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An adhesion of acrylic teeth to various materials intended for the production of removable dentures

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ABSTRACT: Aim of this study was to define the connection between different types of acrylic resin and teeth made of polymethyl methacrylate.Material and methods: Three types of heat polymerizable materials, ProBase Hot, Villaryl H Plus and Superacryl Plus, and 3 types of self-cure ProBase Cold, Villacryl SP, and Duracryl Plus materials were used in the study. Materials wereconnected to one typeof acrylic teeth which surface were change, using mechanical expansion of the surface with retention holes and chemical surface treatment by wash the surface with monomers for 120 sec. This adhesion was tested after 24 hours and 30 days of storage samples in distilled water.Results: There were not statistically different in adhesion between heat curing and self-curing materials. After storage in distilled water for a longer period of time, the strength of the bond between the acrylic materials and the teeth are reduced by about 5%. In all cases, a cohesive type of connection was observed.Conclusion and clinical significance: In fact, the connection between the acrylic tooth and the denture plate is not dependent on the type of material, but on the method of preparing the denture by grinding the tooth surface, using retention elements and washing the tooth surface with monomer.

Key words: tooth adhesion, self-curing acrylic resin, heat curing acrylic resin

I. INTRODUCTION

Acrylic resins are one of the most used materials in dental prosthetics. They are used, among others, for the production of removable dentures, temporary crowns and bridges, removable orthodontic appliances and repair of these restorations in the event of their damage [1]. Until recently, in literature it is possible to find quite a clear information on the use of materials. Thermally polymerized materials were used to make dentures and self-cure materials were recommended for their repair [2,3]. In the last decade, however, in the articles and on the internet (web side of producer, YouTube), attentive readercan find more and more information about the production of removable dentures with the use of pouring material, which according to the classification are polymerizing materials at low temperatures (up to 65^{o}C) [4,5]. A careful observation make it possible to discover variations between thermally polymerized materials and resin used for pouring techniques [6]. For this it is important to ask, what will be the connection between the teeth and the denture plate when using these two different types of acrylic materials [7].In the literature, exist information's on the connection of acrylic teeth with the denture plate, both in the case of heat and cold polymerized materials, but the information is not fully consistent. In the other side, there are many acrylic materials on the market, and the information contained in the literature concerns only acrylics of a few leading manufacturers, not considering local markets and products popular there [7,8,9].

It is interesting therefore to investigate the connection between acrylic teeth and different types of acrylic materials. On beginning of this work it was performed literature studies to find key information's on the correct connection of acrylic teeth with the denture base [7-10].

The informations show, that such adhesion can be increased in two ways by using of physical factors: thorough boiling of the wax, extension of the tooth surface with tools or sandblasting, or retention elements [7,9,11]. The second group of factors includes chemical treatments, the main task of which is to dissolve the surface layer of polymethyl methacrylate (PMMA) on the surface of the teeth. This can be done with the use of various types of bond, acetone, chloroform or, most often, methyl methacrylate (monomer) [12-14].

The aim of this study was to determine the strength of connection of acrylic teeth to the surface of the denture base made of 6 different acrylic materials.The hypothesis put forward at the beginning of this work was that there was a

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difference in the connection between low and high temperature polymerized PMMA.

II. MATERIALS AND METHODS

Six different acrylic materials, two from each manufacturer, were used to investigate the connection between the acrylic teeth and the denture plate. One material from each producer was suitable for polymerization at high temperatures (conventional), the other for polymerization below 65^{o}C under pressure, but recommended by the manufacture for pouring technique for the production of removable dentures. The reference materials were ProBase Cold and Hot (Ivoclar Vivadent, Lichtenstein), compared to Villacryl Hot and Villacryl SP (Zhermapol Poland) as well as Spofacryl Plus and Duracryl Plus (Spofa Dental, Czech Rep.). Information's on the types of materials and methods of their polymerization are presented in Table 1.

