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Application of Temporary Fixed Constructions.

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ABSTRACT

The paper considers the investigation of physical-mechanical properties of material for temporary fixed dentures manufacturing by means of direct process: «Tempokor», «VladMiVa, Russia», «Protemp 4», «3M ESPE, Germany», «CrownTemp» (TBI Company, Germany), «Tempron» (GC Corporation, Japan) in vitro. Bending strength and modulus of elasticity, diametral rupture strength, microhardness, roughness, peak heating temperature of composite material when hardening (polymerizing), colour stability of materials through «coffee test» have been determined. The adhesion data of cariesogenetic and periodontogenic types of microorganisms representatives to the materials investigated have been presented. The technique of primary adhesion in vitro with the application of standard technology of ultrasound treatment to remove microbe cells which have been involved in the process of primary adhesion has been used. Strains from the collection of the Microbiology, Virology and Immunology Department of Moscow A. I. Evdokimov State Medico-Stomatological University have been used: cultures of acid-productive microbiota of cariogenic group (Streptococcussanguinis, Streptococcusmutans), and microbiota of cariogenic periodontal-pathogenic group (Porphyromonasgingivalis, Fusobacteriumnucleatum, Candidaalbicans). The results of the treatment conducted in patients with incomplete/partial teeth loss and hard tissue teeth pathology and the quality of marginal fit of temporary dentures have been studied.

Keywords: temporary crowns, adhesion, oral cavity microflora, composite materials, «Tempokor».

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INTRODUCTION

Up-to-date aesthetic dentures (ceramic-metal, all-ceramic, the dentures based on zirconium oxide and others) have obtained wide application in the dental practice at present. They require considerable hard tooth tissues abrasion. In this connection a prosthodontist faces the necessity of making temporary dentures for the period of manufacturing the permanent ones. Temporary dentures making is obligatory and essential stage of any type of fixed dental prosthetics [1, 11, 12].

Traditional methods of different types of temporary dentures include the direct and the indirect ones. The indirect method implies obtaining a temporary denture in the laboratory that takes certain time (from several hours to a day). The direct method seems to be more efficient due to the necessity of coating the teeth immediately after the preparation.

The choice of material for temporary dentures is not the least of the factors for successful prosthetics in patients with acquired defects of teeth and jaws. It is necessary to foresee strength, physic-chemical, microbiological and aesthetic properties as well as the possibility to carry out the denture correction [2]. The required time of temporary dentures use is determined by a number of the listed properties [8, 9, 10].

Nowadays import materials are mostly in demand for manufacturing of temporary dentures applying the direct method while domestic materials are not used. Closed Corporation «Free Economic Area «VladMiVa»» in Belgorod has developed new domestic composite material of chemical cure on the basis of multifunctional methacrylates for manufacturing of temporary dentures applying the direct method «Tempokor». This new substance is released in the form of two pastes – basic and catalytic, which are mixed in equally before the application [3].

MATERIALS AND METHODS

Physical-mechanical properties of materials for temporary fixed dentures manufacturing by means of direct process «Tempokor», «VladMiVa, Russia», «Protemp 4», «3M ESPE, Germany», «CrownTemp» (TBI Company, Germany), «Tempron» (GC Corporation, Japan) in vitro have been investigated on the basis of Closed Corporation «Free Economic Area «VladMiVa»» in Belgorod. According to the manufacture's instruction eight test samples have been made for the trial.

Eight samples of materials in question have been made according to the instruction of the manufacture. The methods of physico-chemical properties of these materials include:

The definition of the bending strength and the flexibility module (according to SSS (State Standard Specification) R 51202-98)

In three minutes after mixing the samples were put into the vessel with water and after that into the thermostat (37±1°C) for 15 minutes. Then the samples were pulled out of the forms and put in the vessel with the distilled water in the thermostat (37±1°C) for 24 hours.

Then the material was retrieved from the distilled water and its size was measured in cross-section calculated to 0,01 mm. The device for the bending test and the samples were temperature-controlled at 37±1°C during 10 minutes straight before the trial. Then they were carried to the tearing machine of Instron class providing the speed of loading device movement or traverses (0,75±0,25) mm/min and maximum load – 5000 H. The samples were loaded till destruction and the value of ultimate breaking load and the diagram «loading-deformation» were recorded [4].

