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ORIGINAL ARTICLE

Tendency For Gingival Hypertrophy in Patients with Fixed Orthodontic Appliances - Clinical Data

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ABSTRACT

Fixed orthodontic appliances passively affect the health of periodontal tissues by preventing access to good oral hygiene, resulting in accumulation of bacterial plaque. This study has the purpose of finding data about the clinical evaluation of gingival hypertrophy, caused in patients treated with fixed orthodontic appliances in the oral cavity. At 34 patients with fixed orthodontic appliances, clinical data about vertical growth index and horizontal growth index of papillary gingiva, in Ramfjord teeth, were recorded. Data about the index of gingival hemorrhage were also recorded. Statistical analysis of the data was performed using the McNemar test to compare the frequency of correct responses, compared to the frequency of incorrect responses against specific items included in the questionnaire prepared for use in this study. Fisher's exact test was used to make the comparison in a 2x2 contingency table. Vertical index of hypertrophy (IV) in tooth 11 is more reduced than in tooth 31. Horizontal index of hypertrophy (HI) is in the same values in both teeth. PBI-index has higher values in tooth 31. For teeth 14 and 34, IV-index is higher in tooth 14, and IH-index for the same PBI index. For teeth 26-46: IV-index and IH-index are higher in 26 than in 46 with the same difference range of 0.4. The PBI is higher at 46 than at tooth 26 with a value difference of 0.3. According to age groups IV, the highest values of I are in the post-adolescent age of 17-21 years, while IH is in the adolescent age of 12-16 years. The highest IH-index is in adolescence and the most reduced in adulthood. PBI regardless of gender has the same values, where in men it reaches the highest values in adulthood, while in women it reaches the highest value in adolescence. The mandibular incisor is more prone to coronal coverage from orthodontic appliance-induced gingival hypertrophy than the maxillary incisor. Gingival hypetrophy caused by the insufficient plaque removal at orthodontic appliance in 14 has a more obvious cubic shape than in 34.

Keywords: Fixed orthodontic appliances, PBI-index, IV-index, IH-index, Gingival hypertrophy

1 INTRODUCTION AND AIM

Gingival hypertrophy is a widely accepted terminology to describe the increase in size of the gingiva. It is a multifactorial condition that develops in response to various stimuli and interactions between the host and the external environment. Based on its extent and expressed degree, gingival hypertrophy can lead to functional disorders, such as speech changes, chewing difficulties, and aesthetic and psychological problems[1-3].

Gingival hypertrophy influences the quality of life related to oral health in patients followed by fixed orthodontic appliances[4, 5]. Its correct management will depend on establishing an accurate diagnosis. According to etiopathogenesis, hypertrophy can be:

1. Inflammatory

2. Influenced by medications,

3. Associated with a systemic condition or disease

4. Neoplastic or false enlargements.

According to the location, hypertrophy can be marginal, papillary or diffuse. Based on the distribution it can be localized or generalized. Localized hypertrophy can be further divided into three subtypes: isolated, discrete, or regional. Isolated hypertrophy is limited to the gingiva adjacent to one or two teeth (eg, gingival/periodontal abscess). Whereas discrete lesions are isolated pedunculated, tumor-like enlargements (eg, fibroma/pyogenic granuloma). Regional extensions refer to the involvement of the gingiva of three or more teeth in one or more areas of the mouth. Generalized enlargement refers to the involvement of the gingiva adjacent to almost all the teeth present[5-8].

In this case, gingival hypertrophy is the result of local irritants associated with the gingiva. Among the most important irritants we mention: microbial deposits (bacterial plaques and calculus), fractured teeth, hanging restorations, ill-adapted prostheses, orthodontic brackets, etc.[8].