To investigate the connections between different acrylics, one type of acrylic teeth (Dentex, color A3 Zdunska Wola, Poland) was used to eliminate other the dependence factors.

To test the connection, the methodology described in the ISO 20795-1:2013 standard [15] was used, consisting in the polymerization of acrylic material in a cuvette together with gypsum. First, the acrylic teeth are embedded in the wax plate - Ceradent Wax (Spofa Dental, Czech Rep.). which was then placed in the polymerization cuvette and poured over with Stodent III plaster (Zhermapol, Poland).

Based on information from the literature the correct connection of acrylic teeth with the denture plate, it is necessary to remove the wax in proper way. During this study Ceradent was removedfrom cuvette through a 10-minute-long boiling in hot water(using calibrated stopwatch and a thermometer). After boiling the wax, the plaster surfaces and the acrylic teeth embedded in it were first washed with a 5% water solution of dishwashing liquid (Ludwik Veritas, Poland) and then twice with 200 ml of hot water (temperature 95^{o}C) to thoroughly remove wax residues from the surface of the plaster and teeth acrylic.

In order to obtain a proper connection between the acrylic teeth, and denture plate is necessary to combine physical and chemical factors.The surface of each tooth was ground with a carbide drill (Komet, Germany) and additionally a conical retention element was made in each tooth (Figure 1).

Then the gypsum surfaces were covered twice with the Izosol gypsum-acrylic separator (Zhermapol, Poland), paying special attention not to let the insulator get onto the surface of the acrylic teeth. After the separator had dried, the monomer from heat curing materials was applied

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twice to the surface of acrylic teeth. The time of interactions between methyl methacrylate and tooth surface was 120 seconds, which was measured with a certified stopwatch (Figure 2).

Figure 2 Surface of acrylic teeth are washed with monomer

In the meantime, acrylic materials have been prepared, by mixing the powder with the liquid in the proportion recommended by the manufacturer. In the case of self-cure materials, the material was poured into a plaster mold after 2 minutes. Heat cure materials were placed in a plaster mold after 15 minutes, when they did not stick to the vessel wall or to the hands.

The cuvettes with thermally polymerized materials were pressed in a press under a load of 2500 kg for a period of 15 minutes and polymerized in hot water. The temperature and polymerization time for each material are shown in Table 1. The self- cure materials were polymerized in the Ivomat (Ivoclar Vivadent) according to the manufacturer's recommendations (Table 1).

Form each material was made of 2 plates with 6 teeth (12 plates, 60 incisors) Figure 3. After polymerization and removal from the plaster molds, the plates were stored in distilled water at 37 °C in a calibrated laboratory dryer. After 24 hours, the first plate was removed and subjected to breaking force with a deviceVaclav Lapka, Brno Czech Republic, calibrated until November 2023.

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The second plate was stored for 30 days at 37C. Distilled water was replaced every 7 days with new portions.

Figure 3. Acrylic resin connected to the wax plate

Table 1 Material used for testing

Material and producer	Type	Polymerization
Probase Cold (Ivoclar Vivadent)	Self-cure	2 g powder/ 1g liquid, Polymerization is carried out in a pressure device at 40°C and at 6 bar pressure for 15 minutes.
Probase Hot (Ivoclar Vivadent)	Heat cure	2.2g powder/ 1 g liquid Heat up to 100 °C and let boil for 45 minutes.
Villacryl Hot (Zhermapol)	Heat cure	2.4 g powder/ 1 g liquid, water at temperature 60°C. Heat it up for 30 minutes to reach temperature 100°C. Maintain it at boiling for 30 minutes
Villacryl SP (Zhermapol)	Self-cure	10g powder 6.7 g liquid, 20 minutes in water having temperature 65°C under pressure 2 bars
Superacryl Plus (Spofa Dental)	Heat cure	2.2g powder/ 1 g liquid. Temper up to 70°C within 30 minutes. Keep the temperature during the next 30 minutes. Increase the temperature on 100°C within 30 minutes. Keep the temperature for the further 30 minutes.

