

STUDIES REGARDING THE WETTABILITY OF ACRYLIC AND SILICONE DENTAL MATERIALS

CRISTINA TEODORA PREOTEASA¹, SULTAN ABDULLA NABIL¹,
LĂCRĂMIOARA POPA^{2*}, MIHAELA VIOLETA GHICA²,
ECATERINA IONESCU¹, ANA MARIA CRISTINA ȚÂNCU¹, ELENA
PREOTEASA¹

¹ *University of Medicine and Pharmacy "Carol Davila", Faculty of
Dental Medicine, 19 Plevnei str., 010232 Bucharest, Romania*

² *University of Medicine and Pharmacy "Carol Davila", Faculty of
Pharmacy, 6 Traian Vuia str., 020956 Bucharest, Romania*

**corresponding author: lacramioara.popa@gmail.com*

Abstract

The evaluation of the biomaterials by clinical and experimental tests represents an important and necessary aspect for the success of dental treatments and for obtaining a real biological integration, meaning optimal tolerance and functionality. The objective of this study was a comparative estimation of the wettability of the surface for several types of materials currently used in dentistry (soft and hard acrylic materials and silicone ones). Seven commercial products were chosen and for each of them there were made 5 specimens, which were analyzed by the contact angle method. According to our results, the self-cured hard acrylic materials showed the smallest contact angle, followed by the soft acrylics, the heat-cured hard acrylic materials and the silicone materials. The characteristics of the materials from the point of view of their wettability can be an advantage, as well a disadvantage, accurate information related to the particular characteristics of each case being essential conditions when choosing the optimal therapeutic solution.

Rezumat

Evaluarea biomaterialelor, prin teste clinice și experimentale, reprezintă un aspect important și necesar pentru succesul tratamentelor medicale dentare precum și pentru obținerea unei integrări biologice reale, în sensul toleranței și funcționalității optime. Obiectivul prezentului studiului a fost aprecierea comparativă a capacității de udare a suprafeței mai multor tipuri de materiale cu utilizare curentă în medicina dentară (materialele acrilice moi, rigide și siliconice). Au fost alese 7 produse comerciale și s-au realizat 5 specimene pentru fiecare, acestea fiind analizate prin metoda unghiului de contact. În urma determinărilor realizate, materialele acrilice rigide autopolimerizabile au prezentat unghiul de contact cel mai mic, urmate de cele acrilice moi, cele acrilice rigide termopolimerizabile și materialele siliconice. Caracteristicile materialelor din punct de vedere al capacității de udare a suprafeței poate fi atât un avantaj, cât și un dezavantaj, o bună cunoaștere a lor în corelație cu caracteristicile particulare ale fiecărui caz, fiind condiții esențiale ale alegerii soluției terapeutice optime.

Keywords: acrylic, silicone, contact angle, wettability, dental materials.

Introduction

The oral health condition represents a key element in assuring the “well-being” of a person and is the central point of the present perception of the World Health Organization regarding health [7]. The tooth decay, periodontal disease, edentulousness and dental malpositions may have negative loco-regional consequences, may affect the self esteem together with the lowering of social interactions and damaging of life quality [1,5,8,9,14]. In many cases the dental interventions imply the use of materials which get into direct or indirect relation with the oral structures. Within this frame, the evaluation of the biomaterials, by clinical and experimental tests represents an important and necessary aspect for the success of the dental treatment and also to obtain a real biological integration, meaning optimal tolerance and functionality.

Nowadays, the removable prosthetic treatments and the orthodontic ones are more and more frequently used [2]. Among the most used biomaterial categories within this frame of treatment are the soft and the hard acrylic materials and also the silicone ones. These are used to make the total and partial dentures, the removable orthodontic appliances and for their adaptation and optimization by tissue conditioning and soft and hard relining for a long or short period of time [13]. Taking into account their use, sometimes for a long time or during the oral structures’ healing, it is necessary to have an optimal biocompatibility (meaning a low cytotoxicity and microbial loading), as well as optimal biomechanic features, stable for a long time.

