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COMPARATIVE ANALYSIS OF WATER SORPTION BY DIFFERENT ACRYLIC MATERIALS

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Acrylic materials are used daily for the production of mobile dental restorations and orthodontic appliances. The presence of residual monomer, as a product of incomplete polymerisation of material, results in more porous structure of the material, which greatly reduces the mechanical and physical quality of the acrylic restorations and increases the absorption of liquids. The aim of this study was to examine the water absorption of different types of resin material. In the study it was assumed that the cold polymerized acrylates show a greater potential for absorbing fluid from the environment in relation to the hot polymerized acrylic. The study included two hot and two cold polymerized acrylates, and cold polymerized acrylate impregnated with aesthetic pearls. In order to determine the degree of water absorption, the mass of the samples was measured before and after one day, seven days and thirty days of immersion in a water bath of body temperature. The tested hot and cold polymerized acrylates after immersion in water bath showed standard values of water absorption. The degree of water absorption was not significantly influenced by the type and manner of polymerisation. Water absorption values were significantly higher after seven days and thirty days of water storage relative to the observational period of one day. *Acta Medica Medianae 2014;53(2):5-9.*

Key words: *resin material, water sorption*

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Introduction

Acrylic materials largely meet the requirements set by the profession, and for decades are used to create mobile dental restorations and orthodontic appliances. Acrylic based resins are intensively used in dentistry as restorative practice, liners or as denture base materials. These materials can be classified as cold, heat or light polymerized depending on the factor that initiates the polymerization reaction.

To integrate acrylate reimbursement in the orofacial system and smoothly carry out its function, it should possess adequate mechanical and physical properties, i.e. flexural strength, modulus of elasticity, impact strength, microhardness, water absorption and solubility (1,2). Physical and mechanical properties vary among different groups of acrylic, which is a result of differences in their chemical structure, the model and the length of the polymerization process (3-5). The presence of residual monomer results in a more porous structure of the material, which greatly reduces the quality of resin restorations, the strength and modulus of elasticity and increases the sorption of liquids and solubility (6-12).

The aim of this study was to examine the water sorption of various types of acrylate materials. In the study it was assumed that the cold polymerized acrylates show a greater potential for absorbing fluid from the environment in relation to the hot polymerized acrylate.

Material and methods

Two heat and two cold curing acrylic based resins were tested in this study. Their characteristics are listed in Table 1. In the study, Ortotopli material was used, impregnated with glittering sequins (OI), which are in practice applied to orthodontic mobile dentures for aesthetic reasons.

The aluminium rectangular-shaped patterns (50 x 15 x 2 mm) were invested in denture flasks with dental plaster. After the setting of the plaster, the flasks were opened and the patterns removed, leaving rectangular-shaped multi-piece cavities that were used as matrixes for the fabrication of acrylic resin specimens. After mixing the acrylic resin according to the manufacturers' instructions, the molds were filled with the resins and polymerized (Table 2).

Table 1. Acrylic based resins tested

Product	Code	Manufacturer	Powder/Liquid ratio	Composition		Polymerization condition
				polymer	monomer	
Triplex Hot	TH	Ivoclar Vivadent, Lichtenstein	23.4g/10ml	PMMA	MMA EDGMA	45 min in boiling water
Lucitone 199	L	Dentsply International Inc. USA	21g/ 10ml	PMMA	MMA	90 min at 72°C+30 min in boiling water
Triplex Cold	TC	Ivoclar Vivadent, Lichtenstein	13g/10ml	PMMA	MMA EDGMA	In pressure device at 40°C, 2-6 bar, 15 min
Ortopoli	OP	PoliDent	Spray-on technique	PMMA	MMA EDGMA	In pressure device at 30-40°C, 6 bar, 10-15 min

PMMA-Poly(methyl methactylate); MMA- methyl methactylate; EDGMA-ethylene glycol dimethacrylate

Table 2. Experimental design

Experimental group		Observation period
S1	Storage in water bath at 37 ° C (GFS, Germany)	24 h, i.e. 1 day
S7		7 days
S30		30 days

