.

Conclusions: Among the risk factors that underlie gingival growth during multi-attachment therapy, the amount of plaque is not found. The qualitative assessment of the plaque and its evolution during treatment could clarify the role of the biofilm in the occurrence of gingival overgrowth.

Background

Among the periodontal diseases that occur during fixed orthodontic treatment, we find mainly orthodontic gingivitis or more precisely “gingivitis induced by bacterial biofilms and modified by local risk factors” in the new Chicago classification [1], gingival recessions (or “peri-dental muco-gingival abnormalities”) and gingival growth [2]. This increase results from a localized or diffuse increase of the gingival mucosa, the three parts of which can be reached (marginal gingiva, interdental papilla and attached gingiva). It is most often due to an increase in the extracellular matrix of the mucosal chorion (collagen and fundamental substance with glycosaminoglycans such as hyaluronic acid, heparan sulfate or chondroitin sulfate, elastin, laminin or fibronectin) and more rarely bound to the epithelium.

The exact mechanism of this increase is not yet fully elucidated; it is not necessarily associated with an increase in the number or size of fibroblasts. It is more likely a gingival enlargement or gingival increase “gingival overgrowth or gingival enlargement” than a strictly hypertrophy or gingival hyperplasia. Increased expression of type I collagen mRNA and regulation of growth of keratinocyte growth factor
receptors may play an important role in excessive proliferation of epithelial cells and development of gingival growth [3].

The placement of orthodontic brackets leads to adverse changes in the composition of the bacterial plaque, both quantitatively and qualitatively, increasing both the periodontal risk and the carious risk. Indeed, an increase in *spirochetes, periodontal pathogens such as Prevotella Intermedia, Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis or Fusobacterium Nucleatum* [4], (as well as in *Candida sp.* [5]) is reported, and the presence of orthodontic brackets obviously makes the maintenance of good oral hygiene, particularly in interproximal spaces more difficult. [6]. Finally, orthodontic treatments are often undertaken in adolescents, that means when compliance and adherence to oral hygiene are quite difficult to obtain [7].

The accumulation of supra-gingival plaque then induces inflammatory alterations of the gingival tissues. However, the responses to this aggression both in their clinical form and in their time of appearance greatly vary with the individual. These responses may depend on the quality and / or quantity of the biofilm and the host’s immune response to this aggression [8].

While some studies clearly indicate poor hygiene as responsible for gingival growth [9] [10], others demonstrate that gingival changes during orthodontic treatment are transient and do not imply any permanent alteration of periodontal tissue [11]. These lesions, without real loss of attachment, must not be neglected and require treatment.

To our knowledge, no study has yet hierarchized the risk factors associated with gingival growth during orthodontic treatment. The aim of this study was therefore to evaluate the prevalence of gingival growth during fixed orthodontic treatment and the factors associated with it, with a particular focus on the role of biofilm in its development.

**Methods**

*Study population*

All patients undergoing fixed orthodontic treatment were selected from patients treated in the dentofacial orthopedics department in the University Hospital of Nice.

The study was a comprehensive cross-sectional survey: all patients treated with fixed attachments were eligible. Informed consent explaining the objectives of the study was signed and kept in the service. The included patients had to be in good general health and they should not be subjected to any medical treatment. Pregnant women were excluded. Clinical examinations of all the patients were carried out by the same clinical operator, previously calibrated by the members of the periodontal department.

*Survey*

A questionnaire was completed by the investigator for each patient. It was structured in 3 parts:
- A first paragraph containing general data: age, gender, socioprofessional category, ethnicity, medical status and drug treatments.

- The second paragraph dealt with periodontal health: evaluation of the quality of oral hygiene by Silness and Loë's plaque index (PI) (0: absence of plaque; 1: plaque not visible to the naked eye but detachable with the probe, 2: plaque visible to the naked eye, 3: abundant plaque visible to the naked eye in the sulcus and on the marginal gingiva [12], gingival inflammation by the gingival index (GI) of Loë and Silness (0: absence of inflammation, 1: mild inflammation, 2: moderate inflammation and induced bleeding, 3: severe inflammation, spontaneous bleeding) [13] and gingival phenotype (thin: periodontal probe visible through the marginal gingiva, or thick: probe not visible by transparency) [14], the brushing habits (frequency, hygiene equipment), the date of the last periodontal scaling were also noted. Also, the presence of overgrowth and, if any, the severity and localization were noted: The extent of gingival increment was classified as localized (<4 papillae involved) or generalized (> 4 papillae involved) [15]. Its severity was assessed with the Seymour gingival growth index (0 = no increase, 1 = increase ≤ 2 mm, 2 = increase> 2 mm) measured at the periodontal probe [16].

