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Personified Orthodontic Treatment of Adults with Malocclusions and Deformations in Dentition Depending on the Degree of Caries Resistance of the Dental Enamel

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Abstract

Background: To increase the effectiveness of orthodontic treatment in children with various degrees of dental enamel caries resistance using a personified orthodontic treatment.

Materials and Methods: The present study included 108 adults (6-16 years old) with the first class of occlusion who referred for the Department of Pediatric Dentistry with orthodontics in Voronezh pediatrics' dental clinic №2" Russian Federation. According to the study design, it can be characterized as open, prospective, and clinical. The electrometric diagnostics of dental enamel and electromyography of the masseter and temporalis were recorded.

Results: Functional therapy with the proposed personified orthodontic treatment normalized the mean number of biopotential masseters and temporalis muscles and improved caries resistance of hard dental tissues. However, the examination on the group of children with a low degree caries resistance of dental enamel resulted in the decrease in the mean number of electrometric diagnostics from 4.0 (3.6; 6.0) μA-1.6 (1.5; 3.37) μA (differences are statistically significant, $p<0.05$) after 18 months of replacement therapy. In turn, the mean number of bioelectric activity of masseter and temporalis muscles changed from 324.25 (303.75; 345.75) μV-332.5 (318.75; 347.25) μV, $p<0.05$.

Conclusion: Employing the personified orthodontic treatment depending on the degree of caries resistance of the tooth enamel, determination of the functional state of the masseter and temporalis, and electrometric diagnosis of dental hard tissues enhanced the effectiveness of orthodontic treatment.

Key Words: Electromyography, Teeth, Transformable treatment, Mouthguard, Remineralization.

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1- INTRODUCTION

The current trend in dentistry is to preserve the health of the oral cavity, especially in childhood. From an orthodontic point of view, therapeutic measures are more appropriate to be started in early childhood, when it is possible to affect the growth of the jaws, to eliminate and prevent dental anomalies and deformities. It is recommended to carry out remineralizing therapy depending on the initial degree of caries resistance of hard dental tissues to increase the resistance of dental enamel. In this regard, patients with sufficient average caries resistance have to carry out the remineralizing twice a year. In contrast, patients with reduced average caries resistance should increase the number of remineralizing measures up to four times a year with preliminary professional oral hygiene (1). The lack of preventive measures in orthodontic patients and those in the dental enamel formation period leads to an increase in caries growth (2).

In children who are not on orthodontic treatment, preventive measures to prevent the carious process are also the main task of dentists since the complications of early childhood caries lead to inflammation of the pulpo-periodontal complex, destruction of the dental crowns, dental early removal, violation of the formation of the correct height of the bite, and deterioration of the relationship of the dental rows (3-6). The tone of the masticatory muscles of the maxillofacial region directly correlates with the resistance of the hard dental tissues to the carious process (7). Timely detection of lesions of hard dental tissues and myofunctional dysfunctions before the start of orthodontic treatment is particularly relevant (8). Currently, the evaluation methods of the carious process are based only on calculating the formula for the intensity of dental caries, analyzing only the resulting feature without taking into account the prediction and assessment of the risk of its development. However, there is a need to prescribe therapeutic and preventive measures for clinically healthy patients to prevent the development of the carious process (9). Therefore, the present study aimed to increase the effectiveness of orthodontic treatment in children with various degrees of dental enamel caries resistance using remineralizing therapy with transformable treatment and prophylactic elastic mouthguard.

2- MATERIALS AND METHODS

2-1. Study Design

This study was conducted as a prospective longitudinal study investigating the prevalence of amplitude of biopotentials of masseter and temporalis and level of caries resistance. A cross-sectional study was carried out. The sample population consisted of Russian school children with 6–16 years old of Voronezh city, Russia. To form two comparable groups, they were matched according to age, social status, gender, class I malocclusion. All subjects underwent the caries examination before the start of active orthodontic treatment after 18 months. Overall, 108 subjects, including 46 adults with 6-12 years old (42.8% of the total), and 62 subjects with 13-16 years old (57.2% of the total) (regardless of gender), participated in the study. To ensure random selection from the schools, a stratified sampling method within different clusters was employed in a sample population comprising 6–16-year-old subjects.