Water sorption is the increase in volumetric mass of acrylic resins per unit volume. Water sorption was calculated in accordance with ISO specification 1567, except for specimen's dimensions and period of water immersion. Immediately after polymerization, the specimens were dried in the desiccator in the oven at 37°C. Specimens reached constant mass (m_1) (variations were less than 0.2 mg). Volume / mm^3 (V) was calculated for each sample. Specimens were immersed in distilled water at 37°C for 1, 7 and 30 days. After this period the samples were left at room temperature for 30 minutes and weighed in an analytical balance and reconditioned to constant mass (m_2). Water sorption (WS) was calculated in micrograms per cubic millimetre by the formula:

$$WS=(m_1-m_2)/V$$

Statistical analysis

The data were statistically analyzed with one-way analysis of variance (ANOVA), with statistical significance set at $p < 0.05$.

Results

Water sorption amount after immersing water is summarized in Table 3 and shown graphically in Figure 1. As can be seen, the lowest water sorption was obtained after one-day soaking the specimens made from resin material L (0.7±0.67 μg/mm^3) and highest one after thirty-day soaking the specimens made from resin material OP (25.1±1:05 mg/mm^3). Also, there was no significant difference after 7 and 30 days of soaking the specimens made from TC resin material.

Table 3. Water sorption

Acrylic resin	Water storage	Water sorption μg/mm^3	
		Mean	SD
TH	S1	1.7	0.33
	S7	19.4	0.5
	S30	24.5	2.47
L	S1	0.7	0.67
	S7	20.7	0.94
	S30	22.5	0.55
TC	S1	0.8	0.55
	S7	17.2**	1.91
	S30	20.2**	2.66
OP	S1	1.1	0.29
	S7	21.1	1.92
	S30	25.1	1.05
OI	S1	1.2	0.55
	S7	20.1	2.08
	S30	23.8	2.02

** Groups which are not significantly different ($p > 0.05$).

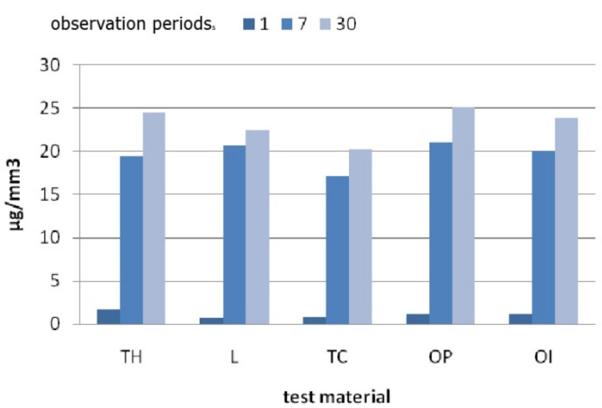

Figure 1. Mean values of water sorption after water storage

Discussion

In order to assess the influence of type of acrylate on the degree of water sorption its values were measured after one-day, seven-day and thirty- day soaking the material samples in distilled water at body temperature and thus the conditions which exists in the oral cavity were simulated during a prolonged period of time. The study included two hot and two cold polymerized acrylates, as well as the modification of one of cold polymerized acrylate. Determining the level of water absorption after three observational periods of water storage of samples of different acrylic materials, indirectly was done a comparative analysis of the degree of their polymerization, and therefore the mechanical quality. Namely, in order to avoid possible harmful biological effects of acrylates in the oral cavity and to improve the mechanical properties of the material, poli-merization should be more complete. The denser networks of polymers have a lower ability of water absorption, and it can be used as a measure of the degree of polymerization and cross-linking (13).

Nonpolymerized (residual) monomer is continuously released into the oral cavity. It has been found that water molecules may be able to penetrate inside the polymer matrix and act as a plasticizer, thus decreasing mechanical properties of acrylic resins. Water absorbed into the material acts as and plasticizer and decreases their mechanical properties (6,12). Absorbed water reduces the hardness and strength of the polymer, but also has a positive effect in the release of internal stresses within the acrylates (1,6,12). Water enters the polymer network due to its porosity, and the amount and rate of absorption depends on the density of the network, potential hydrogen bonds and polar interaction tests (14).

According to ISO 1567, the increase in volumetric mass of acrylic resins per unit volume (water sorption) should not exceed 32μg/mm^3 (15).

