



ISSN: 0975-766X  
CODEN: IJPTFI  
Research Article

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**THE STUDY OF DESTRUCTION OF THE COMPOSITIONS RESTORING THE DENTITION  
INTEGRITY UNDER UNIAXIAL TENSION**

**Alexander V. Tscymbalystov, Alexander A. Kopytov, Elena A. Kuzmina, Sergey N. Gontarev  
Arman A. Oganessian**

Belgorod State University, 308015, Russia, Belgorod, Pobedy Str., 85.

*Email: [kopitov.aleks@yandex.ru](mailto:kopitov.aleks@yandex.ru)*

*Received on 15-10-2016*

*Accepted on 18-11-2016*

**Abstract.**

Using vital teeth as supports for non-removable prostheses has a known beneficial effect on the rehabilitation of patients suffering from partial adentia. In this case, dentinal tubules remain exposed after their preparation, which leads to tooth hypersensitivity. At the same time, the effects of chemical and physical agents, as well as bacteria and their metabolic products may promote the development of pulpitis of teeth being a part of orthopedic structure. Boring of abutment stumps with sealant “SuperGAP+” prevention from dental pulp irritation, in terms of the minimum reduction of the adhesion of dental cements to dentin. This paper is devoted to the study of the influence of the sealant “SuperGAP+” on the adhesive ability of dental cements.

**Keywords:** Artificial crown, mineralized sealant, stump wall convergence, uniaxial tension, dental cement.

**Introduction.** An adequate tooth preparation determines the success of orthopedic treatment [1-4]. To form the prosthetic plane, the dentist needs to remove a sufficient amount of hard tissue, thus it is considered desirable to preserve the tooth pulp [5-9]. As experimental, functional and clinical studies have determined, the degree of iatrogenic convergence of tooth side walls should range 3 to 10° at a height of the crown part within 10 mm [10].

Increase in the tooth taper reduces the area of adhesion between the tooth surfaces and crown walls, which leads to a reduced retention and decementation of non-removable prosthesis. The area of adhesion of the tooth stump is almost impossible to increase. It is limited, on the one hand, with the height of the central occlusion - it is necessary to remove the amount of tooth tissue that ensures sufficient strength properties of the structure. On the other hand, forming a circular ledge at the level of the gingival margin is considered the best solution, which is a prerequisite for prevention of periodontitis. Solving this problem, the chemical composition “SuperGAP+” was developed based on

Alexander A. Kopytov\**et al.* /*International Journal of Pharmacy & Technology*  
nano-sized hydroxyapatite. The drug is intended to reduce the sensitivity of teeth stumps with the unconditional preservation of conditions for reliable fixation of a non-removable structure.

**Objective of the research:** comparative evaluation of the adhesive properties of fixing cements in a combined application with mineralizing sealant “SuperGAP+” at different convergence angles of the tooth stump walls.

**Materials and methods.** Forty formed premolars, removed for orthodontic indications, were selected for the study.

Each of four teeth was subjected to uniaxial tension:

1. a tooth was processed at wall convergence angle of  $3^\circ$  (total angle -  $6^\circ$ ), the strength of the cement adhesion to dentin without dentin pretreatment with mineralizing sealant was determined;

2. the strength of the cement adhesion to dentin after dentin pretreatment with mineralizing sealant was determined;

3. a tooth processing was finished at increased wall convergence angle of  $6^\circ$  (total angle -  $12^\circ$ ), the strength of the cement adhesion to dentin without dentin pretreatment with mineralizing sealant was determined;

4. the strength of the cement adhesion to dentin after dentin pretreatment with the same mineralizing sealant was determined.

The accepted for study teeth were divided into two groups, depending on the cement used to fix the cast-metal crowns (crowns). The groups, in turn, were divided into equal sub-groups in order to study the effect on the adhesion of cements to dentine depending on the applied sealants. As sealants, “Kaltcetac” and the composition developed “SuperGAP +” were tested. The precleaned with air-water mixture materials were applied onto the dried surface of the tooth stump. The crowns were installed on the teeth after their careful treatment with “Anhydrin” and fixed with zinc phosphate cement “Unitcem” or glass ionomer cement “Tcemion-F”. To remove cement residues, the teeth stumps after each uniaxial tension were manually finished with sandpaper P600 according to ISO (77), grain size -  $24.8-26.8 \mu\text{m}$ . Teeth fixation, for uniaxial tension of the crown-tooth system, was performed by using an original device and method for determining the effect of sealants on the adhesion strength between the dental materials and tooth tissue [11]. For correct tooth preparation a device was used applied in the studies [12,13].

