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STUDY OF TEMPORARY FIXATION MATERIALS ON SINGLE ORTHOPAEDIC STRUCTURES BY SIMULATING CHEWING LOAD

STUDIJA O SIMULACIJI OPTEREĆENJA ŽVAKANJEM KOD MATERIJALA JEDNODELNIH ORTOPEDSKIH KONSTRUKCIJA ZA PRIVREMENE FIKSACIJE

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Abstract

The adhesiveness and impermeability of dental temporary cements are investigated: Eugenol-free TempoCem NE (DMG), Eugenol Repin (SofaDental), and Cinnamic Water Dentin (VladMiVa). With the help of these materials, individual steel caps are fixed on the biological preparations of the teeth. To simulate the chewing load and other characteristics of the oral cavity, an imitation complex is used. A crank mechanism set in motion a gypsum block with teeth fixed on C-silicone with individual steel caps. As a registration of leakage and penetration, the experiment is carried out in an aqueous solution of methylene blue, and walnut kernels are used as a chewing substrate. For two weeks, the teeth with steel caps were subjected to cyclic loads, repeating morning, lunch, and evening meals, as well as cold and hot meals. Adhesion, tightness, and penetration of cements are investigated on parallel saws under magnification.

Ključne reči
- privremeni cement
- nepropusnost
- adhezija
- penetracija
- biologija zuba
- opterećenje žvakanjem

Izvod

Ispitivana su svojstva adhezije i nepropusnosti privremenih zubnih cemenata: Eugenol-free TempoCem NE (DMG), Eugenol Repin (SofaDental), i Cinnamic Water Dentin (VladMiVa). Pomoću ovih materijala se izvodi fiksiranje pojedinačnih čeličnih krunica na biološku pripremu zuba. Za simulaciju opterećenja žvakanja i ostalih karakteristika usne duplje upotrebljava se kompleks imitacije. Mehanizam sa kolenastim vratilom pokreće pločicu gipsa sa zubima fiksiranim na C-silikon, sa pojedinačnim čeličnim krunicama. Radi detekcije curenja i penetracije, eksperiment se izvodi u vodenom rastvoru metilenskog plavog, a kao supstrat za žvakanje se koriste jezgra oraha. Zubi sa čeličnom krunicom su tokom dve nedelje podvrgnuti cikličnom opterećenju, ponavljanjem jutarnjih, dnevnih i večernjih obroka, kao i uticaju hladnih i toplih obroka. Adhezivnost, nepropusnost i penetracija cementa je ispitivana na paralelnim isečcima pri uvećanju.

INTRODUCTION

Diseases of the teeth and dentitions remain one of the main problems of modern dentistry, /1/. Damage and loss of teeth is not only a dysfunctional, /2/, (chewing disorders and the formation of food lump, loss of bone tissue, the formation of the Popov-Godon phenomenon, violation of the tooth-jaw system, the formation of traumatic bite), but also a social factor, /3/, (worsening of the patient's psychological state, decrease in working capacity, aesthetic defect). The main task of the dentist in assisting the population is to restore not only the anatomical shape of the tooth and the continuity of the dentition, but also the aesthetic parameters. Prosthetic dentistry is directly related to these criteria.

The creation of fixed orthopaedic structures carries the risk of errors at any stage of treatment, /4/, starting with the preparation of teeth and ending with the fixation of the prosthesis. Use of temporary cements create the possibility of making adjustments to the finished structure. Temporary cements play an important role in the work of the orthopaedic dentist. Despite the fact that these cements are in the oral cavity for a short period of time, the quality of orthopaedic treatment depends on them. Today there are such groups of temporary cements: based on calcium hydroxide, zinc oxide eugenol, zinc oxide without eugenol, zinc polycarboxylate, zinc-sulphate composite, /5/. The main property of temporary cements is adhesion and retention to the hard tissues of the tooth, which allows you to firmly fix the prosthesis for a short time, and also effortlessly remove the structure and then replace the cement or temporary structure with a permanent one.