An inadequate retention of the mentioned dental appliances may be associated to the masticatory, phonetic and aesthetic deficiencies with negative influences on the oral and general health, the perception of the self, with social and psychological implications. Within this frame, an important characteristic in assuring the integration of this type of materials is the wettability, with a role in the process of adhesion. This is a key element in denture’s retention, in keeping the appliance in a correct relation with the oral structures, as well as for the comfort of the patient with the oral appliance.

The objective of the present study was the comparative estimation of the wettability of the surface of several types of materials currently used in dentistry, with increased frequency in prosthodontics and orthodontics. This feature was studied comparatively for soft, hard acrylic materials, and silicone ones, as well within the frame of the same category of material taking into account the subclasses with various curing mechanisms. A better knowledge of these features may help to understand some oral pathological

aspects which were noticed, as well to select the adequate materials, with positive consequences regarding their morpho-functional integration.

Materials and Methods

There were used seven commercial products which corresponded to three types of materials used in orthodontics and removable prosthodontics: hard acrylic, soft acrylic and silicone materials. (Table I). *The hard acrylic materials*, based on polymethylmethacrylate (PMMA), are the most used in making the removable dentures and removable orthodontic appliances, as well as for their relining and repairing. Depending on the way of manufacture, there are chemical cured, heat cured and light cured variants. The materials are under the form of bicomponent products, powder and liquid, with chemical cure or heat cure and they are hard at the end of the cure. *The soft acrylic materials* are used for temporary relining, for tissue conditioning, as well as for functional impression. Like the hard ones, they are under the form of powder and liquid and after the cure they remain plastic and elastic. *The silicone materials* are used for temporary relining (indicated in certain cases, as after implant placement or in the presence of prominent, aching muco-osseous zones). They are usually used for a longer period of time as compared to the previous ones. They are under the form of a paste and after the cure they remain elastic, but not plastic.

Table I

The selected commercial products, with details about the type of material and indications.

Commercial product (Producer)	Type of material	Usage
Duracryl® (<i>Spofa Dental</i>)	Self cure hard acrylic material	Dentures and orthodontic devices repair Direct and indirect denture relining
Superacryl® (<i>Spofa Dental</i>)	Heat cure hard acrylic material	Denture base Removable orthodontic appliances base Indirect relining
Prothyl Hot® (<i>Zhermack</i>)		
Viscogel® (<i>Dentsply De Trey GMBH</i>)	Soft acrylic material	Tissue conditioning Direct and indirect denture relining for short and medium period of time
GC Tissue Conditioner® (<i>GC Europe</i>)		
Elite Soft Relining® (<i>Zhermack</i>)	Silicone material	Elastic denture relining for short and medium period of time
Mollosil® (<i>Detax GmbH</i>)		

Sample preparation

For each product there were made 5 specimens, resulting 35 samples. In order to get samples with smooth plane surface, compatible with the chosen analysis method, these were prepared according to the indications of the producer and then put on a microscope slide. In order to reduce the errors and to raise the fairness results, the specimens were codified and then registered and the research team was blinded (they did not know what material was analysed).

Contact angle determination

The contact angle (θ) method represents a quantitative technique for evaluating the wetting of a solid by a liquid (wettability), being linked to another phenomenon like adhesion. It is geometrically defined as the angle made by the liquid drop at the border of the three stages: liquid, solid and gaseous (Figure 1a and b). Low values indicate a good wettability, while as the angle increases the wettability decreases. Contact angle measurements were performed with KSV Instruments CAM 101 experimental device equipped with high speed digital video camera C 200 – HS (KSV – Finland) [4]. Measurements were made using liquid distilled water (density 0.9986 g/cm³) in the air (density 0.0013g/ cm³) at the room temperature ($t=20^{\circ}\text{C}$). There were used drops with small volume as the effects of misrepresentation due to the gravitation are minimal. There were registered values of the contact angle for 45 seconds continuously at every 5 sec.