Preparation of the teeth was carried out by standard method, with air-water cooling turbocharged tip, with diamond drills “RosBel” 314.199.532.012. A circular ledge was formed 1 mm apical of the enamel-cement border, the tooth stump was treated with a water-air mixture for 1 minute and dried with air jet, the impressions were obtained, and a cast-metal crown with a retention ring in the center of the chewing surface was produced.

Then, to determine the effect of sealants on the adhesion strength between dental materials and tooth tissue, the device with a tooth fixed thereto with self-hardening plastic and with a cement-reinforced crown was placed in a thermostat for 48 hours at 37°C and 100% humidity. The next step involved determination of the adhesion strength between cement and dentin. The device was fixed in a universal floor electromechanical testing machine Instron 5882. The test speed of uniaxial tension was 1 mm/min. After separation of the metal composition from the tooth the loading was calculated (in MPa), and results were subjected to statistical analysis.

Microscopic study of the teeth fractured on the axis was performed with the use of raster ion-electron microscope Quanta 200 3D, equipped with a digital camera Digiview II.

**Main part.** The first uniaxial tension. A cast-metal crown was set on the teeth of first group, without any pretreatment of the stumps with sealant, using zinc-phosphate cement “Unitcem”. Application of uniaxial tension equal to  $2.0\pm 0.07$  MPa resulted in crown decementation. Teeth of the second group were attached with the crown, without any pretreatment of the stumps with sealant, using glass-ionomer cement “Tcemion-F”. Upon reaching the tensile force equal to  $4.1\pm 0.09$  MPa, the composition broken down. The second uniaxial tension. The crowns were fixed to the teeth of first group using zinc-phosphate cement “Unitcem”, pre-treating the tooth stumps of the first subgroup with sealant “SuperGAP+”, and the stumps of the second subgroup -with sealant “Kaltcetat”. In the first case, the composition broken down at tensile force equal to  $1.9\pm 0.07$  MPa, in the second -  $1.5\pm 0.06$  MPa. Consequently, the adhesion strength in the subgroups of the first group decreased by 5% and 25%. The crowns on the teeth of the second group were fixed with glass-ionomer cement “Tcemion-F”, pre-treating the tooth stumps of the first subgroup with sealant “SuperGAP+”, and the second subgroup - with sealant “Kaltcetat”. Decementation in the first subgroup occurred at tensile force equal to  $3.96\pm 0.07$  MPa, in the second -  $3.12\pm 0.06$  MPa. The adhesion strength in the subgroups of the second group decreased by 4% and 14%, respectively. The third uniaxial tension. After finishing the tooth stumps up to the wall convergence angle of  $12^\circ$ , the crowns were fixed to the teeth of first group without any sealant-based pretreatment of the tooth stumps with the use of zinc-phosphate cement “Unitcem”, and in the second group - with glass-ionomer cement “Tcemion-F”. The destruction of the compositions under uniaxial tension occurred during loading equal to  $1.9\pm 0.08$  and  $4.0\pm 0.08$  MPa. The tensile force, required for the destruction of the compositions, decreased in groups by 5% and 2%, respectively.

The fourth uniaxial tension. After covering the tooth stumps of first subgroup of the first group with sealant “SuperGap+”, and the second subgroup with sealant “Kaltcetat”, the crowns were fixed with zinc-phosphate cement

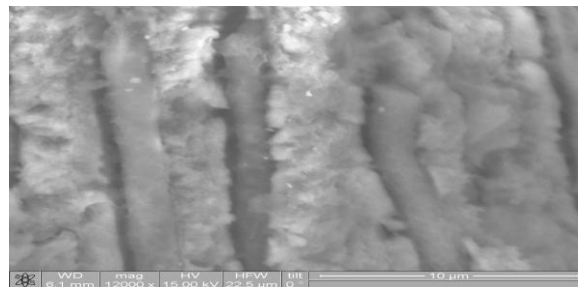
“Unitcem”. Decementation of the crowns in the first subgroup occurred at tensile force equal to  $1.7\pm 0.06$  MPa, in the second -  $1.2\pm 0.05$  MPa. The tensile force, required for the destruction, decreased in groups by 15% and 40%, respectively. Before fixing the crowns with glass-ionomer cement “Tcemion-F”, the tooth stumps of first subgroup of the second group were treated with sealant “SuperGAP+”, and the second subgroup - with sealant “Kaltcetac”. Destruction of compositions occurred under tensile force equal to  $3.76\pm 0.08$  and  $2.94\pm 0.07$  MPa, respectively. The strength of compositions decreased by 8% and 28%, respectively (Table 1).

