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Investigation of Temporary Bridges Prostheses

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Modern dentistry gives possibility to rebuild damaged or removed teeth, to correct some patalogical and aesthetical defects and etc. Some procedures request intermediate operations. The usage of temporary bridges prostheses and protective crowns are the best example of these operations. The products are used for a limited time, but must rise above the crowd in following properties: strength, wear resistance, low absorption of liquids and calorific materials and etc. The main goal of this work is to investigate the maintenance properties of temporary bridges, made of the materials of different manufacturers, by estimating their resistance to the effecting powers within the time of chewing, wear resistance and liquid absorption. The following materials meant for the production of protective crowns were used: GC Unifast LC, STOMA Acryloxide, VOCO Structur2SC, 3M Protemp3Garant. The first and the second materials are based on acryloxide, and the other ones are based on composite resin. The strength, absorption and abrasion of temporary bridge prostheses, made of above-mentioned materials, were determined. The studies show that none of them meet all the required indications maximally.
Keywords: temporary (protective) bridge, protective crown, Godon/Popov phenomenon, retraction of gum, periodontal.

1. INTRODUCTION

Besides planning of treatment, preparation and production of restorations, temporary protective materials play an important role in modern restorative dentistry. These materials are used both for individual crowns and for temporary bridges prostheses (TBP) [1 – 5]. In case of treatment when temporary bridges are used the professionality of specialists and the usage of high quality materials are very important. The five types of follow materials are assigned at these days (Table 1) [6 – 8].

Table 1. Types of materials designed for crowns and temporary bridges prostheses [6 – 8]

Type	Dispensation method	Composition
Acrylic	Power/liquid	Polymethylmethacrylate (PMMA) beads + peroxide, ethacrylate monomer + activator
Acrylic	Single paste (light activated)	PMMA + monomer + light activators
Higher methacrylate	Power/liquid	PMMA beads + peroxide, isobutylmethacrylate + activator
Composite	Paste/paste	Multi-functional methacrylate + + fillers + initiators + activators
Composite	Single paste (light activated)	Multi-functional methacrylate + + fillers + light activators

The goals of treatment with temporary restorations can be defined as follows [4, 9]:

- Protection of the prepared tooth from chemical and thermal stimuli;
- Adjustment of the clench height, in case it is not enough vertical height for permanent restorations;
- Possible halting of teeth migration (the Godon/Popov phenomenon), in case the treatment is long lasting;
- Aesthetical purposes in zone of the forward teeth, in case they are removed or after preparation of hard tissues of the teeth;
- Conditional retraction of gum.

For the temporary (protective) bridge or crown to be able to perform these functions, the material of which it is made must possess certain physical properties [10 – 16]:

- Resistance to the effecting powers within the time of chewing. It is always possible to rack up the soft tissues in the mouth if a temporary bridge or crown breaks. And it is inadmissible. In case when TBP or crown break the kinetic energy of stubs and spalls must be as little as possible;
- Abrasive resistance. If the materials are not enough abrasive resistance, geometry of TBP or crown will change at the exploitation time. These parts will become thinner. Thus, the strength of prosthesis depends on degree of its abrasion. On the other hand, the height of vertical occlusion must be steady. Else the parts will miss one of theirs purposes;
- The absorption of liquids and colorific materials. It must be as little as possible because of prosthesis may change its initial color. It causes aesthetical problems – the TBP or crown in a lot of cases may look anaesthetically.

Masticatory muscle (m. masseter, m. temporalis, m. pterygoideus lateralis) can generate force up to 3.6 kN [9, 10, 12, 13]. Through teeth and periodontal this force transfers to the jaw. Thus, only strong and resistant materials can withstand such great forces.

In this study TBP were analyzed with the aim to compare some mechanical properties of the popular materials, used by odontology specialists in Lithuania.

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2. THEORETICAL CONSIDERATION

The complex dynamic loads act on temporary prostheses and crowns within the time of chewing. At the most cases TBP breaks close to the fix points. Those points are supporting teeth. A load force F compresses supporting teeth (Fig. 1). This force generates a bending moment M around the supporting tooth. Thus, the supporting teeth are not only compressed, but they are bent too.