2-2. Methods

Patients were differentially distributed in four clinical groups depending on the results of assessing the state of hard dental tissue (1). However, group 1 - patients with High Caries Resistance (HCR), group 2 - with a Medium Caries Resistance (MCR), group 3 - with a Low Average Caries Resistance (LACR), group 4 - with

a Low Degree Caries Resistance (LDCR). The functional state of the enamel was also examined during the first visit using the DentEST apparatus (**Figure.1**) of Geosoft Dent, Moscow, Russia (it was determined on permanent teeth by the equator of the vestibular surface of the crown part at least 1.5 years after the eruption). Methodology Ivanovoj G.G., Leont' evym V.K. We utilized the surface electromyography procedure using the four-channel portable Synapse electromyography (**Figure.2**) of Neurotech Company (Russia) to monitor the state of the muscles of the maxillofacial region. The methodology of this study was based on the accepted standards (10). Bioelectric activity indicators of the chewing and temporal muscles were recorded for 30 seconds while chewing five grams of hazelnuts (according to I. S. Rubinov) on the right side, left side, and with general chewing, in the most relaxed mode for the patient.

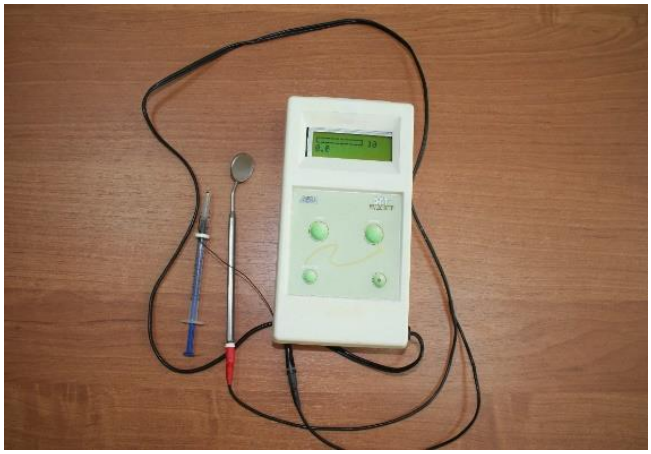

Fig.1. DentEST apparatus (GeosoftDent CJSC, Moscow, Russia).

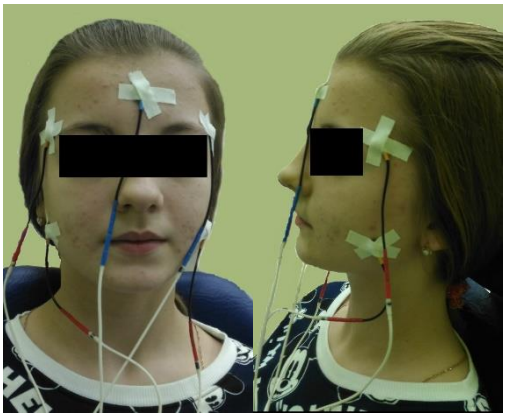

Fig.2. Methodology of electromyography by Synapse (Neurotech Company, Russia).

2-3. Intervention

Remineralizing therapy using the Clinpro ™ WhiteVarnish was prescribed at home for all groups of patients, except for those with a high degree of dental caries. For the members of LACR, the use of this drug twice a year is sufficient. Moreover, the remineralizing measures are recommended once every three months for the LDCR group. For children with a low degree of caries, dental enamel applications were performed once every two months. In all study groups, remineralizing therapy of

dental hard tissues was carried out after oral cavity rehabilitation. Remineralizing therapy was carried out simultaneously with hardware orthodontic treatment using the transformable treatment and prophylactic elastic mouthguard (**Figure.3**, TTPEM). Mouthguard was packed in the oral cavity and was used all night and for at least 4 hours during the day or at bedtime (on average, 14 hours a day). The treatment period was 18 months.

