Artificial tooth and polymer-base bond in removable dentures: the influence of pre-treatment on technological parameters to the bond's strength

Vez med umetnim zobom in polimerno osnovo v snemljivi zobni protezi: vpliv tehnoloških parametrov pred-obdelave na trdnost nastale vezi

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Abstract: The aim of this study was to evaluate the artificial tooth and polymer-base bond, and to measure any formed gaps between tooth and base. Acrylic models were classified into four groups depending on the type of surface pre-treatment. A pre-treatment of the surface combining mechanical and chemical procedures led to the highest bond strength between the acrylic tooth and the denture-base. The fore-mentioned pre-treatment had a significant influence on gap formation with an average value of 68.250 μm, which is 70 % of the gap for the untreated samples. Furthermore, the measured compressive strength was above 6000 N/mm^2, yet only 3200 N/mm^2 on the untreated samples.

Izvleček: Študija predstavlja raziskavo nastale vezi med umetnim zobom in polimerno osnovo z meritvijo nastale špranje med zobom in osnovo. Za ta namen so bili pripravljeni akrilatni modeli, ki smo jih uvrstili v štiri skupine in sicer v odvisnosti od vrste površinske pred-obdelave. Površinska pred-obdelava, ki je predstavljala kombinacijo mehanske in kemijske, omogoča nastanek trdne vezi med akrilnim zobom in polimerno osnovo. Takšna pred-obdelava ima velik vpliv na nastanek špranje s povprečno vrednostjo 68,250 μm, kar predstavlja le 70 % velikosti špranje, ki je nastala pri neobdelanem vzorcu. Še več, rezultati meritev tlačne trdnosti za vzorec s pred-obdelavo kažejo vrednosti nad 6000 N/mm^2, medtem ko smo pri neobdelanih vzorcih izmerili le 3200 N/mm^2.

Key words: bond, acrylic tooth, polymer base, technological parameters
Ključne besede: vez, akrilni zob, polimerna osnova, tehnološki parametri

Technical paper

INTRODUCTION

The acrylic resin is the most commonly used artificial resin in dentistry. Most mobile dentures over the last 60 years had been created by conventional polymerization. Acrylic materials and the process of polymerization have been modified in the last 10 years, which has consequently resulted in better physical-chemical properties[1]. This has been achieved by adding certain chemical substances, and changing the process of polymerization by adding light and microtalamic energy[2]. Significant research work has shown that almost 30 % of all repairs are due to mistakes during tooth-denture base bonding[3,4]. Consequently, this study focused on the evaluation of various treatments' influences on bonding quality between the denture-base and the artificial tooth, the measurement of gaps between the acrylic tooth and the denture base using an optical or electronic microscope, and the determination of mechanical properties by compressive testing.

MATERIALS AND METHODS

Four groups containing 12 acrylic models with the same dimensions were formed for evaluating the bonds between acrylic teeth and a denture-base (Gnathostar, Pro Base HOT, Ivoclar-Vivadent). The base surfaces of the acrylic teeth were prepared in four different ways as described later. The models were inserted in a brazen mould filled with gypsum. The mould was closed and placed into boiling water after the gypsum had hardened, in order to melt the wax. Then the mould was opened, the elastomer-base removed, and the remains of the wax cleaned.

Finally, 12 special acrylic models (3 for each group) were created for compressive testing with internal dimensions of 20 mm × 9 mm.

Surface Conditioning Methods

Sample A, the surface was untreated and cleaned with 70 % ethyl alcohol (10 seconds), degreased and placed above boiling water (10 seconds). The cleaned tooth was placed on an elastomer-base.

Sample B, the surface coming into contact with the acrylic base was mechanically prepared using a 3M-8691C paper grinder (3M Dental, Pithiviers, France). This paper grinder was pulled over the contact surface twice.

Sample C, the surface was cleaned and moistened using monomer. The model was then left to dry at room temperature. The procedure was repeated after drying.

Sample D, the surface coming into contact with the acrylic base was mechanically prepared, cleaned and moistened using monomer (20 seconds). The model was then left to dry at room temperature. The procedure was repeated after drying.

A heat-polymerized cyclic resin (Pro Base HOT, Ivoclar-Vivadent, Schaan, Liechtenstein) was prepared and polymerized according to the manufacturer's instructions. The mixed acrilate mixture was left in a closed container at room temperature (23 °C) for 8-10 minutes, and then applied in the mould. The mould was then exposed to a pressure of 2×10^7 Pa (200 bar). The samples were thermally polymerized (at 65-70

°C for the first 45 minutes and at 100 °C for the next 45 minutes). The mould was left for 30 minutes at room temperature and was then completely cooled in cold water. The completely cooled mould was opened and the models extracted, cleaned and polished.