Flexural strength σ was calculated according to the formula:

$$\sigma_{\text{from}} = \frac{3FL}{2bh^2},$$

F- sample rupture loading (H); *L* - the distance between the supports calculated to 0,01 mm; *b*- sample width measured straight before the trial start (mm); *h* - sample height measured straight before the trial start (mm).

Flexibility module was calculated according to the formula:

$$E = \frac{F_1 L^3}{4bh^3 d},$$

F_1 – the loading in the elastic deformation region chosen on the straight portion of the diagram (H);
d – the chosen loading deformation F_1 (mm).

The definition of diametral rupture strength (according to SSS (State Standard Specification) R 51202-98)

In three minutes after mixing the samples were put into the vessel with water and after that into the thermostat (37±1°C) for 15 minutes. Then the samples were pulled out of the forms and put in the vessel with the distilled water in the thermostat (37±1°C) for 24 hours.

In 24 hours the material was retrieved from the distilled water, dried with filter paper and the diameter and the thickness of every sample were measured. The sample was placed on the table of the tearing machine. The samples were subjected to the even compressive force till complete destruction by the traverse of testing machine Instron at the motion speed 10 mm/min [4].

Diametral rupture strength T_p, were calculated according to the formula:

$$T_P = 2P / \pi DL,$$

P – destruction loading, H
D – diameter of the sample, mm
L – thickness of the sample, mm

The determination of microhardness.

Microhardness was determined by micro hardness meter «Digital display micro hardness tester» of HVS-1000B model through indentation of the hardened sample surfaces of dental materials with diamond hand piece (the angle of penetration is 136°) under the loading 0,98 H and measuring the linear value of obtained impression diagonal.

The determination of roughness.

The determination of surface roughness of dental materials hardened samples after final polishing (Cleanpolish, «Kerr») was carried out on the profilometer «TR 100» with permissible error not more than 7%.

The determination of peak heating-up temperature of composite material on hardening (polymerization) at 37°C in thermostat

According to the manufacture instruction mixed dental material were put into the form with thermocouple. Every 15 seconds the temperature change has been recorded till the moment of reaching the peak temperature.

The colour stability determination of materials for manufacturing temporary constructions were performed with the help of «coffee test» during three days at 37°C in thermostat.

In the in vitro experiment in the laboratory of the Microbiology, Virology and Immunology Department of Moscow A. I. Evdokimov State Medico-Stomatological University (the Head of the Department is Tsarev Victor Nickolaevich, doctor of medical science, professor) we studied the adhesion of the representatives of cariesogenic and periodontogenic types of microorganisms to the materials investigated: : «Tempokor» («VladMiVa, Russia») varnished with «Axil» and without covering, «Protemp 4» («3M ESPE, Germany»),

«CrownTemp» (TBI Company, Germany), «Tempron» (GC Corporation, Japan). We used the technique of primary adhesion in vitro with the application of standard technology of ultrasound machining to withdraw microbial cells which entered the process of primary adhesion that allowed us [6, 7] to perform the quantitative assessment with the application of the calculated formula:

$$Ia = IgA/IgN,$$

Ia – primary adhesion index;
lgA – decimal logarithm of adherent bacteria determined by cultural technique;
lgN – decimal logarithm of bacteria quantity in the initial suspension.

Strains from the collection of the Microbiology, Virology and Immunology Department of Moscow A. I. Evdokimov State Medico-Stomatological University have been used: cultures of acid-productive microbiota of cariogenic group, isolated from the patients with caries – Streptococcussanguinis, Streptococcusmutans, and microbiota of parodonto-pathogenic group, isolated from the patients with chronic parodontitis in the stage of exacerbation – Porphyromonasgingivalis, Fusobacteriumnucleatum, Candidaalbicans [2,5,7].

To carry out the test for primary adhesion of test-stains from the composite material investigated discal samples were made beforehand in polyacetate blisters (disk diameter 0,5 cm) which were sterilized in gamma camera. Before carrying out the experiments to analyze primary adhesion all samples were kept in sterile Petri dishes.

To carry out the experiment the sample of the restoration material was placed into the suspension of daily test culture of certain concentration microorganisms (10^8 colony-forming units/ml for bacteria and 10^6 colony-forming units for candida that makes up 8,0 и 6,0 in logarithmic expression respectively. The material samples were kept for 2 hours at temperature 37° C and microaerophilic and obligate anaerobic bacteria stains were kept in anaerobiosis. The exposure for fungi was also 2 hours at room temperature.