2-4. Ethical consideration

This study was approved by the Department of Education, Science and Youth Policy of the Voronezh Region. Parents of patients or their official representatives have issued informed consent for the diagnosis and treatment of their children.

2-5. Inclusion and exclusion criteria

The exclusion criteria for this study were: subjects with craniofacial anomalies (clefts and syndromes), hypodontia, oligodontia, cleft-lip/palate, and smoking. Physically healthy participants had the class I malocclusion, and dentoalveolar deformities of the dentition and position of the teeth were recruited.

2-6. Data Analyses

Descriptive data were presented in univariate Tables. The normality of the analyzed indicators and the equality of the variances of the distributions of features in the groups were checked using the Basic Statistics and Tables module of the STATISTICA 6.0 Statsoft Inc (for Windows) using the Shapiro-Wilk test, which was applied with an initially unknown mean and standard deviation. The critical level of statistical significance p0 was initially assumed to be 0.05, and to overcome the with multiple comparisons issues; the Bonferroni correction was used - recalculation of the significance level p for multiple pairwise comparisons using the formula p0 / n, where n is the number of paired comparisons.

3- RESULTS

The procedure of electrometric diagnosis of dental hard tissues was used to assess the state of dental hard tissues and the dynamics of the treatment. The obtained results are presented in **Table.1**. The mean of the electrometric diagnostic indicators in the HCR group, regardless of age, was 0.25 (0.1; 0.29) μA, which was higher than pre-treatment. The median of the parameter in the remaining groups decreased and amounted to 0.3 (0.2; 0.4) μA, 0.5 (0.45; 0.68) μA, and 1.6 (1.5; 3.37) μA for children with an MCR, LACR, and LDCR groups, respectively.

Table-1: Indicators of electrometric diagnosis of individuals with various degrees of caries resistance of tooth enamel before treatment and after 18 months of therapy.

Study groups	Indicators of electrometric diagnosis (μA) before treatment	Indicators of electrometric diagnosis (μA) after treatment
HCR enamel, n=20	0,1 (0,1;0,2)	0,25 (0,1;0,29)
AMCR enamel, n=42	0,4 (0,3;0,4)	0,3 (0,2;0,4)
LACR enamel, n=36	1,2 (1,1; 1,34)	0,5 (0,45;0,68)
LCR enamel, n=12	4,0 (3,6; 6,0)	1,6 (1,5;3,37)

Note: differences are statistically significant at $p<0.05$.

We performed the surface electromyography (EMG) procedure of the masticatory and temporal muscles before and 18 months after treatment to examine the dynamics of the myofunctional state of the masticatory muscles after treatment using a transformable treatment-and-prophylactic elastic mouthguard and a complex of myostatic and myodynamic exercises. The results are presented in **Table.2**, where TD is the right temporal muscle, MD is the right chewing muscle, TS is the left temporal muscle, and MS is the left chewing muscle.

Table-2: The mean of the functional state of the actual masticatory and temporal muscles before treatment and after 18 months of therapy.