- The last paragraph concerned orthodontic data: treatment duration, type of brackets, alloys used for orthodontic arches, type of ligatures.

**Statistical Analysis**

The statistical data was collected in a spreadsheet and analyzed using IBM SPSS software version 18.0 (Statistical Package for Social Services, Chicago, IL, USA). Descriptive statistics were performed with flat sorting: frequencies for the qualitative variables, means and standard deviations for the quantitative variables. The effect of different variables on the presence of a gingival increase was studied. Some variables were “binarized” when the numbers were too small. The plaque index and the gingival index were dichotomized in “visible plaque”: yes / no and in “gingival bleeding”: yes / no.

The increase was considered “present” if it concerned at least 4 papillae [15]. It was analyzed thanks to cross-tabulations and Chi-square test for qualitative variables. For quantitative variables the t-test was used. The significance threshold was set at 0.05. Potentially significant variables (p> 0.25) in univariate analyses were then entered into a multivariate logistic regression model and variables that remained significant were ordered to hierarchize risk factors.

**Results**

**RESULTS**

*Description of the sample*
A total of 193 patients were included in the study. They were divided into 68 boys and 125 girls. The Caucasians were the most numerous (more than half) while the Maghreb people accounted for about one third of our sample. Overall, all the patients were in good general health (Tab.1).

**Periodontal parameters**

Considering that at least 4 papillae should be involved, gingival enlargements concerned nearly half of the patients treated with fixed attachments (49.7%) and boys were more affected (60.3%) than girls (44%) \((p = 0.035)\). These gingival complications did not depend on ethnicity, although they tended to be more frequent among the Maghreb people \((p = 0.56)\). No relationship could be found with general health \((p = 0.41)\), whereas impaired ventilation had a significant impact on gum health: more than half of oral ventilators (53.6%) had gingival enlargement while only one-third (35%) of those who normally breathed, through the nose \((p = 0.05)\) were concerned. The gingival phenotype was also found to be a risk factor for gingival growth since it was much more frequent when the periodontium was thick (61%) \((p = 0.043)\).

Univariate analyses showed that the presence of bacterial plaque seems to have played a determining role in the occurrence of gingival hyperplasia since its prevalence increases gradually from 20% in the absence of plaque \((IP = 0)\) to 72% in case of abundant plaque \((IP = 3)\), passing through 46% if the plaque was detectable only after scraping with the probe \((IP = 1)\) and 55% if it was visible to the naked eye \((IP = 2)\) \((p = 0.004)\). These results are different from those found by multivariate analysis which does not reveal the amount of dental plaque as risk factor in enlargement overgrowth.

However, brushing frequency did not appear to be statistically related to gingival enlargement \((p = 0.89)\). The increase in probing depth values corresponded to the measurement in millimeters of gingival hyperplasia at the periodontal probe (Seymour score). Since no loss of attachment has been found, this increase highlights the presence of false pockets characteristic of gingival overgrowth related to orthodontic mechanics.

**Orthodontic parameters**

Gingival overgrowth were more common with metal brackets (53%) than with ceramic brackets (26%) \((p = 0.021)\). The presence of nickel in the arch did not influence their appearance \((p = 0.18)\). On the other hand, elastomeric ligations appear to have clearly favored them (58%) compared to metal ones or self-ligating brackets (38.9%) \((p = 0.007)\) (Tables 2 and 3). Significant variables (sex, kind of ventilation, amount of plaque, gingival phenotype, type of ligations, type of brackets) in univariate analyzes, were therefore...
included in a logistic regression model. Thus, it became possible to hierarchize the risk factors for gingival overgrowth during orthodontic treatment with fixed appliance: conventional metal brackets increased the risk by 3.5; oral ventilation, by 3; being a boy multiplied the risk by 2.2; the thick periodontium was twice as concerned as the thin periodontium and the elastomeric ligatures also increased the risk by a factor of about 2. On the other hand, the amount of plaque that appeared very significant in univariate analyses became not significant in the multivariate one, since its 95% confidence interval included the value 1 (Table 3).

**Discussion**

In our study, considering that at least 4 papillae should be involved, according to the definition of “localized” form as described by Sibaud et al., about half of the patients exhibited gingival overgrowth. Our study allows to hierarchize the risk factors for this side effect of fixed orthodontic treatment. The male gender, oral ventilation, the nature of the materials constituting orthodontic appliances appeared as risk factors. On the other hand, plaque, in its quantitative aspect (Plaque Index), does not appear directly related to the development of gingival growth.

