EVALUATION OF MICROVASCULATURE TISSUES VIABILITY AFTER THE IMPOSITION OF REMOVABLE ORTHODONTIC APPLIANCES IN CHILDREN AND ADOLESCENTS

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TOPICALITY

One of the important problems in modern pediatric dentistry is the study of adaptive reactions of children and adolescents dentition when using removable orthodontic appliances [12].

Oral tissues adaptive capacity can be described by the following parameters: value of the capillary blood flow at the level of attached gingiva, secretion rate, and chemical composition and properties of saliva, which change dynamically in the course of orthodontic treatment [2,3]. The scores of the indicators mentioned depend on the initial state of prosthetic bed tissues, qualities of construction materials used for the manufacture of orthodontic appliances, microbial species composition, as well as the severity of microbial colonization and antigen stimulation [4,6].

It is a proven fact that with all the modern construction materials, production technologies, and improved orthodontic appliances available the appropriate assessment of dentition adaptive reactions is possible only on condition that up-to-date biochemical, immunological and functional analyses are used [7,10]. For instance, the research data available suggest that the restorative materials used to manufacture orthodontic equipment do not have an impact just on the quantity of the oral liquid (the amount and rate of secretion), yet on its quality as well (pH, the buffer systems ratio, the content of the macro- and microelements, and the indicators of biochemical & immunological activity) [5].

Currently a considerable interest is focused on the functional studies, allowing getting quantative data concerning linear and volumetric parameters of the microvasculature structure, and the intensity of hemodynamics in prosthetic bed tissues while using removable orthodontic appliances [1,8]. The research data were published on the gingival tissues microhemodynamics after application of removable orthodontic appliances in adult patients [9,13].

However, studies of microcirculatory perfusion parameters that allow assessing the recovery period of capillary blood flow in the gingival tissues beneath the orthodontic appliances' base materials in the pediatric population, are few and systematized. Virtually no comparative data are available on the adaptation time for orthodontic appliances made of different types of base materials in children and adolescents.

The integrated assessment of gingival tissues microhemodynamics with laser Doppler flowmetry (LDF) will help to analyze tissue microvasculature viability after application of orthodontic appliances and provide significant data for pediatric dentistry [11,15].

Individualized and evidence-based selection of the plastic base for orthodontic appliances will contribute to the accelerated adaptation as well as optimized vascularization in prosthetic bed tissues providing long-term efficacy of therapeutic measures.

THE AIM

To improve efficiency of orthodontic treatment when using removable orthodontic appliances in children and adolescents on the basis of integrated assessment of gingival tissues microhemodynamics with laser Doppler flowmetry.

MATERIALS AND METHODS OF RESEARCHING

Three types of base materials used for the manufacture of orthodontic appliances (according to the current international classification ISO 1567:1999 (Dentistry – Materials for denture)), were under consideration [14]. As for the type 1, fast cold-cured plastic based on polymethylmethacrylate (PMMA) Vertex self curing (Vertex, Holland), was studied, which is a copolymer based on acrylic resins. The powder was a fine suspension of PMMA containing initiator – benzoyl peroxide, and activator – disulfanil; the liquid was a methyl ester of methacrylic acid containing activator – dimetilparatoluidin. Orthodontic appliances were produced by method of gypsum based hydropolimerization in Ivomat IP3 (Ivoclar–Vivadent). As to the second type, hot polymerization plastic based on PMMA ProBase Hot (Ivoclar-Vivadent, Liechtenstein) was studied, which belongs to the group of graft copolymers based on acrylic resins. The powder was a fine suspension graft copolymer of methyl methacrylate acid; the liquid was a methyl ester of methacrylic acid, containing diphenylolpropane dimethacrylic ester as a cross-linking agent. Orthodontic appliances were produced by method of compression molding in water polymerizer Acrydig 4 (F. Manfred). As for the third type, the base material Triad Denture Base (Dentsply, USA) was studied, which is a cross-linked acrylic resin structured as interpenetrating polymer network not containing PMMA. Orthodontic appliances were made using the technology of gypsum based light cure in Triad 2000 VLC Unit (Dentsply). All the materials were polymerized in accordance with the cycle parameters specified by the manufacturer. After removal of the plaster, each orthodontic device was machined and polished at first with a muslin polishing wheel using pumice and water, and then with polishing paste to the glossy shine. All constructions were placed in distilled water for 50 hours at 37° C.