Specimens' preparation

The specimens (Figure 1) for microscopic analysis were prepared using an *ISOMET slow rotation saw*, abrasive diamond paste (3-9 μm), and special paper grinders. Alcohol and ultrasound were then used for cleaning. The prepared models were analysed using a light-inverse *NIKON Epiphot 300 microscope*. The selected models were also analysed with a (SEM) – *Sirion 400 NC scanning microscope* for visualisation of the microstructure. The size of each gap was measured on six different spots.

Compressive testing

Pressure testing was performed on a *Zwick/ Roell Z010* pressure machine. The compressive tests were supposed to establish any influence of the surface preparation procedure and resulting border surface on the point tooth – denture-base regarding pressure from chewing forces that dental prostheses pass-on to the jaw segment during their function in the oral cavity. The problem in this case was specific, since molar teeth were chosen for testing, which are only subjected to direct pressure forces. Special supports were created so that the models could be fixed into the machine, and the supports were placed in such a way as to simulate the occlusal relationship between the upper and the lower teeth in the mouth (Figure 2).

Figure 1. Acrylic model after its removal from the mould, prepared for microscoping
Slika 1. Akrilni model po odlitju, pripravljen za mikroskopijo

Results

Gap-width and compressive strength depend on the type of mechanical-chemical pre-treatment. The results for measured gap width (Figure 3) show (A (x = 88-105 μm) > B = C (x = 68-86 μm) >D (39-66 μm)) justify the hypothesis on homogenous variances (Test of Homogeneity of Variances, ANOVA) (Table 1 and 2). It confirms that there are statistically significant differences between all four sample groups. In addition, the compressive test results show differences between samples A(3200 N/mm^2)<C(5800 N/mm^2)<B(6000 N/mm^2)<D(6050 N/mm^2).

Conclusions

It can be concluded from the acquired results that the thickness and width of the gap depend on the type and mechanical pre-treatment of the tooth's surface. Microscopic examinations show that there is no statistically significant difference between roughened models and those wetted with a monomer, but there is one between rough-

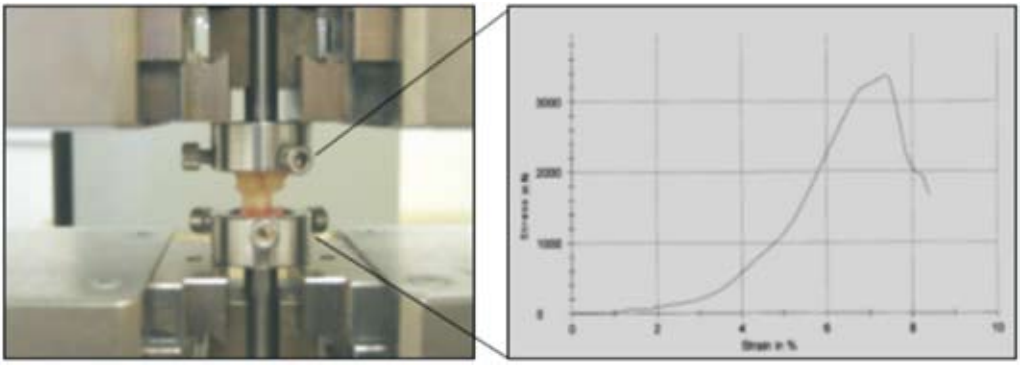

Figure 2. Compressive testing and typical σ-ε diagram for sample A
Slika 2. Tlačni preizkus in tipični σ-ε diagram za vzorec A

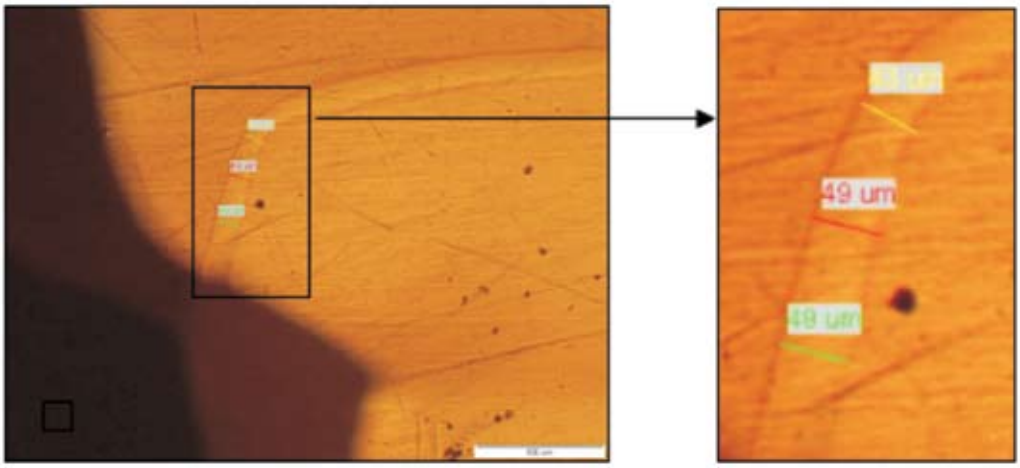

Figure 3. Schematic survey of measuring points at a micro-level
Slika 3. Shematski prikaz meritvenih točk na mikro-nivoju