The purpose is to conduct an *in vitro* study of the adhesion and tightness of temporary dental cements of various groups on the hard tooth tissues with individual steel caps under conditions of simulated chewing load. The tasks are:

1. to simulate the chewing load on the teeth, covered with individual stamped caps,
2. assess the adhesion of temporary cements in the conditions of modelling the load on them,
3. compare the tightness of temporary cements.

MATERIALS AND METHODS

For this study, 34 human teeth are prepared, removed due to periodontitis, for orthodontic reasons, as well as dystopic and impacted, /6/.

Biological preparations are done *in vitro* according to the method proposed by E.S. Erofeeva, O.S. Gilyova, /6, 7/: the teeth are washed in running water, soft tissues are cleaned with an excavator, processed with an ultrasonic scanner and a circular brush with toothpaste to remove the plaque (Detartrin, Septodont) on a micromotor tip. The prepared biological samples are stored in isotonic solution (0.9 % sodium chloride solution). The study used the teeth of the chewing group, because these teeth have a wide occlusal surface.

As a temporary fixation material, various dental cements are used, divided into groups: 12 caps are fixed on TempoCem NE, 12 caps on Repin, 10 caps on water dentin. For the experiment, we took these cements, because they are representatives of various groups of temporary cements and are also widely distributed on the market. Steel caps are made by method of combined stamping. The original apparatus is used to simulate the chewing load and a 1 % solution of methylene blue is used for recording leakage /8/.

Previously cleaned teeth are prepared by diamond burs with a turbine tip with water-air cooling under an artificial stamped crown. Stamped caps are manufactured from standard steel sleeves (Fig. 1). The peculiarity of the manufacture for this work is a tight fit to the tooth stump, thereby imitating a cast crown (Fig. 2). This technique is chosen because of the ease of manufacture, the possibility of creating longitudinal sections, because the alloys for casting (i.e. CXS) have pronounced strength properties. Using more solid alloys would be difficult to manufacture cuts, due to the strong heating of the metal, which could have led to incorrect results due to the heating of the alloy and the melting of the cement itself.

Figure 1. Group of prepared teeth.

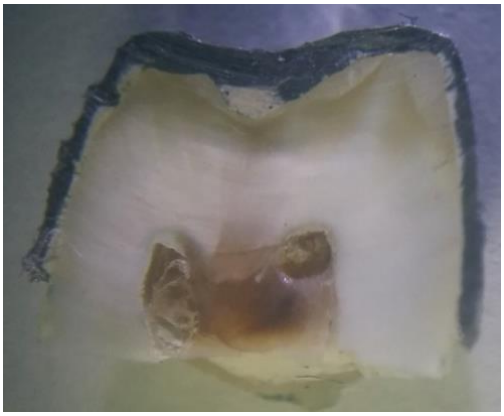


Figure 2. Steel stamped crown covering the tooth.

To simulate the chewing load, an original apparatus is created capable of developing a load of up to 30 kg. In its design, it contains an electric motor with a gearbox, which converts the rotational into reciprocating motion. With the help of a crank mechanism, the load is transferred to a gypsum platform, cast with holes for teeth from gypsum class 4 (Convertin Hart Type 4, 'SofaDental'). The upper block creates pressure due to the abutment into the lower block with imprints of teeth with crowns (Figs. 3 and 4). Thus, the original apparatus models have a 3-phase chewing movements cycle, /9/, which is of great interest because of the high load. At the base of the tank with the lower unit there are 4 strain gauges that record the instant chewing load (Fig. 4). Sensor values are projected on to the LCD display.

Figure 3. Forms from plaster: with imprints of teeth crowns (left), with fixed teeth (right).

Figure 4. Moment of pressure of the upper block on the lower block.

To simulate the retaining and shock-absorbing functions of the periodontal, the biopreparations of the teeth are fixed in a block of super-gypsum using C-silicone (Zeta Plus 'Zhermack') (Fig. 5).

Figure 5. Form of super-gypsum with fixed teeth on C-silicone.