To remove the microorganisms that were not enter into the specific adhesion they were washed off thrice in 5 ml of sterile isotonic solution of sodium chloride. Then every sample was placed separately into the vessels containing 1 ml of sterile isotonic solution of sodium chloride. Then the samples were placed into the ultrasonic bath and were treated with the ultrasound at the frequency of 60-70 KHz (10-minute exposure) in order to put the microbes entered into the process of primary adhesion with the restoration material surface into the suspension state.

After that from the suspension received by ultrasound treatment the plating of 20 microliter of the suspension was carried out with plastic spatula on blood anaerobic agar with hemin and menadion (for anaerobes) and on chromogenic medium (for fungi).

Anaerobic stains platings were placed into the thermostat in anaerobic conditions with the use of anaerobic jar by «Highmedia-Labs» (India).

In 7 days of ray fungus and obligate anaerobe cultivation and in 2 days of streptococcus and fungi cultivation the calculation of colonies grown was carried out with research microscope Eclips (Nikon). Decimal logarithm was determined for the primary adhesion index to the certain material according to the formula described above [5, 6, 8].

Statistical data manipulation was carried out by variation statistics technique with the use of Biostat 9.0 for Microsoft programme. Values $p<0,05$ were accepted as significant difference.

In the technique of making temporary dentures the choice of construction material optimal for the certain clinical picture of the certain patient taking into account the periodontium tissues state and the oral cavity microbiocoenosis is the major task of practical dentistry.

Based on those mentioned above the treatment of 80 patients (36 men and 44 women) at the age from 23 to 57 with partial teeth loss and hard tooth tissue pathology seeking for dental help in Voronezh Region Autonomous Health Care Institution «Voronezh Regional Clinical Dental Polyclinic» was carried out.

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The period of temporary dentures functioning according to the treatment plan varied from 1 to 5-6 weeks.

The patients were divided into 4 groups of 20 people, similar by age and gender, topography of the teeth and dentitions being made prosthetic appliance, the etiology of pathological process, the clinical picture of teeth crowns and dentitions defects, vital and devitalized teeth ratio including those reinforced by pivot constructions. Each group corresponded to the material chosen for making temporary constructions.

Patients examination was carried out by generally accepted technique. The choice of denture construction was based on clinical and roentgenologic examinations data.

The clinical stages of the investigation were performed identically in both groups:

- proper teeth preparation with making gingival even ledge with rounded interior angle;
- making precision silicone impressions with obligatory gum retraction applying the «double suture» technique;
- obligatory use of temporary denture constructions;
- use of temporary cement TempBondNE (by Kerr, the USA).

The clinical assessment of manufactured constructions of temporary dentures was performed in the course of case follow-up on checks: on the day of denture fixation, in two weeks and in one month.

Besides traditional clinical examination we studied qualitative parameters effectiveness of temporary dentures use on the supporting teeth:

- the quality of marginal abutment of the fixed dentures (edge fissure)
- the condition of edge periodontium (according to PMA index) of dentured and intact teeth.

RESULTS OF THE INVESTIGATION AND DISCUSSION

The analysis of the results in vitro showed that composite material «Tempokor» demonstrated bending strength values, flexibility module, and diametric rupture strength comparable with similar values of other materials presented on the market for making temporary dentures through the direct method (table 1). The material «Tempokor» excelled the import analogs which indicates the strength of the material.

Table 1: The results of physical-mechanical trials of dental materials for temporary dentures by different manufactures

№	Indextitle	Material title			
		«Tempokor», «VladMiVa», Russia	**«CrownTemp» *3M ESPE, Germany***	**«CrownTemp», *TBI Company, Германия***	**«Tempron», *GC Corporation, Япония***
1	Microhardness, HV	21,1±0,48	15,9±0,91	14,2±0,46	16,4±0,9
2	Diametral Rupture Strength, MPa	44,4±1,3	52±6,2	37,1±2,9	28,6±2,1
3	Flexural Strength, MPa	83,6±7,4	91,2±9,8	77,9±3,6	65,2±5,0
4	Flexibility Module, GPa	2,8±0,39	2,7±0,25	2,1±0,44	1,8±0,14
5	Roughness, micron	0,21±0,03	0,14±0,06	0,17±0,02	0,20±0,03
6	Peak heating up temperature on hardening, °C	41,2	41,1	42,0	43,5