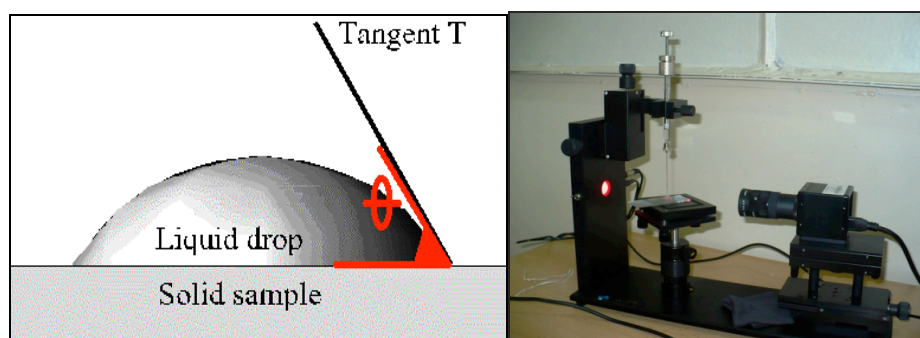


Figure1

a. Contact angle (θ) **b.** KSV Instruments CAM 101 device

Statistical analysis

The data analysis was made using Statistical Software, version 11. The values for the contact angle were reported as mean $\pm$ standard deviation (SD). Kruskal Wallis nonparametric test was used for variance by ranks

analysis between groups corresponding to the analyzed materials. After Kruskal Wallis analysis across 7 groups, Mann Whitney test was applied between each pair of groups for mean values comparison, performing multiple *post hoc* comparison.

Results and Discussion

According to the measurements performed, the self cured hard acrylic materials showed the smallest contact angle, followed by the soft acrylic ones and heat cured hard acrylics. The highest values of the contact angle were noticed for the silicone materials (Table II). The volume of the drop was $5.35 \mu\text{Å}$ (SD 1.42). Ranks were significantly different among the 7 commercial products ($p < 0.001$). As a result of *post-hoc* comparisons we noted that the contact angle values among the commercial products belonging to the same material category with the same curing mechanism did not show statistically significant differences, except the silicone materials Mollosil[®] and Elite[®] ($p = 0.009$). There were no statistically significant differences between the self cured hard acrylic materials and the soft acrylic ones. As for the other categories of materials, there were statistically significant differences regarding the contact angle values.

Table II

Contact angle values and analysis of the differences between the materials

Commercial product		Contact angle	Statistical differences between materials						
		mean $\pm$ SD	1	2	3	4	5	6	7
1	Duracryl [®]	75.97 $\pm$ 3.77							
2	Superacryl [®]	84.81 $\pm$ 1.14	*						
3	Meliodent [®]	85.19 $\pm$ 1.74	*	NSS					
4	Viscogel [®]	77.34 $\pm$ 3.87	NSS	*	*				
5	Tissue Conditioner [®]	76.44 $\pm$ 3.67	NSS	*	*	NSS			
6	Mollosil [®]	98.44 $\pm$ 3.77	*	*	*	*	*		
7	Elite [®]	96.50 $\pm$ 3.09	*	*	*	*	*	*	

SD – standard deviation

* - materials that were significantly different at the $p = 0.05$ significance level

NSS – not significant

A proper wettability represents a favorable aspect in denture retention, and also for maintaining the prosthetic device in a correct relation with the oral structures while performing functions. A good wettability is usually associated to a hydrophilic character, these representing useful features in forming the surface saliva film and in getting the dimensional stability of the dentures by counter-balancing the contraction occurred after the curing. Also it favors the intra-oral adaptation by decreasing the friction

with the oral mucosa and increasing the patient's comfort. At the same time, for patients with hyposialia, who develop a lower tolerance regarding the denture wearing, a material with a low contact angle is recommended. In many cases the patients who get these types of treatment are either older patients, with a precarious immunity, susceptible for infections, or children. In both cases, frequently, the oral and appliance hygiene is deficient and thus, the treatment may be a risk factor in the appearance of stomatitis [10-12]. On the other side, the increased hyposialia is a disadvantage because it develops conditions for the adherence and development of microbial germs, favoring the appearance of surface biofilms. The hydrophilic character contributes to the decreasing of the mechanical resistance of the device in time by a degrading process, increasing the risk of fractures as well as favoring discolorations. Thus, through a good knowledge of the features of the materials related to the particular characteristics of each case, the dentist can choose the best therapeutic solution.