Fixed orthodontic appliances passively affect the health of periodontal tissues by preventing access to good oral hygiene and thus resulting in the accumulation of bacterial plaque. The most common periodontal tissue changes detected during fixed orthodontic therapy are gingivitis, gingival recession, and gingival enlargement[9]. During fixed orthodontic therapy, adolescents tend to have more chances of gingivitis and gingival hypertrophy than adults[10]. The exact mechanism of the development of gingival hypertrophy is still not completely clear, but it is thought to involve increased production of amorphous ground substance with a high level of glycosaminoglycans by fibroblasts. Increased expression of collagen type I mRNA and upregulation of keratinocyte growth factor receptor may play an important role in the excessive proliferation of epithelial cells and the development of hypertrophy[11]. This situation may lead to more inflammation and further accumulation of bacterial plaque entering a vicious circle. Thus, there is a transformation of the gingival sulcus into a periodontal pocket creating an area where plaque removal becomes impossible[6, 8, 12].

At first, this clinical manifestation appears as a slight swelling of the papilla or marginal gingiva, which can then increase in size and spread in a generalized manner. Clinically it can appear light blue or bright red, soft and with a shiny surface which can bleed easily. Sometimes, chronic inflammatory hypertrophies may appear firm, resilient, pink, and fibrotic, indicating the presence of abundant fibroblasts and collagen fibers[11-13]. Not good oral hygiene and small doses of nickel released at the level of the epithelium from the corrosion of orthodontic appliances, can be causes of gingival hypertrophy in orthodontic patients.

Fixed orthodontic appliances usually include brackets, bands and arches made of steel, nickel-titanium or nickel-cobalt alloys which can leach metal ions. The study conducted by Faccioni F *et al*. (2003) examined the biocompatibility of fixed orthodontic appliances by evaluating the presence of metal ions in oral mucosal cells, their cytotoxicity and their potential genotoxic effects. The results showed that nickel and cobalt concentrations were 3.4 and 2.8 times higher in patients than in the control group, respectively, and that nickel and cobalt released from fixed orthodontic appliances could induce DNA damage in oral mucosal cells[9-11]. A study was conducted to determine the prevalence of nickel allergy in a group of orthodontic patients and to compare the periodontal status between them and patients not allergic to nickel. The results of this study indicated a progressive effect of nickel on the occurrence of clinical periodontal abnormalities such as bleeding, hyperplasia and color changes throughout fixed orthodontic therapy in patients allergic to nickel [12-14].

Gursoy UK *et al*., undertook to evaluate the role of nickel accumulation and cell proliferation in the occurrence of gingival hyperplasia in orthodontic patients. Healthy and hyperplastic gingiva samples were taken from 10 orthodontic patients. Histological analyzes showed an increase in epithelial thickness and also a significant increase in epithelial cell proliferation at low-dose nickel concentrations, and with a toxic response to a higher dose. The results of the study affirm that the effect of a continuous release of low-dose nickel on the epithelium is the initiating factor of the overgrowth of gingiva caused by orthodontic treatment[15-18].

This study aims to find data about the clinical evaluation of gingival hypertrophy, caused in patients treated with fixed orthodontic appliances in the oral cavity, to analyze the ethological factors, differences in terms of localization, age, duration of ortho therapy with fixed appliances.

2 METHODS

The study is based on the collection of data on patients with fixed orthodontic appliances placed in the oral cavity. The study was not designed with a control group as it aims to evaluate gingival hypertrophy in patients with fixed orthodontic appliances, only to evaluate and not to compare these data. There is no dental intervention in these patients to see the changes that the dental intervention brings, but on the other hand, the reasons for the occurrence of gingival hypertrophy may not be related only to the orthodontic appliance, as explained in the introductory part of the article. On the other hand, an attempt has been made to exclude patients based on the exclusion criteria of this study in order not to include patients suffering from systemic pathologies that cause gingival hypertrophy regardless of whether or not the orthodontic appliance is in the oral cavity. About 34 patients were included in this study, whose demographic data and data on the duration of orthodontic treatment or more precisely on the duration of placement of the fixed orthodontic appliance in the oral cavity were recorded. The patients were selected ad-hoc in a specialized dental clinic, where they were presented for the next treatment in the orthodontic appliance treatment protocol. Consent was requested from all of them for inclusion in the study before the collection of the necessary data for further analysis in this study. The teeth in the patients included in the study were numbered according to the FDI World Dental Federation notation system (ISO 3950). The recorded data were the index of vertical growth and horizontal growth of the gingival papilla in Ramfjord teeth in the papillary gingiva. The data was recorded by the same dentist after his full consultation in the literature on the methodology of evaluating the gingival hypertrophy indices and the way of recording it in the relevant excel tables designed for this study. In the same patients, after evaluating the indices of gingival hypertrophy, the index of gingival hemorrhage was also recorded. This article was carried out in full compliance with the national rules of ethics, respecting the regulations of the Council of Ethics of the respective Institutions of the authors.