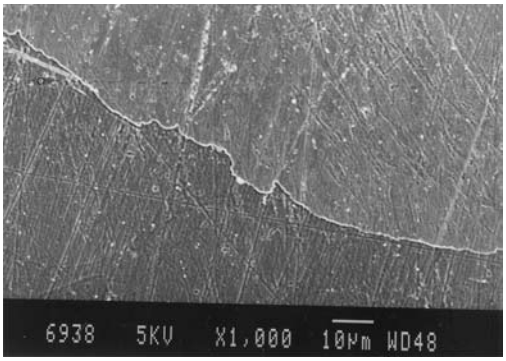

Figure 4. SEM picture of the sample D
Slika 4. SEM fotografija vzorca D

Table 1. Test of Homogeneity of Variances
Tabela 1. Test homogenosti varianc

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
v_edge	1,550	3	44	,215
v_200	,044	3	44	,988
v_curve	3,210	3	44	,032
v_centre	2,930	3	44	,044
v_max	,563	3	44	,642
v_min	4,660	3	44	,006

Table 2. Two-way ANOVA of gap dimensions
Tabela 2. Dvo-smerna ANOVA za dimenzije špranje

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
v_edge	Between Groups	7580,333	3	2526,778	68,110	,000
	Within Groups	1632,333	44	37,098		
	Total	9212,667	47			
v_200	Between Groups	8947,083	3	2982,361	64,679	,000
	Within Groups	2028,833	44	46,110		
	Total	10975,917	47			
v_curve	Between Groups	9813,729	3	3271,243	167,935	,000
	Within Groups	857,083	44	19,479		
	Total	10670,813	47			
v_centre	Between Groups	6634,833	3	2211,611	32,697	,000
	Within Groups	2976,167	44	67,640		
	Total	9611,000	47			
v_max	Between Groups	8575,729	3		28,510	,000
	Within Groups	4411,750	44	2858,576		
	Total	12987,479	47	100,267		
v_min	Between Groups	9950,396	3	3316,799	137,086	,000
	Within Groups	1064,583	44	24,195		
	Total	11014,979	47			

ened and monomer wetted models, and untreated models. Those models prepared by roughening and wetting with a monomer had the most homogenous structure and the smallest gap (Figure 4). Border surfaces showed that untreated samples often have faults, such as porosity, and discord between border surfaces, which then have a strong influence on the quality of any bond between an artificial tooth and denture-base.

Consequently, gap thickness has an influence on the mechanical characteristics of a sample, there are namely they are inversely connected, the higher the gap-width, the lower the compressive strength of the artificial tooth and the polymer-base model.

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POVZETEK

Vez med umetnim zobom in polimerno osnovo v snemljivi zobni protezi: vpliv tehnoloških parametrov pred-obdelave na trdnost nastale vezi

Vez med umetnim zobom in polimerno osnovo v snemljivi zobni protezi je eden od glavnih dejavnikov, ki vpliva na kvaliteto in funkcijo končnega izdelka ter ima tudi pomembno klinično vlogo.

V predstavljeni *in vitro* raziskavi je bila merjena in primerjana špranja, ki nastaja na mestu vezi med umetnim zobom in polimerno osnovo v snemljivi zobni protezi. Raziskava je zajemala vzorce, ki so bili izdelani na štiri različne načine.

Rezultati raziskav so pokazali, da je najmanjša izmerjena špranja na tistih modelih, kjer je bila kontaktna površina mehansko obdelana in navlažena z monomerom. Statistična obdelava dobljenih rezultatov je pokazala, da so meritve pri obdelanih površinah statistično nižje kot pri neobdelanih. Posledica le teh je večja špranja in oslabljena vez na kontaktni točki, kar je seveda pomemben statistični pokazatelj.

Na podlagi navedenega lahko zaključimo, da je potrebno kontaktne površine med umetnim zobom in polimerno osnovo mehansko in kemično obdelati, kljub splošno znanim izkušnjam iz stomatološke prakse, ki zagovarjajo le nujnost mehanske obdelave (retencije).

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