Muscle under study	EMG (μV) HCR enamel		EMG (μV) AMCR enamel		EMG (μV) RMCR enamel		EMG (μV) LCR enamel	
	Before therapy	After therapy	Before therapy	After therapy	Before therapy	After therapy	Before therapy	After therapy
TD	398,0 (294,5; 437)	413,0 (391,5; 425,5)* p=0,0003	345,0 (309; 415)	351,0 (344; 371)	364,0 (329; 391)	364,0 (345; 381)* p=0,00003	321,5 (310; 339)	325,5 (313; 329)* p=0,0015
MD	392,0 (369; 426)	402,5 (371,5; 437)* p=0,00004	361,0 (282; 431)	364,0 (312; 378)* p=0,0175	342,0 (321; 370)	345,0 (324; 367)	331,0 (310; 351)	338,0 (326; 361)* p=0,0013
TS	403,5 (299; 434)	418,0 (363,5; 426)* p=0,00187	327,0 (300; 393)	339,0 (296; 386)	349,0 (332; 374)	362,0 (322; 380)	325,0 (297; 348)	330,5 (315; 344)* p=0,0200
MS	381,5 (355,5; 405)	401,0 (378; 419,5)* p=0,04034	381,0 (284; 471)	399,0 (322; 426)* p=0,0086	351,0 (313; 367)	364,0 (342; 385)	319,5 (298; 345)	336,0 (321; 355)* p=0,0370

Note: * differences are statistically significant at $p<0.05$.

4- DISCUSSION

The present study aimed to develop the method of orthodontic treatment for patients with malocclusions and deformities of dentoalveolar arches using the combination of remineralization treatment and prophylactic elastic mouthguard. Moreover, the myofunctional therapy was carried out to improve the efficiency and reduce the time of complex treatment. The personified complex showed effectiveness in HCR group. Dynamics of indicators of electrometric diagnostics of dental enamel and the level of intensity of caries in children indicates an increase in the electrical conductivity of dental enamel in the lack of cooperation with physician and dental therapists, and not performing remineralizing therapy during the time of orthodontic treatment with removable burl devices (according the results of our study over 18 months, the increase was 1.5 [0; 3.5] s zero). The proper implementation of preventive and therapeutic measures caused the index to decrease, indicating a lack of education new foci of demineralization. Moreover, the effectiveness of the application integrated orthodontic treatment on the electrical conductivity of dental enamel in patients after treatment was proved, which indicates increasing its resistance to carious agents. Timely identification of both existing foci of demineralization and prevention of the emergence of new carious solid demineralization dental tissue is the immediate responsibility of the physicians before orthodontic treatment. Since the electromyographic indicators studies on the masticatory muscles are in direct correlation with electrical conductivity of dental enamel, at the planning steps of orthodontic treatment is necessary use of such additional studies like surface electromyography of the

masticatory muscles and electrometric diagnosis of dental enamel. Planning further appropriate treatment methods depending on the tone itself chewing and temporal muscles and the degree of caries resistance of dental enamel. The results are consistent with previously published studies on the aggravation of the state of hard dental tissues and an increase in the intensity of the carious process during orthodontic therapy (5, 9). Adults with a high degree of dental caries resistance using of removable orthodontic appliances without remineralizing preparations leads to an increase in the electrometric conductivity of dental enamel, which indicates a decrease in its resistance. The results are consistent with previously published studies on the aggravation of the state of hard dental tissues and an increase in the intensity of the carious process during orthodontic treatment (6, 10).

Even with a high degree of dental caries resistance, the use of removable orthodontic appliances without remineralizing preparations leads to an increase in the electrometric conductivity of dental enamel, which indicates a decrease in its resistance. Dentoalveolar deformities treatment in children, which affects both the chewing muscles and hard dental tissues, helps to increase the effectiveness of therapeutic measures. Orthodontic treatment performed using the transformable treatment-and-prophylactic elastic mouthguard and a set of myogymnastic exercises for children allows to increase the total bioelectric activity and bring the bioelectric activity of the chewing and temporal muscles into balance. However, in individuals with a high degree of dental caries resistance, the indicators of total bioelectric activity increased from 1575 μV-1634.5 μV, in individuals with a sufficient average degree of dental caries resistance, these indicators were 1414 μV before treatment, and after 1453 μV. Moreover, in individuals with a lower average of the degree of dental caries resistance indicators of total bioelectric activity increased from 1406 μV-1435 μV. Furthermore, individuals with a low degree of dental caries resistance, had the indicators before treatment of the transformable treatment-and-prophylactic elastic mouthguard of 1297 μV, and after1330 μV. Simultaneous exposure to remineralizing therapy (dosed individually) and myofunctional training proved effective in children with various degrees of caries resistance of dental enamel. The dynamics of the indicators of electrometric diagnosis of dental enamel and the level of intensity of caries in children indicates an increase in the conductivity of dental enamel.