Consent was requested from all of them for inclusion in the study before the collection of the necessary data for further analysis in this study. The consent requested from the patients included in the study was obtained verbally, since in this study there is only a recording of real data in the oral cavity of the patients evaluated by means of selected periodontal indices. It is emphasized that there is no intervention, even mini-invasive, in the patients, since the purpose of this study was only the collection of data, something for which the patients were well-informed. To maintain the anonymity of the patient, each patient was initially registered by staff not involved in the index assessment, but who only recorded the patient's initials by corresponding a number, to be the number that would later represent the patient in the later stages of the patient.

This study was approved by the Institutional Ethics Committee of Albanian University (02.06.2019), Tirana, Albania, according to national regulations (according to the rules of the institution also)(no.320/2).

Continuous data were presented in mean and standard deviation, while discrete data were presented in absolute value and percentage. Different types of graphs and tables (simple and composite) were used to present the data. Statistical analysis of the data was performed using the McNemar test to compare the frequency of correct responses, compared to the frequency of incorrect responses against specific items included in the questionnaire prepared for use in this study. Fisher's exact test was used to make the comparison in a 2x2 contingency table. P values less than 0.05 were considered statistically significant. Statistical analysis was performed mainly using MS Excel.

Patients excluded from registration and further data processing are those who take medications that cause gingival hypertrophy and those who are allergic to metals or dental materials, regardless of whether they have fixed orthodontic appliances in the oral cavity.

3 RESULTS

Based on the data collected from clinical examinations of patients with orthodontic appliances, who agreed to be part of the study, they were processed and presented according to the tables below.

Table. 1 shows the average values of the vertical and hozitonal index and the bacterial plaque index, respectively, for teeth 11 and 31, with the aim of comparing these values.

Fig. 1 shows the data of Table. 1.

Table. 2 shows the data on the average values of teeth 14 and 34 respectively.

Fig. 2 shows the data of Table. 2.

Table. 3 shows the average values of indexes for teeth 26 and 46.

Fig. 3 shows the data of Table. 3.

Table. 4 shows data on the average values of the bacterial plaque based on the age groups of the patients included in the study.

Fig. 4 shows presentation of the average values of the vertical and horizontal index of gingival hypertrophy and the bacterial plaque index according to the age groups defined in the study.

Table. 5 shows the IV, IH and PBI indices divided by age groups 12-18 years and 19-31 years, but also divided by gender. This table makes the possible differentiation of gingival hypertrophies caused by sex hormones and their fluctuations according to the age of adolescence or according to gender.

Table. 6 shows the data on the average values of the indices divided by gender and age groups of the patients included in the study.

Fig. 5 shows the data of Table. 6.

Table 1: Average values of horizontal, vertical and bacterial plaque indices for teeth 31 and 11, respectively

11-31 Years of treatment	Tooth	1-2 years	3-4 years	5-6 years	Average
Average values					
IV	11	1.2	1.4	1	1.2
	31	1.4	2	1.6	1.6
IH	11	0.6	1.7	1.6	1.3
	31	1	1.5	1.6	1.3
PBI	11	1.1	1.1	1	1.06
	31	2.2	1.4	1.6	1.7

Table 2: Average values of horizontal, vertical and bacterial plaque indices for teeth 14 and 34, respectively

14-34 Years of treatment	Tooth	1-2 years	3-4 years	5-6 years	Average
Average values					
IV	14	2	2	2	2
	34	1.3	1.6	1	1.3
IH	14	1.3	2.3	1.6	1.7
	34	1	0.6	0.6	1
PBI	14	1.5	1.6	1	1.4
	34	1.8	1.7	1.3	1.6