The study of gingival tissues microhemodynamics was held in 60 children and adolescents with satisfactory and good indices of oral hygiene. Patients were divided into the control group and two dispensary supervision groups. The control group consisted of 20 patients with orthognatic bite without defects of dentition, who were under routine supervision. The first group included 20 patients with malocclusion without defects of dentition, who were provided with 26 orthodontic appliances (8 units made of base plastic of the first type, 9 units made of base plastic of the second type, and 9 units made of the type 3 materials). The second group consisted of 20 patients with malocclusion and dentition defects due to the premature loss of teeth, who were provided with 29 orthodontic appliances (8 units made of base plastic of the first type, 10 units made of base plastic of the second type, and 11 units made of base plastic of the third type). The appliances studied had been in constant use for 3 months. All respondents were trained in standard methods of cleaning teeth, adapted to their age and the rules of care for orthodontic appliances. Hygiene skills monitoring was held in children aged 7–11 years by means of hygiene index (Fedorov-Volodkina, 1972), 12–16 years old – a simplified hygiene index OHI-S (Green J.C., Vermillion J.K., 1969; Kuzmina E.M., 2001).

LDF was performed using the laser analyzer of capillary blood flow (LAKK-02; version 2 – with two radiators at the wavelength 0.8 micrometers) with a quartz fiber optic probe, 3 mm in diameter and 1.8 m longwise (LAZMA, Moscow). The study of the gingival tissues microcirculation was carried out in a sedentary position in a dental chair. Sensor was set at level of the attached gingiva (AG) in the area of prosthetic bed tissues, and also in the projection of a toothless area of the alveolar process, ensuring perfect conformity of the probe's distal part to the gingival surface.

The data received on microcirculation index (MI) were represented in perfusion units (PU), prior to the application of orthodontic appliances made of different base plastics and after that – in 7 days, 1 month and 3 months.

The research data available allow to state that normal MI in adults ranges from 18.3 ± 0.19 to 21.2 ± 0.14 PU (20.0 ± 0.15 PU on the average). No data on the normal MI in children and adolescents were published.

The integrated assessment of microhemodynamics in different areas of the alveolar process (with or without the defect) helped us to work up a microcirculation indices' difference gradient (Gr), which was calculated as the ratio of the difference in microcirculation indices in the area of the defect and the intact area and their sum:

$$Gr = \frac{MI_{max} - MI_{min}}{MI_{max} + MI_{min}}$$

Dopplerograms processing was carried out using specialized software to the apparatus LAKK-02 (LAZMA) – software package LDF 2.20.0.507WL. T-test (t) was used to assess the reliability of numeric differences.

RESULTS AND DISCUSSION

The results of these experimental and clinical studies suggest that MI variability in the control group, as well as in the patients from the first group prior to the application of orthodontic appliances ranges from 13.06 ± 0.71 to 13.85 ± 0.83 PU. Midrange value of 13.44 ± 0.78 PU was conditionally taken for the norm as it corresponds to the state of perfusion in healthy tissues.

Microcirculatory perfusion parameters in prosthetic bed tissues in children and adolescents with malocclusion without defects of dentition while using removable orthodontic appliances made of 3 types of base plastics – Vertex self curing, ProBase Hot and Triad Denture Base – are represented in Table 1.

Table 1. Microcirculatory perfusion in prosthetic bed tissues in children and adolescents with malocclusion without defects of dentition while using removable orthodontic appliances made of 3 types of base plastics (PU)

Terms of supervision	Base plastic			P
	Vertex self curing	Pro Base Hot	Triad DentureBase	
Prior to the orthodontic treatment (normal state)	13.44 ± 0.78	13.44 ± 0.78	13.44 ± 0.78	>0.05
In 7 days from the treatment start date	18.37 ± 0.33**	17.16 ± 0.57*	16.22 ± 0.52*	<0.01
In a month from the treatment start date	17.65 ± 0.91	16.13 ± 0.86	15.38 ± 0.78	>0.05
In 3 months from the treatment start date	15.81 ± 0.28**	14.87 ± 0.43*	13.76 ± 0.81*	<0.01

P – differences between the 3 types of base plastics;
* – differences' significance in comparison with the normal figures <0.05;
** – differences' significance in comparison with the normal figures <0.01

The quantitative analysis of prosthetic bed tissues microhemodynamics in patients from the first group (in 3 months from the treatment start date) suggests that the highest perfusion rates can be observed in patients provided with fast cold-cured plastic based appliances, while the optimal MI (correspondent to that of the healthy tissues) seems to be associated with the light-cured base plastics.

Microcirculatory perfusion parameters in the defect area in children and adolescents with malocclusion and defects of dentition while using removable orthodontic appliances made of 3 types of base plastics – Vertex self curing, ProBase Hot and Triad Denture Base – are represented in Table 2.

The quantitative MI-analysis of prosthetic bed tissues in patients from the second group suggests that the light-cured base plastics orthodontic appliances cause significantly increased perfusion in the defect area during the first week of treatment. Soon after that the perfusion rate starts to decrease gradually, and in a month comes to a level close to the normal, although the indices are significantly higher than those prior to the imposition of the orthodontic appliances. This can be confirmed by the orthodontic appliances congruence with prosthetic bed which is due to the qualities of the materials used and the technological methods of manufacture.