Note: the differences are significant at $p<0,05$

We believe the roughness indices of the materials «Tempokor», «Tempron» exceed the analogous values of «Protemp 4» и «CrownTemp» (table 1) due to manual mixing (void formation) [3]. Closed Corporation «Free Economic Area «VladMiVa»» is currently developing the system of double syringes for the material

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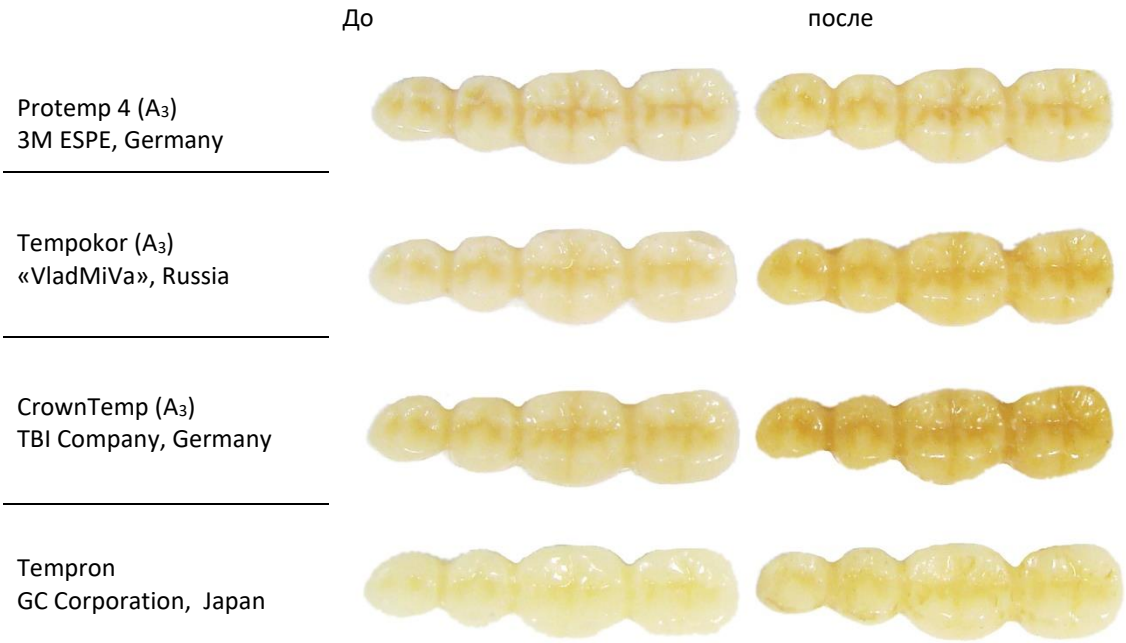
«Tempokor» automatic mixing to improve roughness indices. The analysis of peak temperature measurement on polymerization indicates the necessity of different desensitizers use immediately after vital teeth preparation before temporary dentures making by direct process which may help avoid thermal influence (table 1).

After finding 4 samples in coffee solution during 3 days at temperature 37°C materials «Protemp 4», «Tempokor», «Tempron» showed less change. «CrownTemp» showed the most change of the initial colour shade (figure 1) [3].

Figure 1: Colour resistance results on «coffee test»



On adhesive potency assessment of cariogenic group acid-productive microflora (in our investigations – microaerophilic streptococcus «mutans» and «sunguinis») quite high adhesion level from 0,67-0,76 of «Tempron» material to 0,79-0,88 of «Tempokor» material lacquered was revealed. At the same time «Tempokor» material unlacquered showed moderate adhesion level with indices 0,45- 0,58 which did not differ from the indices for «CrownTemp» material and for «Protemp» material Streptococcus mutans showed particularly high adhesion (table 2).