Table 3: Average values of horizontal, vertical and bacterial plaque indices for teeth 26 and 46, respectively

26-46 Years of treatment	Tooth	1-2 years	3-4 years	5-6 years	Average
Average values					
IV	26	1.4	1.6	1.6	1.5
	46	1.25	1.2	0.7	1.1
IH	26	1.6	2.2	2	1.9
	46	1	1.5	1.6	1.4
PBI	26	1.4	1.6	0.7	1.2
	46	1.5	1.8	1.3	1.5

Table 4: Data on the average values of the horizontal index, vertical index and bacterial plaque index based on age groups

Age group Average values	12-16 years	17-21 years	22-26 years	27-31 years
IV	1.5	1.7	1.4	2
IH	1.7	1.6	1.4	2.2
PBI	1.3	1.8	2	1.8

Table 5: Values of IV, IH and PBI indices according to the age groups 12-18 years and 19-31 years and according to the gender of the patient

Gender		Female		Male	
Age groups		12-16 years	17-21 years	22-26 years	27-31 years
Index	Index value	No. Pat. - %	No. Pat. - %	No. Pat. - %	No. Pat. - %
IV	0		2– 7%		
	1	1 – 3%	1 – 3%	6 – 20%	2– 7%
	2	4 – 13%	9 – 30%	2– 7%	
	3	1 – 3%	2– 7%		
IH	0	1 – 3%	2– 7%		
	1	1 – 3%	2– 7%	3 – 10%	2– 7%
	2	3 – 10%	2– 7%	3 – 10%	
	3	1 – 3%	8	2– 7%	
	4		1 – 3%		
PBI	0	2– 7%	1 – 3%	3 – 10%	
	1	1 – 3%	4 – 13%	4 – 13%	1 – 3%
	2	2– 7%	6	1 – 3%	1 – 3%
	3		3 – 10%		
	4	1 – 3%			
Total		6 – 20%	14- 47%	8-27%	2– 7%

Table 6: Data on the average values of the horizontal index, vertical index and bacterial plaque index based on age groups and by gender

Average values	Age	Female	Male	Average
IV	12-18 years	**2**	**1.3**	**1.7**
	19-31 years	1.8	1	1.4
IH	12-18 years	1.7	1.9	1.8
	19-31 years	1.7	1	1.4
PBI	12-18 years	1.5	1.8	1.7
	19-31 years	1.8	1.5	1.7

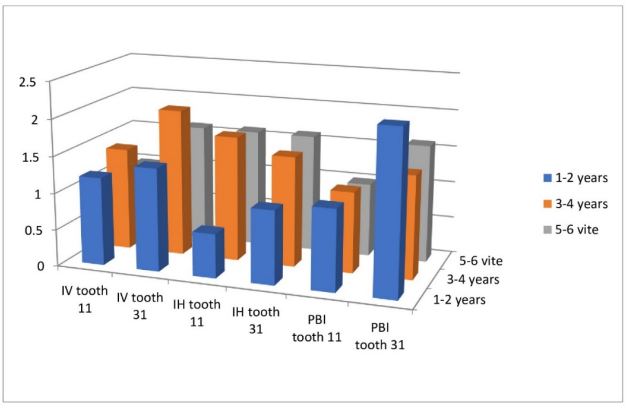

Fig. 1: Average values of IV, IH and PBI for teeth 31 and 11, classified according to years of appliance placement

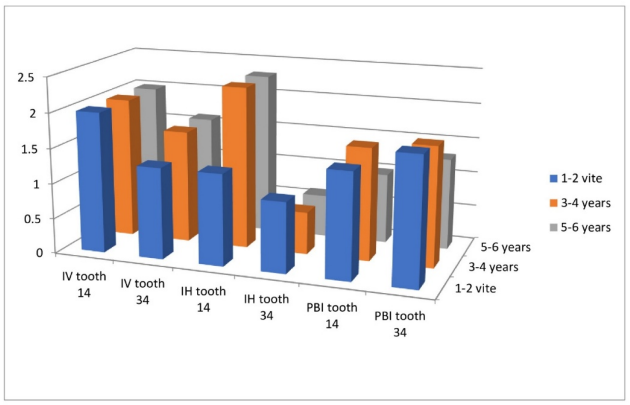

Fig. 2: Average values of IV, IH and PBI for teeth 14 and 34, classified according to years of appliance placement