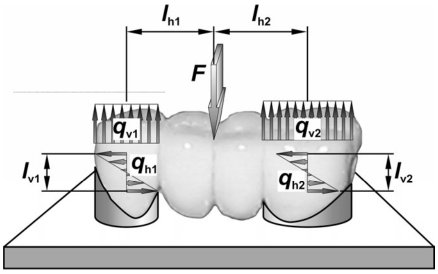

Fig. 1. Simplified scheme of TBP loads

Two main reactions F_v and M, acting in TBP can be separated. Those reactions influence on location of above-mentioned breaking zone. The reaction F_v is complicatedly distributed on horizontal surface of the supporting tooth. Thus, approximately this load q_v can be calculated

$$q_{vi} = \frac{F \cdot l_{hi}}{A_{hi} \cdot (l_{hi} + l_{hj})}, \text{ N/mm}^2, \quad (1)$$

where F is the concentrated load force, N; i is the number of point which is under consideration (if $i = 1$, then $j = 2$, and if $i = 2$, then $j = 1$), l_{hi} and l_{hj} are the distances between force and axes of supporting teeth, mm; A_{hj} is the average area of horizontal surface of supporting tooth, mm^2.

The bending moment M generates horizontal reaction F_h of supporting tooth. Similarly to the vertical reaction F_v, this reaction is not concentrated. It acts along the line where TBP and supporting tooth is in contact. The distribution of this load is complicated too. Approximately horizontal reaction q_h can be calculated

$$q_{hi} = \frac{2 \cdot F \cdot l_{hi}}{l_{vi}^2}, \text{ N/mm}, \quad (2)$$

where l_{vi} is average length of contact line between temporary bridge and supporting tooth, mm.

The vertical loads cut temporary bridge, and reaction of bending moment splits it. Thus, if the temporary protective materials are more fragile than plastic, then it is possible the TBP will break due to shear load (vertical directed loads). If these materials are more plastic than fragile, then it is possible the TBP will break due to split forces.

3. EXPERIMENTAL

3.1. Preparation procedure

The following materials meant for the production of protective crowns have been used: GC Unifast LC (manufacturer GS), STOMA Acryloxide (manufacturer STOMA), VOCO Structur2SC (manufacturer VOCO), 3M Protemp3Garant (manufacturer 3M). The first and the second materials are based on acryloxide, and the other ones are based on composite resin. GC Unifast LC is light cured acrylic resin, and the chemical setting process is natural for the other three materials.

The specimens of temporary bridge prostheses and the holder of TBP were produced according scheme shown in Fig. 2.

The patients teeth were prepared by using an individual spoon and silicone transfer material. Using this transfer the exemplary gypsous model (EGM) was made. The EGM was used for the check of TBP manufacturing precision. At the next step the gypsous moulds of supporting teeth models were produced using the transfer. A teeth technician used these moulds to produce models of supporting teeth and stand. The stand was fixed into tensile machine FP 10/1 with reverse. Force measure scale was used up to 1 kN.

3.2. Test procedure

The plane-bending model applied to determine strength of the bridges [17, 13]. Only vertical directed forces F were fixed. Any other forces, which act in a mouth within chewing time, were not simulated and fixed.

The changes of load and deflection magnitudes were fixed within the whole period of loading.

All TBP specimens were divided into four groups. The first group of TBP was used for initial strength tests. The specimens after 24 hours since manufacturing were loaded by bending.

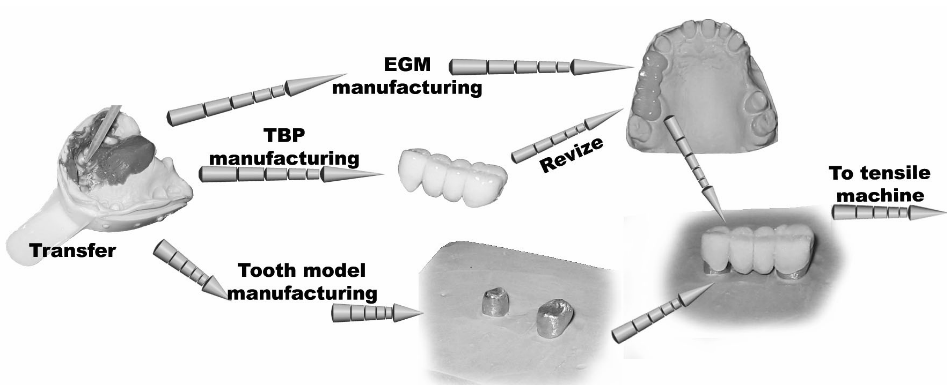

Fig. 2. Simplified scheme of TBP and utilities production

It is much more important to know the change of TBP strength after they were in a mouth. In this purpose, the second group of TBP after 24 hours since manufacturing for two weeks was put into solution containing pH, analogue to that available in the mouth (~pH 6.5). This period is optimal. Throughout this time dentist can prepare teeth, and teeth technician can make the steady restorations (in some cases the time may vary up to 6 months) [5, 9].