Individual crowns are fixed on three types of cement: non-eugenic TempoCem NE (DMG); eugenol Repin (SofaDental); and zinc sulphate water dentin (VladMiVa) (Fig. 6).

Chewing modelling is carried out with a total load of 4-8 kg, (for a free-standing tooth - from 8 to 16 kg), which are average values for molars according to Denis, /9/. Due to the fact that the lower unit had teeth prints with caps, the

maximal pressure is applied to the temporary cement. Walnut kernels are used as a chewing substrate, /10/, which made it possible to simulate various types of chewing load.

The simulation was carried out in an aqueous medium tinted with a 1 % solution of methylene blue. The temperature of the liquid was varied within 25-60 °C, imitating the intake of both hot and cold food. Methylene blue is necessary for the further registration of penetration or leakage of temporary cement on the longitudinal cut.

Figure 6. Temporary cements used in the experiments.

The teeth covered with caps, for two weeks are subjected to stresses for 20 minutes three times a day, with interruptions, simulating the periods of food intake, which ultimately amounted to 14 hours. To assess the condition of temporary cements after aging, a series of longitudinal parallel teeth cuts are made on a specially prepared device. Two guides on which the carriage with a fixed tooth can move freely are connected in parallel on a rigid frame. Also, on the frame there is a fixed tip (Fig. 7). The manipulation is carried out with a diamond-coated disk under water-to-air cooling in order to prevent temporary cements from melting by friction. After each cut, the abrasive tool is replaced.

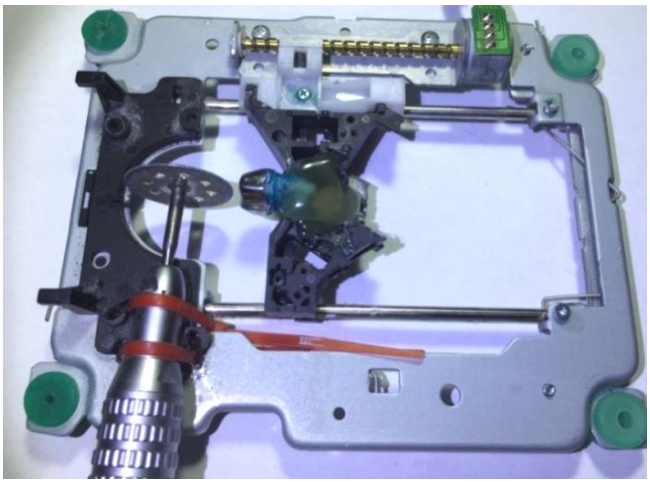


Figure 7. Longitudinal sawing of a tooth with a crown.

RESULTS AND DISCUSSION

By the end of the experiment, all the caps are on the stumps of the teeth. Palpation determined the mobility of the crown fixed to the Aquatic dentin, which indicates a violation of adhesion to hard tissues. The mobility of caps with eugenol and eugenol-free cement was not detected.

During the experiment, the impregnation of temporary cements with a solution of methylene blue is investigated. The original machine effectively coped with its task. For a better study of the properties of the cement, the saw cut was studied under a tenfold increase in lens optics, followed by shooting. It was not possible to determine more precisely, since the staining solution unevenly penetrated, but even under such conditions, a satisfactory result is obtained. The data obtained is shown in Table 1.

Table 1. Evaluation of adhesion and tightness of temporary cements.

	Tightness	Impaired adhesion to hard tooth tissues	Violation of adhesion to metal
Waterdentin	1	2	1
TempoCem NE	4	3	4
REPIN	4	4	3

Notes on used scale:

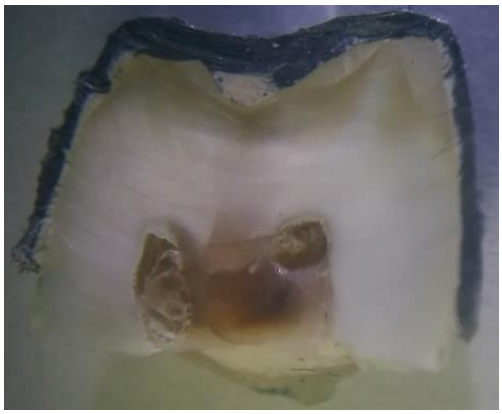
- Impregnation of cement at 0-25 % of the cement surface is designated as ‘4’; 26-50 % as ‘3’; 51-75 % as ‘2’; and 76-100 % as ‘1’.
- The presence of adhesion failure in 0-25 % is designated as ‘4’, a sign in 26-50 % as ‘3’, in 51-75 % as ‘2’, and in 76-100 % as ‘1’.