In a week from the treatment start more significant increase of perfusion in the defect area can be observed when using appliances made of hot and cold polymerization plastics based on PMMA, than made of light-cured plastics.

Table 2. Microcirculatory perfusion in the defect area in children and adolescents with malocclusion and defects of dentition while using removable orthodontic appliances (PU)

Terms of supervision	Base plastic			P
	Vertex self curing	Pro Base Hot	Triad Denture Base	
Prior to the orthodontic treatment	7.67 ± 0.32**	7.67 ± 0.32**	7.67 ± 0.32**	<0.01
In 7 days from the treatment start date	17.12 ± 0.31**	16.45 ± 0.73*	15.57 ± 0.62*	<0.01
In a month from the treatment start date	11.89 ± 0.58	12.58 ± 0.24	14.68 ± 0.83	>0.05
In 3 months from the treatment start date	8.27 ± 0.23**	9.78 ± 0.42*	11.14 ± 0.29*	<0.01

P – differences between the 3 types of base plastics;
* – differences' significance in comparison with the normal figures <0.05;
** – differences' significance in comparison with the normal figures <0.01.

The results of experimental and clinical studies showed that the MI in the cases of dentition defects in the area of AG was significantly lower than the norm (7.67 ± 0.32 PU). MI lowering in premature loss of teeth indicates a decrease in tissue perfusion in the area with the defect of dentition, and locally affected blood supply. This is an indication for prosthetic treatment aimed to improve blood circulation in the area.

In a month microhemodynamics in the defect area is sharply reduced because of the excessive pressure of prostheses and compensatory mechanisms disorder as a result of prolonged adaptation to excessive stress. In 3 months MI in the defect area exceeds the original values, which indicates the partial improvement of hemodynamics.

Microcirculation indices' difference gradient (Gr) in children and adolescents with malocclusion in the areas with dentition defects, and without defects, after imposition of orthodontic appliances made of 3 types of base plastics – Vertex self curing, ProBase Hot and Triad Denture Base – are represented in Table 3.

Table 3. Microcirculation indices' difference gradient in children and adolescents with malocclusion in the areas with dentition defects, and without defects, after imposition of orthodontic appliances (PU)

Terms of supervision	Base plastic			P
	Vertex self curing	Pro Base Hot	Triad Denture Base	
Prior to the orthodontic treatment	0.28 ± 0.03	0.28 ± 0.03	0.28 ± 0.03	
In 7 days from the treatment start date	0.15 ± 0.027**	0.12 ± 0.023**	0.09 ± 0.003**	<0.01
In a month from the treatment start date	0.03 ± 0.019**	0.02 ± 0.017**	0.06 ± 0.002**	<0.01
In 3 months from the treatment start date	0.19 ± 0.031**	0.13 ± 0.024**	0.02 ± 0.002**	<0.01

P – differences between the 3 types of base plastics;
** – differences' significance in comparison with the rate prior to the orthodontic treatment

Microcirculation indices gradient shows a significant difference between healthy tissues and the defect area bloodstreams. Application of removable orthodontic appliances of any type causes immediate and significant decrease of Gr in the defect area, as well as in the intact gingiva (up to 0.09–0.15 PU), indicating a pronounced increase in the microcirculation flow in the defect area. Moreover, while using the appliances made of hot and cold curing basic plastics, Gr reduces significantly within a month after treatment start which indicates an improved blood supply to the defect area.

However, after 3 months of treatment Gr increases dramatically (up to 0.13–0.19 PU), which indicates tissue perfusion changes because of the prolonged use of the appliances, and its obvious deterioration in the area of defect. Gr rates were found to be 1.47–2.15 times lower than those prior to the orthodontic treatment.

Light cured base plastics caused gradual reduction of the Gr (0.09; 0.06 PU), and the values tended to approach 'zero' level (0.02 PU). This indicates that tissue perfusion in the dentition defect area after orthodontic treatment practically corresponds to the parameters of healthy gingivae.

FINDINGS

1. The method of laser Doppler flowmetry can be proposed for the appropriate assessment of microhemodynamics perfusion parameters in prosthetic bed tissues in children and adolescents, corresponding to different phases of orthodontic treatment.

2. The integrated assessment of gingival tissues microhemodynamics with laser Doppler flowmetry (LDF) suggests that the prostheses made of light cured base materials promote improvement of vascularization, trophics and perfusion in prosthetic bed tissues compared with prostheses made of cold and hot cured base plastics.

3. When using removable orthodontic appliances, adaptation time shortening depends on the degree of appliance's congruence with prosthetic bed, the chemical class of the base material, and the type of polymerization (cold, hot, light).

4. Clinical evaluation of the available methods of orthodontic treatment, orthodontic appliances design improvement, alongside with the implementation of modern restorative materials and manufacturing technologies, as well as the improved biochemical, immunological and functional analyses will contribute to the perfected orthodontic care in children and adolescents.

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