One of the most important TBP functions is the regeneration of aesthetical view and food bite off, especially when the forward group teeth are under regeneration. In point of aesthetics it is very important the temporary prosthesis will not change color in a mouth. The change of color is observed when temporary protective materials absorb colorific materials that are included into food products.

In purpose to qualify absorption dynamics the third group of TBP specimens were soaked in solution with pH 6.5. The periods of the soak were 12 hours, 40 hours, 88 hours, 208 hours and 336 hours. TBP specimens were weighed by electronic scale after the every soak. Insulating material covered the inner surfaces of TBP, because of in a mouth these surfaces contact only with supporting teeth and not with liquid.

The fourth group of TBP specimens was used for filing tests. Filing of bridges has been performed using a special stand, imitating the grinding movements taking place during the chewing process. The wear of the chewed surface has been registered. 100 cycles were executed. Every cycle contains 100 clockwise and counterclockwise movements. The compression force was constant and equal to 49 N.

Abrade was executed into abrasive with No P320. Specimens were weighed by electronic scale after the every cycle.

4. RESULTS

The geometrical parameters of TBP were measured and are shown in Table 2.

Table 2. The geometrical parameters of TBP according to equations (1) and (2)

Parameter	Value
Average area of horizontal surface of supporting tooth:	
A_{h1}, mm^2	73
A_{h2}, mm^2	42
Distance between force and axes of supporting tooth:	
l_{h1}, mm	10
l_{h2}, mm	9
Average length of contact line between temporary bridge and supporting tooth:	
l_{v1}, mm	4.3
l_{v2}, mm	3.5

Horizontal and vertical reaction forces were calculated (equations (1) and (2)) for all materials in both supporting tooth at the fracture moment. The main results are presented in Table 3.

Table 3. Horizontal and vertical reactions in supporting tooth

Material	State	q_{v1}, N/mm^2	q_{v2}, N/mm^2	q_{h1}, N/mm	q_{h2}, N/mm
STOMA Acryloxide	Dry	2427.7	3797.6	18655	16790
	Soaked	1839.3	2877.2	14133	12720
3M Protemp3Garant	Dry	2530.7	3935.7	19447	17502
	Soaked	2123.8	3322.3	16320	14688
VOCO Structur 2SC	Dry	2312.5	3617.5	17770	15993
	Soaked	2227.9	3485.1	17120	15408
GC Unifast LC	Dry	1324.3	2071.5	10176	9158
	Soaked	1150.4	1799.6	8840	7956

Materials based on acryloxide were sensitive for vertical (shear) forces q_{vi}, and materials based on composite resin – for horizontal (split) forces q_{hi}. Thus may be explained the character of fracture for both type materials (Fig. 3). Especially, this character was clear for the soaked specimens.

Temporary bridges made of 3M Protemp3Garant demonstrated the greatest force of fracture, while the smallest fracture force and rise was of those made of GC Unifast LC, 974 N and 509 N, respectively (Fig. 4). The strength tests of soaked specimens show, that the greatest strength change was for STOMA Acryloxide (24.24 %), and the least was for VOCO Structur2SC (3.66 %). The strength of TBP made of GC Unifast LC and 3M Protemp3Garant after the soak change was 13.13 % and 16.08 %, respectively.

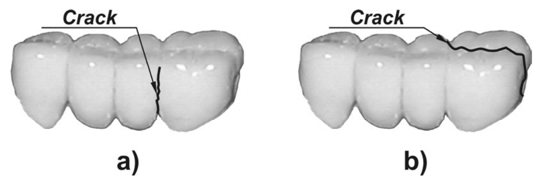

Fig. 3. Character of fracture of TBP made of materials based on acryloxide (a) and composite resin (b)