Orthodontists tend to view the teenage period as very supportive of orthodontic treatment since usually all or most of the permanent teeth have erupted, while craniofacial growth can still be stimulated. This allows the teeth to be displaced and malocclusions corrected while maintaining favorable facial growth [17]. Thus, the majority of orthodontic treatments are undertaken during this period. However, in spite of the oral hygiene instructions systematically given at the beginning of treatment, young patients often have difficulties in maintaining a correct level of oral hygiene, especially during adolescence, where compliance is difficult to obtain [18] and hormonal changes may potentiate gingival inflammation [19]. However, in our study, while we would have expected to find more gingival overgrowth in girls for whom the hormonal impregnation is higher, boys were twice as often affected (p = 0.035). Androgenic factors may therefore be found histologically. Inevitably, placement of a fixed orthodontic appliance creates plaque retention areas that make cleaning difficult [20]. However, the constant presence of bacterial plaque is inevitably accompanied by numerous undesirable effects such as gingivitis, gingival overgrowth, demineralization of enamel (leading to precarious leucomas and even to caries) and, possibly in extreme cases, attachment loss [21] [22].

The effects of oral ventilation on gingival health, known for a long time [23] were confirmed in our study. In the same way, the periodontal environment is a crucial element to consider before starting orthodontic treatment. If orthodontists are very much used to being very cautious in case of proven periodontal disease or reduced periodontium after healing of a past pathology, the gingival phenotype must also be taken into consideration. The importance of the amount of keratinized tissue to maintain periodontal health has long been debated. Some have shown that the presence of keratinized tissue was not essential for periodontal health in the absence of plaque [24], or that the periodontitis could remain healthy even in the case of low height (at least 2mm) and attached gingiva thickness combined with control of plaque control [25]. However, these reduced narrow and thin gingival conditions represent well
and truly a risk factor for the development of gingival recessions, especially if they are associated with a short vestibule, trauma or poor hygiene.

Recently, studies with a long-term clinical follow-up (between 18 and 35 years) have shown that the transformation into a thick gingival phenotype by an epithelio-conjunctive graft favors the health of periodontal tissues [26]. A thick periodontium, in response to bacterial aggression, will tend to thicken and form periodontal pockets. Thus, in our study, hyperplasia was much more common in the case of thick periodontium (61%) than in the case of thin periodontium (44.8%) (p = 0.043). The presence of bacterial plaque also seemed to have played a determining role in the occurrence of gingival overgrowth since its prevalence increased gradually following a real gradient (p = 0.004). However, the frequency of brushing did not appear to be statistically related to gingival enlargement (p = 0.89). Surprisingly, once again, after completion of the logistic regression, the role of the dental plaque quantity, as apprehended by the index of Silence and Löe, seems to fade in favor of the other risk factors. The explanation could be in the qualitative and non-quantitative evolution of the dental plaque during fixed orthodontic treatment.

Concerning orthodontic parameters: gingival overgrowth was more frequent with metal brackets (53%) than with the ceramic ones (26%) (p = 0.021). The presence of nickel in the arches did not influence their appearance (p = 0.18). On the other hand, elastomeric ligatures appear to have clearly favored them (58%) compared with metal ligatures or self-ligating brackets (38.9%) (p = 0.007) (Tables 2 and 3).

**Conclusions**

Risk factors for gingival overgrowth during fixed orthodontic therapy are conventional metal brackets (OR = 3.5), oral ventilation (OR = 3), male gender (OR = 2.2), a thick periodontium (OR = 2) and elastomeric ligatures (OR = 2). After completion of the logistic regression, the amount of plaque would not be directly related to the development of this gingival increase. Studies on the qualitative evolution of plaque during fixed orthodontic treatment are needed to clarify the role of biofilm in the occurrence of these overgrowth.

**Abbreviations**

- **GI**: gingival index
- **OR**: Odds Ratio
- **PI**: plaque index
- **PPS**: pocket probing depth
Declarations

Ethics approval and consent to participate

The research commission of the UFR of odontology of Nice University validated the study and the Delegation for Clinical Research and Innovation of University Hospital of Nice agreed to carry out this study.

Consent for publication

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

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Authors’ contribution

SVB contributed to the writing of the manuscript

LB contributed to the writing of the manuscript.

AG has collected clinical data on patients.

LL did the statistical analysis, the interpretation of the results.

All authors read, corrected and approved the final manuscript.

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