Table 2: The results of oral microbiota adhesion to the materials used for making pharmaceutical crowns

Materials Штаммы	«Tempron»	«Protemp»	«CrownTemp»	«Tempokor»	«Tempokor» + lacquer
Streptococcusmutans	0,76+0,2	0,92+0,2**	0,48+0,1*	0,58+0,2*	0,79+0,2#
Streptococcussanguinis	0,67+0,1	0,45+0,1*	0,46+0,1*	0,45+0,1*	0,88+0,2#
Porphyromonasgingivalis	0,80+0,2	0,60+0,1*	0,60+0,2*	0,60+0,2*	0,60+0,2*
Prevotellaintermedia	0,50+0,1	0,50+0,1	0,47+0,1	0,50+0,1	0,91+0,2#
Fusobacterumnucleatum	0,89+0,2	0,81+0,2	0,40+0,1*	0,58+0,1*	0,54+0,1*
Candidaalbicans	0,58+0,1	0,60+0,1	0,50+0,1*	0,50+0,1*	0,50+0,1*
Candida krusei	0,71+0,1	0,75+0,2	0,50+0,1*	0,75+0,2	0,78+0,2

Note:
* values are significantly lower comparing with column 1
** values are significantly higher comparing with column 1
# values for column «Tempokor + lacquer» are significantly higher comparing with «Tempokor»

On adhesive potency assessment of parodontopathological group anaerobic bacteria higher adhesion levels were revealed in two stains - Porphyromnasgingivalis and Fusobacterumnucleatum though high

adhesion level was shown for «Tempron» material (0,80 and 0,89) and rather low adhesion level was shown for «CrownTemp» material and for the investigated material «Tempokor» regardless of being lacquered or not. As for one more parodontopathological type – Prevotellaintermedia – it possesses relatively low adhesive properties to all the materials (indices within the scope of 0,50).

Finally, on yeast fungus adhesive potency assessment it was established that the most abundant type – Candidaalbicans – possesses relatively low adhesion level to all the materials including «Tempokor» regardless of being lacquered or not (indices within the scope of 0,50). The other type of fungi – CandidaKrusei - on the contrary, is notable for its high adhesive potency to all the material investigated (indices0,71-0,75) except for «CrownTemp» (indices statistically significant 0,50). Adhesion level of this fungi type to «Tempokor» material being lacquered or not was different and makes up 0,75 и 0,78 respectively (table 2) [5].

Table 3: The clinical assessment of periodontal tissues state, PMA index

Materials for temporary dentures manufacturing	Follow-up period	
	on the day of denture application	in 3-4 weeks
«Protemp»	21,3 ± 0,2	22,2 ± 0,3
«Tempokor»	22,1 ± 0,3	23,2 ± 0,4
«CrownTemp»	23,2 ± 0,4	25,3 ± 0,2
«Tempron»	22,3 ± 0,5	33,1± 0,5

Note: the differences are significant at p<0,05.

The analysis of PMA (papillary-marginal-alveolar) index (table 3) showed insignificant increase of «Tempron» values. The values of the rest materials did not differ from the initial ones which indicates the absence of gingival margin inflammation.

CONCLUSIONS

The results of the conducted investigations of physical-mechanical properties of material «Tempokor»: bending strength (83.6 MPa), modulus of elasticity (2,8 GPa), tearing diametric strength (44,4 MPa) are comparable with the similar values of other materials presented on the market. The results of «Tempokor» microhardness (21,2 HV) indicate the strength of this material.

Roughness values of the materials «Tempokor» (0,21 micron), «Tempron» (0,2 micron) exceed the similar values of the materials «Protemp 4» (0,14 micron) and «CrownTemp» (0,17 micron). The measurements of peak temperature on polymerization («Tempokor» 41,2°C) indicate the necessity of different desensitizer use immediately after vital teeth preparation. On the results of four samples being in the coffee solution at the temperature of 37°C materials «Protemp 4», «Tempokor», «Tempron» showed the least change while «CrownTemp» showed the most change of the colour shade.

The results of microbiological investigations conducted allow to draw a conclusion that the adhesion level of cariogenic group microbes to the material «Tempokor» generally is not different from imported analogs. The material «Tempokor» demonstrates lower adhesion data to cariogenic periodontal-pathogenic group microbes than those of some analogs. The adhesion of fungi *Candida albicans* to all the materials is lower than in more rare fungi type *Candida Krusei.*

The analysis of patients physical examination when they use these materials showed insignificant increase of «Tempron» PMA (papillary-marginal-alveolar) index values. The rest of the values did not differ from the initial ones which indicates the absence of gingival margin inflammation.

The presented results of experimental trials allow to recommend the material «Tempokor» as an import-substituting agent and continue the study of its effectiveness in the clinical practice.

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