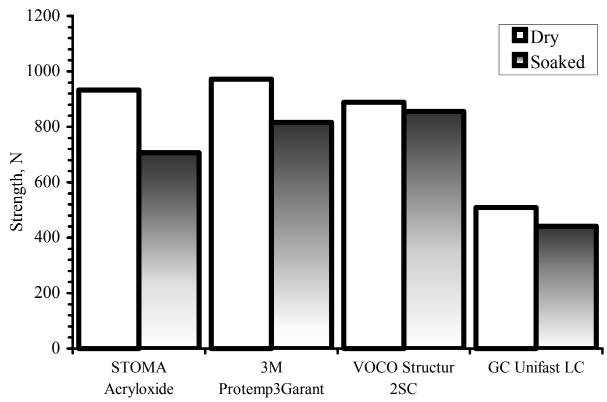

Fig. 4. Strength of temporary bridge prostheses

Character of specimen fracture was observed too. From clinical point of view it is very important to know how TBP breaks, because of stubs and spalls can rack up the soft tissues in the mouth, especially if they are sharp.

The most plastic character of fracture was observed for STOMA Acryloxide. The most fragile were TBP made of materials based on composite resin: VOCO Structur2SC, 3M Protemp3Garant. The stubs and spalls of these materials were very sharp. Visually was observed, that all spitted spalls have great kinetic energy. The most acute were the parts, splintered off from specimens made of 3M Protemp3Garant.

The absorption dynamics was estimated after 0 hours, 12 hours, 40 hours, 88 hours, 208 hours, and 336 hours (Fig. 5). It was determined that the greatest absorption was characteristic to STOMA Acryloxide, while the smallest – VOCO Structur2SC. The difference was even 1300 %. The mass change after soaking was: for STOMA Acryloxide – 3.21 %, for GC Unifast LC – 1.77 %, 3M Protemp3Garant – 0.82 % and for VOCO Structur2SC – 0.25 %.

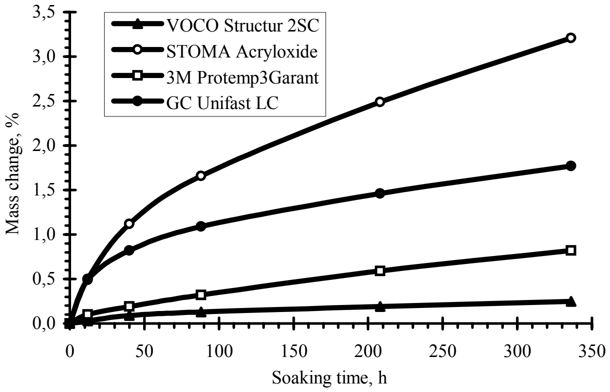

Fig. 5. Kinetics of TBP absorption

The least and the greatest abrasion was for STOMA Acryloxide (0.67 %/10000 cycle) and VOCO Structur2SC (0.84 %/10000 cycle), respectively (Fig. 6). The difference of resistance to abrasion between these materials was 26.4 %. The difference of resistance to abrasion between STOMA Acryloxide and GC Unifast LC was insignificant (1.35 %), and difference between STOMA Acryloxide and 3M Protemp3Garant presents 20.37 %.

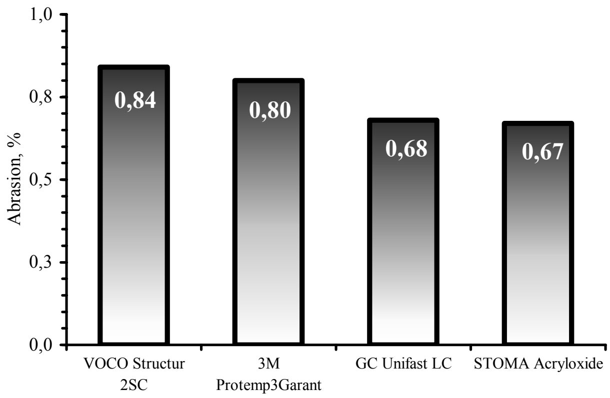

Fig. 6. Abrasion of temporary bridge prostheses

CONCLUSIONS

1. After complex assessment of the properties of GC Unifast LC, VOCO Structur2SC, 3M Protemp3Garant and STOMA acryloxide, it can be concluded that none of them meet all the required indications completely.
2. VOCO Structur2SC, based on composite resin, demonstrated the best maintenance properties of the studied materials.
3. Clinically dangerous and undesirable side effect – acute edges of the splintered off particles – visually were observed in the great number of specimens of all materials. Especially, VOCO Structur2SC demonstrated other negative effect – large kinetic energy.
4. It was determined, that the biggest absorption was for STOMA Acryloxide, and the smallest for VOCO Structur2SC. The difference was up to 1300 %.

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