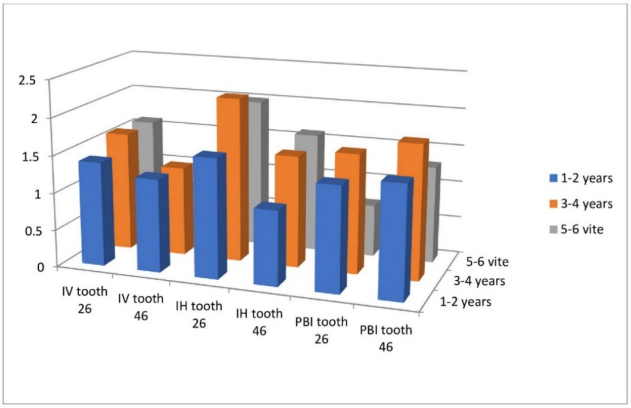

Fig. 3: Average values of IV, IH and PBI for teeth 31 and 11, classified according to years of appliance placement

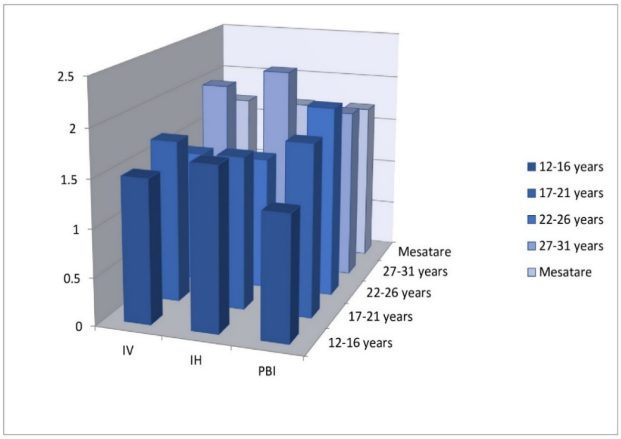

Fig. 4: Presentation of the average values of the vertical and horizontal index of gingival hypertrophy and the bacterial plaque index according to the age groups defined in the study

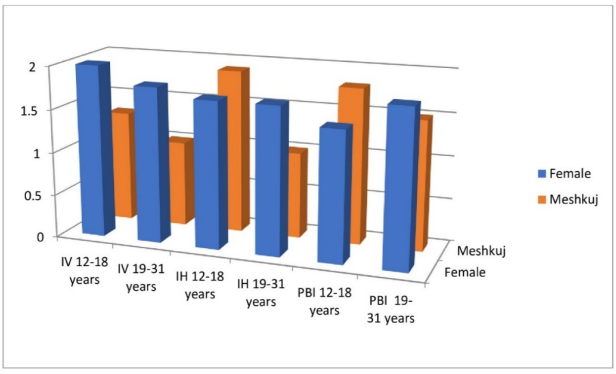

Fig. 5: This chart shows the average values of the IV, IH and PBI indices classified according to the patient's age and gender