TempoCem: on cuts of 12 teeth on cement, no traces of methylene blue are found, adhesion to hard tooth tissues is not disturbed in 91.7 %. During sawing, no crown was detached from the tooth, which indicates good adhesion to the metal (Fig. 8).

Repin: not detected impregnation of cement with methylene blue. During sawing, 2 crowns (16.7 %) disintegrated, while the material itself remained on the inner surface of the crown (Fig. 9).

Water Dentin: in the study of cuts, the cement is impregnated with a solution of methylene blue, as evidenced by a light blue colour, while 7 crowns (58.3 %) disintegrated during sawing. The remains of aqueous dentin remained

mostly on hard tooth tissues (Fig. 10). Preliminary cuts at the end of the first week did not reveal changes, so this material can be used for short-term perspectives.



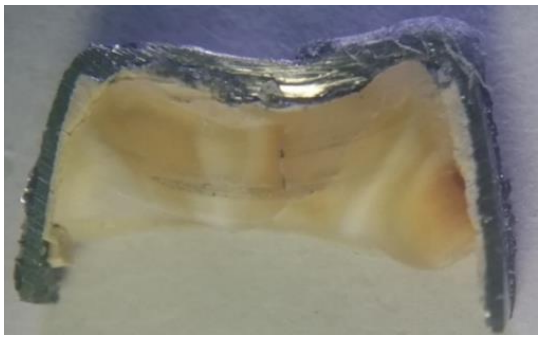


Figure 8. Longitudinal section of crowns fixed to TempoCem NE.

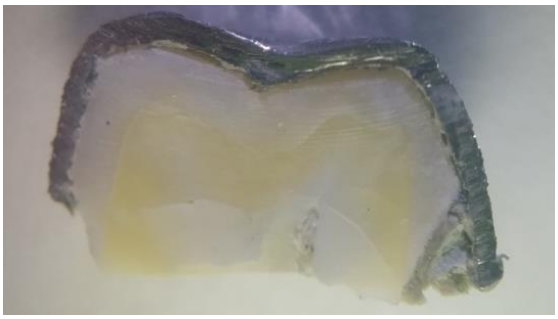


Figure 9. Longitudinal cut of the crown fixed on Repin.

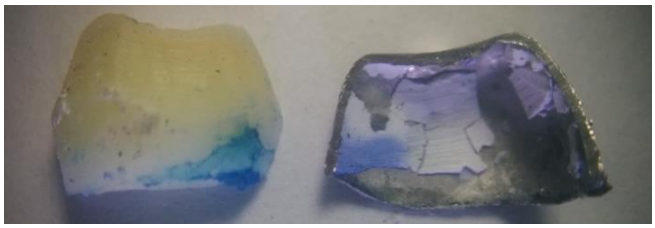


Figure 10. Longitudinal section of a crown fixed to Water Dentin.

DISCUSSION AND CONCLUSIONS

The proposed original machine allowed to simulate 3 phases of the cycle of chewing movements in the experiment. The loads experienced by stamped caps fixed on temporary cement are similar to the effects of external factors on orthopaedic structures. The results obtained allow us to conclude:

– the stamped caps fixed to the temporary cement under experimental conditions experienced a chewing load similar to the crown life cycle for 2 weeks;
– materials less susceptible to fluid penetration - Repin, TempBond NE; material that is more susceptible - Water Dentin;
– temporary cements of pronounced adhesive and hermetic properties - TempBond NE, Repin, are least pronounced in Aquatic Dentin.

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