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Duracryl Plus (Spofa Dental) Self -cure	2g powder/ 1g liquid. Water 55°C, 30 minutes, pressure 3 bar

The statistical analysis was performed as Two Way Anova with post-hoc Tukey HSD (Honestly Significant Difference) Test Calculator using an unmodified tooth sample as a reference. The p <0.05 coefficient was adopted as the confidence level. Free software from the website was used for statistical processing (https://astatsa.com/OneWay_Anova_with_Tukey HSD/).

III. RESULTS

The test results for the connection between acrylic resin and denture plate are summarized in Table 2.

Table 2 Connection between acrylic teeth and acrylic materials.

Material and producer	Adhesion force after 24 hours [N]	Adhesion force after 30 days [N]	Type of connection
Probase Cold (IvoclarVivadent)	129.67±10.31	123.42±10.33	cohesive
Probase Hot (Ivoclar Vivadent)	151.33±7.78	147.61±8.85	cohesive
Villacryl Hot (Zhermapol)	145.26±8.44	138.51±9.39	cohesive
Villacryl SP (Zhermapol)	135.83±9.31	127.23±8.31	cohesive
Superacryl Plus (Spofa Dental)	144.21±7..94	135.12±9.23	cohesive
Duracryl Plus (Spofa Dental)	131.21±8..56	124.17±6.15	cohesive

The conducted test shows that the Dentex acrylic teeth are attached to each of the tested acrylics. The joints are of the cohesive type, which means that the joint breaks either to the tooth structure or to the structure of the acrylic material. The connection weakens slightly under the influence of storage in water, but this is not statistically significant. Greater adhesion was observed in the case of high temperature polymerized material, but it is not statistically significant.

Figure 4 Cohesive type of adhesin between acrylic teeth and plate

IV. DISCUSSION

The thesis presented at the beginning of this work was only partially confirmed. Materials polymerized in hot water by boiling have greater adhesion to the denture plate, but it is not statistically significant [7.9,10]. Over time, when the samples are stored in water, there is a slight weakening of the connection between the teeth and the denture plate [11]. According to many authors, this is due to the fact that water penetrates into the acrylic [16,17]. In in vivo tests, it is very common to notice the formation of a micro-gap between the acrylic tooth and the denture plate. Dyes from

consumed food penetrate it and can also be a habitat for various types of microorganisms [18].Therefore, it is very important to obtain the right connection, both chemical and mechanical, between the surface of the acrylic tooth and the denture [7,8,13].

Numerous authors pay attention to three very important matters which may affect the connection between the teeth and the prosthesis.At the beginning it will be the correct proportions of mixing the powder with the liquid (according to the manufacturer's recommendation). Too much monomer leads to too much shrinkage during polymerization, which can cause stress at the tooth-denture base boundary and consequently weaken the joint Which over time can lead to tooth loss [19].

The second very important thing is the proper boiling of the wax, what was tested by Choudhry at al.The remaining rests of this material staying at the boundary of the acrylics act as an insulator, preventing a chemical bond. When insulating a gypsum with acrylic separator, it is very important not to apply the insulator to the surfaces of the teeth [20].

Finally, the third factor determining the correct connection is the use of mechanical retentions by grinding the surface of the prosthesis and making retention elements in the form of an inverted cone [7, 21].Also, the application of the monomer to the surface of acrylic teeth causes a partial dissolution of PMMA, which creates chemical bonds between the tooth and the polymerized acrylic material. According to Vallittu et all, the time of monomer contact should be from 120-180 sec, so that methyl methacrylate has enough time to penetrate between the polymethacrylate chains and create new chemical bonds during polymerization [12,21].During this work, I tried to follow all these recommendations and therefore a proper connection was obtained between the acrylic teeth and the denture plate made of various types of acrylic materials [22].

V. CONCLUSIONS

- The material for thermal and self-cure polymerization is combined with acrylic teeth in a cohesive manner.
- This force is slightly reduced over time as a result of the absorption of water by the material.

Conflict of interest None

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