Many authors emphasize the importance of maintaining the best oral hygiene, especially in patients with fixed orthodontic appliances, in order to avoid the occurrence of gingival hypertrophy. Thus, during a study conducted by Eid HA *et al*. (2014) found that patients who performed oral hygiene steps more than three times a day did not show gingival hypertrophy. On the other hand, patients who brushed their teeth and used dental floss only once a day had the highest percentage of gingival hypertrophy (Grade 2)[10]. Another study also mentions that gender, age, oral hygiene and duration of orthodontic treatment are among the most important risk factors for gingival hypertrophy[12]. In accordance with the research of the above authors, another research was conducted to compare the efficacy of chlorhexidine, Persica mouthwash and electric brush in improving gingival hypertrophy in patients with fixed orthodontic appliances. The results show that the efficacy of Persic was similar to that of chlorhexidine in improving gingival condition. Both manual brushing, electric brushing, and manual brushing combined with Persica mouthwash or chlorhexidine failed to reduce gingival hypertrophy to clinically satisfactory levels[13]. Various attempts have been made to discover a paste formula. or various gargles which have a positive effect on the elimination of bacterial plaque. But based on a 2018 research, it was concluded that the clinical and microbiological effects of using centylpyridinium chloride toothpaste and mouthwash in orthodontic patients are limited in terms of their impact on reducing bacterial plaque accumulation and gingival inflammation[14]. The use of a 40% chlorhexidine varnish in patients with fixed orthodontic appliances was shown to decrease gingival hypertrophy. And although it is a very promising result, further studies are needed to determine the frequency and time sufficient for its application[15]. Another very important factor is the level of oral hygiene in patients who undergo organ transplants, and respectively that of the liver, where it was seen that 41% of patients who were followed with ciclosporin after the transplant showed gingival hypertrophy. It was seen that the condition of oral health in patients was not good and that there is a need for implementation of oral health programs before and after surgery for these patients[16].

In a study conducted to evaluate the influence of the duration of therapy on the degree of gingival hypertrophy and on some features of the abscess, it was found that hypertrophy was greater in patients presenting the highest Plaque Index and who were followed by appliances fixed orthodontics for more than 12 months compared to patients who had less than 6 months or 6 to 12 months of follow-up with this treatment. It was also seen that the increase in salivary fluid and pH values had a relationship with the increase in the Plaque Index, with the increase in the Gingival Index, and the Gingival Hypertrophy Index in patients with a longer duration of therapy.[9] Boke, Fatma *et al*. (2012) conducted a retrospective study in patients of the Department of Orthodontics, Faculty of Dentistry, University of Gaz, during the period 2006-2012[17-20]. It turned out that in patients treated with fixed orthodontic appliances, bacterial plaque, inflammation and gingival recession showed a significant increase after treatment. No statistically significant difference was found in patients treated with functional appliances before and after treatment[17].

During their study, the authors saw that the more intensive use of a soft brush, dental floss, interdental brushes, and gargles could bring a decrease in the values of this index[20]. On the other hand, a study conducted by Mulla *et al.* (2020) to evaluate periodontal parameters between patients with transparent masks and those with three different types of traditional brackets (metallic, self-ligating and ceramic) concluded that the Hemorrhage Index, as well as other periodontal indices, show higher values lower in patients followed with transparent masks compared to the traditional method[21]. At the beginning of the research conducted by Hadzic *et al*., (2022), before the placement of the fixed orthodontic appliance, 23.7% of the respondents had gingival hyperplasia, while after the end of a two-year therapy, this percentage had increased to 73.7 %. The authors stated that the results were expected to some extent, because poor oral hygiene was indicated as the main cause of gingival hyperplasia, while the Plaque Index value also increased[19, 22].

In a study conducted to examine the prevalence of periodontal disease in primary teeth in children with cerebral palsy, the Plaque Index, Calculus Index, Gingival Index, Simplified Oral Hygiene Index, and Gingival Hyperplasia index were measured. At the end of the study, it was found that children with cerebral palsy show higher values of these indices in the primary dentition than the control group. On the other hand, there is a difference in these values for children who have the care of their parents for the maintenance of oral hygiene[23].

Fixed orthodontic appliances lead to increased expression of IL-1β and IL-8. In the study by Giannopoulou C *et al*., increased levels of IL-1β and IL-8 were also associated with high values of hypertrophy and probing bleeding index. This may reflect biological activity in the periodontium during orthodontic tooth movement[24]. Parameters such as periodontal pocket depth, gingival index, plaque index and IL-1β levels were higher in cases of bands placed on premolars compared to teeth with brackets. On the other hand, these parameters showed a significant decrease when chlorhexidine varnish was applied [8, 25-30].

According to age, the division of ad-hoc patients is for the female gender 12-21 years old against the age 22-31 years in the ratio 1.5:1, while for the male gender in the ratio 3:1. Only according to gender, the female: male ratio is 2:1, where the minimum age is 12 years, the maximum age is 30 years for the female gender

(average age 21 years). For the male gender, the minimum age is 13 years and the maximum age is 31 years (average age 18 years). According to the years of placement of the orthodontic appliance, patients are classified; 1-2 years in 29%, 3-4 years in 59% and 5-6 years in 12%. IV in tooth 11 is more reduced than in tooth 31. IH is in the same values in both teeth. PBI has higher values in tooth 31.