**Table 1. Uniaxial tension value (MPa) destructive to the compositions.**

	group 1 - fixing the crowns with cement “Unitcem”		group 2 - fixing the crowns with cement “Tcemion-F”	
Research stage	“SuperGAP+” subgroup 1	subgroup 2 “Kaltcetac”	“SuperGAP+” subgroup 1	subgroup 2 “Kaltcetac”
Wall convergence angle $6^\circ$ , teeth not pretreated	2.0±0.07		4.1±0.09	
Tooth stumps treated with sealants	1.9±0.07	1.5±0.06 *	3.96±0.07	3.12±0.06 *
Wall convergence angle $12^\circ$ , teeth not pretreated	1.9±0.08		4.0±0.08	
Tooth stumps treated with sealants	1.7±0.06 *	1.2±0.05 *	3.76±0.08 *	2.94±0.07 *

\*Differences in the applied force destructive to the composition are reliable with respect to the initial values ( $p \leq 0.05$ ).

At the final stage of the study, microscopy of the tooth stump surfaces previously treated with sealant “SuperGAP+” was conducted. In order to exclude the hypothesis of selective filling of dentinal tubules with sealant “SuperGAP+”, the teeth were axially cracked, and the dentin layer forming the chewing surface was investigated. When studying the tubules with gaping mouths, the filled tubules were visualized apical of the mouths, which allows us to conclude about the total and extended filling of the dentinal tubules with sealer “SuperGAP+”. Location of the sealant in the dentinal tubules is shown in Figure 1.



**Figure 1.** Treating the dentinal tubules with sealer “SuperGAP+” to a depth of 10-50  $\mu\text{m}$ . Uniaxial destruction resulted in removal of the hardened sealant from several mouths. The mouths of the dentinal tubules, facing the chewing surface, are gaping.

**Discussion.** To solve the problem of preserving the vitality of the abutment teeth, the material “SuperGAP+” was developed with improved rheological properties. Water-alcohol “SuperGAP+” contains:

- Hydroxyapatite - a filler mineralizing the hard tissues of the tooth (longitudinal crystal size - 80-100 nm, transverse size - 20-30 nm);
- cetrimide - quaternary ammonium salt - antiseptic, reduces the surface tension of water systems, and promotes penetration of the material in the dentinal tubules;
- calcium hydroxide, creating a bactericidal alkaline environment and stimulating the formation of secondary dentine;
- potassium salt, reducing the nerve impulse of pain senses.

Alkaline environment of the drug neutralizes the excess of phosphoric acid in zinc-phosphate, silicate, silicophosphate cements, as well as polyacrylic acid in glass ionomer cement by the formation of calcium salts, providing an effective barrier against acid exposure and a chemical protection of dentin and pulp. The colorimetric characteristics of the drug prevent from unwanted dentin staining. Due to its rheological properties, the drug can be easily applied on the treated surface and penetrates into the dentinal tubules, forming the sealing plugs when drying inside the tubules. The rheological and thixotropic properties of the material ensure its penetration into the lumen of the dentinal tubules, eliminating the need for both careful drying of each applied layer and observance of the discreteness of layer applications, mandatory in cases of the film-forming agents and varnishes. The drug does not adjoin (no biofilm effect) the dentin surface but penetrates to a depth of 10-50  $\mu\text{m}$  and, filling the dentinal tubules, retains the surface rough, which improves the cement adhesion to dentin. The filler (calcium hydroxide and fluoride) consists of particles that differ granulometrically and structurally, which provides for rough dentin surface and creates conditions for adhesion. The sealant by adhering to the surface of dentin occludes the dentinal tubules, which prevents the lower layers and the pulp from various kinds of chemical and physical damage.

### **Summary:**

1. Increase in the wall convergence angle from  $6^\circ$  to  $12^\circ$  in the absence of tooth stump pretreatment with sealants resulted in no significant reduction in tensile force causing decementation of the crowns under uniaxial tension.
2. The lowest tensile force (1.2 MPa), resulting in decementation, was observed in the second subgroup of the first group when fixing the crowns with zinc phosphate cement “Unitcem” after the stumps pretreatment with sealant

Alexander A. Kopytov\**et al.* /*International Journal of Pharmacy & Technology*  
“Kaltcetat”. The reason for this may be the fact that the hydrophobic polystyrene film impairs the adhesion of hydrophilic (water-based) cements to dentin.

3. The decementation of the crowns fixed with glass-ionomer cement “Tcemion-F” after the stumps pretreatment with sealant “SuperGAP+” in the first subgroup of the second group was reached under tensile force equal to 3.96 MPa, which is 4% less than the original force.
4. The ability of the sealant “SuperGAP+” to penetrate into the lumen of the dentinal tubules and form plugs, retaining the same roughness of dentin, allows recommending this sealant in combination with any of the known cement in the clinic of orthopedic dentistry.

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