The study results confirmed water sorption within the allowed limits for all tested materials, and the degree of water absorption is not significantly affected by the type of tested acrylates. In contrast to obtained results, Jagger et al. and Pheiffer et al. demonstrated a significantly higher water absorption with cold polymerized materials, which can be explained by their less homogeneous structure and a higher content of residual monomer (9,16). The lack of solid cold polymerized acrylates is their physical-mechanical inferiority relative to all other types of acrylates. Inhomogeneous internal and surface structure is the result of faster and incomplete polymerization (17-19). Due to the porosity and presence of significantly greater amount of residual monomer compared to other acrylic materials, cold poly-merized acrylates show a lower hardness, strength, resistance to fracture, and bending, as well as higher solubility, water absorption and release of potentially toxic components (7,18,20,21).

Values of water absorption were statistically significantly increased with the increase in the length of the observation period. Nearly twentyfold increase of these values after seven days compared to one-day water storage speaks in favour of more intensive release of residual monomers and consecutive absorption of the surrounding fluid in the first days of wearing acrylic fees or orthodontic appliances, which is consistent with previous studies and findings of other authors (10,12,22). Minor differences in the values of water absorption after seven days and thirty day immersion in water bath is an evidence of stabilization of release of residual monomer, and thus of water absorption.

It has been found that a cold polymerised impregnation of acrylates in order to improve their mechanical characteristics increases the absorption of water, and possibly weakens the structure of materials. Particles in a variety of colours and patterns are added to the a cold polymerised acrylates immediately after mixing the main components (liquid and powder) with the aim of making aesthetically pleasing braces for children. On the other hand, the connection between the particle and the acrylate is not chemical, so with their addition the compactness of the mass is reduced, which possibly potentiates the release of large amounts of residual monomer and higher water absorption. Addition of various particles and fibers within the structure of the acrylate significantly improves their mechanical properties, although the authors refer to the adhesive material imperfections and described armature (9,23).

Dimensional changes of restorations made from acrylates are theoretically possible, and due to absorption of water during the polymerization process and during their usage (24,25). The absorption of fluids from the oral environment in solid acrylate material is negligible and a slight expansion caused by it while wearing dentures cannot be considered responsible for imprecise fit of denture on supporting tissues (12,24).

Conclusion

The tested hot and cold polymerized acry-lates after immersion in water bath showed standard values of water absorption. The degree of water absorption is not significantly influenced by the type and manner of poly-merization. Water absorption values were signi-ficantly higher after seven days and thirty days of water storage relative to the observational period of one day.

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UPOREDNA ANALIZA APSORPCIJE VODE OD STRANE RAZLIČITIH AKRILATNIH MATERIJALA

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Akrilatni materijali se svakodnevno koriste za izradu mobilnih zubnih nadoknada i ortodontskih aparata. Prisustvo rezidualnog monomera, kao proizvoda nepotpune polimerizacije materijala, dovodi do poroznije strukture materijala, što bitno smanjuje mehaničko-fizički kvalitet akrilatnih nadoknada i povećava apsorpciju tečnosti. Cilj rada bio je ispitivanje vodene apsorpcije različitih tipova akrilatnih materijala. U istraživanju se pošlo od pretpostavke da hladni polimerizovani akrilati pokazuju veći potencijal za apsorpciju tečnosti iz okruženja u odnosu na toplo polimerizovane akrilate. Ispitivanje je obuhvatilo dva toplo i dva hladno polimerizovana akrilata, kao i hladno polimerizovani akrilat impregniran estetskim perlama. U cilju određivanja stepena vodene apsorpcije merena je masa uzoraka pre i nakon jednodnevnog, sedmodnevnog i tridesetodnevnog potapanja u vodeno kupatilo telesne temperature. Ispitivani toplo i hladno polimerizovani akrilati su nakon potapanja u vodeno kupatilo pokazali standardne vrednosti vodene apsorpcije. Stepen vodene apsorpcije nije značajno zavisio od vrste i načina polimerizacije materijala. Vrednosti vodene apsorpcije bile su značajno veće nakon sedmodnevnog i tridesetodnevnog potapanja u vodu u odnosu na jednodnevni opservacioni period. *Acta Medica Medianae 2014;53(2):5-9.*

Ključne reči: *akrilatni materijali, vodena apsorpcija*