For teeth 14 and 34, it can be said that IV is higher in tooth 14, as well as IH for the same PBI index. For teeth 26-46 it can be said that IV and IH are higher in 26 than in 46 with the same difference range of 0.4. The PBI is higher at 46 than at tooth 26 with a value difference of 0.3. According to age groups IV, the highest values of I are in the post-adolescent age of 17-21 years, while IH is in the adolescent age of 12-16 years. PBI has high values in 27-31 years old adults. Bad oral hygiene and small doses of nickel released at the level of the epithelium from the corrosion of orthodontic appliances can be causes of gingival hypertrophy in orthodontic patients.

Fixed orthodontic appliances usually include brackets, bands and arches made of steel, nickel-titanium or nickel-cobalt alloys which can leach metal ions. The study conducted by Faccioni F *et al*. (2003) examined the biocompatibility of fixed orthodontic appliances by evaluating the presence of metal ions in oral mucosal cells, their cytotoxicity and their potential genotoxic effects. The results showed that nickel and cobalt concentrations were 3.4 and 2.8 times higher in patients than in the control group, respectively, and that nickel and cobalt released from fixed orthodontic appliances could induce DNA damage in oral mucosal cells[25]. A study was conducted to determine the prevalence of nickel allergy in a group of orthodontic patients and to compare the periodontal status between them and patients not allergic to nickel. The results of this study indicated a progressive effect of nickel on the occurrence of clinical periodontal abnormalities such as bleeding, hyperplasia and color changes throughout fixed orthodontic therapy in patients allergic to nickel[26]. Gursoy UK *et al*., undertook to evaluate the role of nickel accumulation and cell proliferation in the occurrence of gingival hyperplasia in orthodontic patients. Healthy and hyperplastic gingiva samples were taken from 10 orthodontic patients. Histological analyzes showed an increase in epithelial thickness and also a significant increase in epithelial cell proliferation at low-dose nickel concentrations, and with a toxic response to a higher dose. The results of the study affirm that the effect of a continuous release of low-dose nickel on the epithelium is the initiating factor of the overgrowth of gingiva caused by orthodontic treatment[27].

4 CONCLUSIONS

According to gender, women have higher IV regardless of age, where these values peak in adolescence. The highest IH in men is in adolescence and the lowest in adulthood. PBI regardless of gender has the same values, where in men it reaches the highest values in adulthood, while in women it reaches the highest value in adolescence. Despite the same values of the amount of bacterial plaque, the mandibular incisor is more prone to coronal coverage from gingival hypertrophy caused by the insufficient plaque removal at orthodontic appliance than the maxillary incisor. The mechanical removal of bacterial plaque against the habits or method of brushing teeth in premolars is the same regardless of whether it is maxillary or mandibular. Gingival hypertrophy caused by the insufficient plaque removal at orthodontic appliance in 14 has a more obvious cubic shape than in 34. For gingival hypertrophy caused by the insufficient plaque removal at orthodontic appliance, tooth 26 is more prone than tooth 46, despite the fact that bacterial plaque persists more on tooth 46.

List of abbreviations

IV – vertical Index

IH – Horisontal Index

PBI – Index of Bacterial pllaque

5 DECLARATIONS

Ethical Approval: As the authors of the article, we state that there is no violation of the code of ethics during the realization of this article. Consent in the participation of patients in the study was performed with the signature of the patients themselves, procedures based on national protocols. This study was approved by the Institutional Ethics Committee of Albanian University (02.06.2019), Tirana, Albania, according to national regulations (according to the rules of the institution also)(no.320/2).

Availability of data and materials: The datasets analyzed during the current study are available from the corresponding author.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: IR and RK collected the scientific data and wrote the manuscript. SH revised and edited the manuscript. Literature research was conducted by SH. IR and VO collected the scientific data. All authors read and approved the final manuscript.

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