The effectiveness of the use of complex orthodontic treatment proves a decrease in the electrical conductivity of dental enamel in patients after treatment, which indicates an increase in its resistance to carious agents. The median of the electrometric diagnostic indicators in the HCR group was 0.25 (0.1; 0.29) μA, which is higher than pretreatment. The median of the studied parameter in the remaining groups decreased and amounted to 0.3 (0.2; 0.4) μA, 0.5 (0.45; 0.68) μA and 1.6 (1.5; 3.37) μA for MCR, LACR, and LDCR, respectively. The timely identification of both existing foci of demineralization and the preventive effect of the appearance of a new carious demineralization of the hard dental tissues is a direct responsibility of the physician before starting orthodontic therapy. Since the of the electromyographic indicators of masticatory muscles are directly related to the electrical conductivity of dental enamel, at the planning steps of orthodontic treatment it is necessary to use such additional research methods as surface electromyography of masticatory muscles and electrometric diagnosis of dental enamel; and, depending on the tone

of the actual chewing and temporal muscles and the degree of caries resistance of dental enamel, plan further treatment tactics.

5- CONCLUSION

Dentoalveolar deformities treatment in children, which affects both the chewing muscles and hard dental tissues, helps to increase the effectiveness of therapeutic measures. Orthodontic treatment performed using the transformable treatment-and-prophylactic elastic mouthguard and a set of myogymnastic exercises for children allows to increase the total bioelectric activity and bring the bioelectric activity of the chewing and temporal muscles into balance. However, in individuals with a high degree of dental caries resistance, the indicators of total bioelectric activity increased from 1575 μV-1634.5 μV, in individuals with a sufficient average degree of dental caries resistance, these indicators were 1414 μV before treatment, and after 1453 μV. Moreover, in individuals with a lower average of the degree of dental caries resistance indicators of total bioelectric activity increased from 1406 μV-1435 μV.

Furthermore, individuals with a low degree of dental caries resistance, had the indicators before treatment of the transformable treatment-and-prophylactic elastic mouthguard of 1297 μV, and after1330 μV. Simultaneous exposure to remineralizing therapy (dosed individually) and myofunctional training proved effective in children with various degrees of caries resistance of dental enamel. The dynamics of the indicators of electrometric diagnosis of dental enamel and the level of intensity of caries in children indicates an increase in the conductivity of dental enamel. The effectiveness of the use of complex orthodontic treatment proves a decrease in the electrical conductivity of dental enamel in patients after treatment, which indicates an increase in its resistance to carious agents. The median of the electrometric diagnostic indicators in the HCR group was 0.25 (0.1; 0.29) μA, which is higher than pretreatment. The median of the studied parameter in the remaining groups decreased and amounted to 0.3 (0.2; 0.4) μA, 0.5 (0.45; 0.68) μA and 1.6 (1.5; 3.37) μA for MCR, LACR, and LDCR, respectively. The timely identification of both existing foci of demineralization and the preventive effect of the appearance of a new carious demineralization of the hard dental tissues is a direct responsibility of the physician before starting orthodontic therapy. Since the of the electromyographic indicators of masticatory muscles are directly related to the electrical conductivity of dental enamel, at the planning steps of orthodontic treatment it is necessary to use such additional research methods as surface electromyography of masticatory muscles and electrometric diagnosis of dental enamel; and, depending on the tone of the actual chewing and temporal muscles and the degree of caries resistance of dental enamel, plan further treatment tactics.

6- CONFLICT OF INTEREST: None.

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