The studies on this topic within the scientific literature [3,6,15] are very few and the results are not uniform regarding the contact angle values: for self cured hard acrylics 73.4° and 75°; for heat cured acrylic materials 75.356°, 68.7°, 77.4° and between 71.8° and 77.3°; for soft acrylic materials 85.625° and 59.9°-69.6°; for silicone materials 119.990° [3] and 63.9° and 81° when a varnish is used [16]. Yet we must mention that from the commercial products analyzed in these studies, we only used one in our research, namely Mollosil®. Thus we can say that the silicone materials develop a greater contact angle than the acrylic ones [17], but as for the values of the soft and hard acrylics the opinions are contradictory.

The present study showed the contact angle values of some materials frequently used in prosthodontics and orthodontics, that may be a decisive parameter when choosing the type of material.

Conclusions

The materials used for dentures or orthodontic appliances base, develop different wettability and hydrophilic/hydrophobic character. The smallest contact angle values were registered for the acrylic materials for hard and soft relining, with average values for long term acrylics. The highest values were registered for the silicone materials. The acrylic materials behavior used in soft and hard relining explain the increase of adhesion and retention, developed after relining, as well as the microbial adherence and the occurrence of denture stomatitis. The acrylics behavior for relining or conditioning, completes the range of their disadvantages which limit the duration of their use.

Taking into account the features mentioned above, the soft acrylic materials can be, successfully used for a correct relationship with the oral structures during impression maneuver.

The silicone materials, through their hydrophobic character, develop a more reduced wettability and microbial adherence than the soft acrylics. This explains the possibility of their long term usage. There should not be neglected the chemical composition and their behavior in the oral environment. The more reduced microbial adhesion of the silicone materials explains their indication after implant placement. Also, the soft acrylics are indicated in temporary relining, tissue conditioning and the impression phase.

Accurate information on the difference of the wettability between materials may help for a better choice of the most indicated relining materials in different medical situations like hyposialia (soft acrylic materials are more indicated than the silicone ones).

The range of values of the wettability for the hard acrylics lead to an accurate choice of these materials, taking into account the oral environment and the saliva flow particularities.

References

1. Baniță M., Pisoschi C., Stănculescu C., Mercuț V., Scrieciu M., Hâncu M., Crăițoiu M., Phenytoin-induced gingival overgrowth – an immunohistochemical study of tgf-β1 mediated pathogenic pathways, *Farmacia*, 2011, 59(1):24-33.
2. Centers for Disease Control and Prevention. Total tooth loss among persons aged > or = 65 years-selected states, 1995-1997. *MMWR*. 1999; 48(10):206-10.
3. Jin N.Y., Lee H.R., Lee H., Pae A., Jin N.Y., Lee H.R., Lee H., Pae A., Wettability of denture relining materials under water storage over time, *J. Adv. Prosthodont.*, 2009; 1(1):1-5.
4. KSV Instruments, Operating Manual for Contact Angle and Surface Tension Determination, 2008.
5. Melescanu Imre M., Preoteasa E., Buzea M.C., Preoteasa C.T., Implant based overdenture-a piece within an ethical domino, *Romanian Journal of Bioethics*, 2009; 7(4):62-67.
6. Nishioka M., Yamabe Y., Hisatsune K., Fujii H., Nishioka M., Yamabe Y., Hisatsune K., Fujii H., Influence of polishing of denture base resin and metal surfaces on wettability with water and saliva, *Dent. Mater. J.*, 2006; 25(1):161-5.
7. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19 June - 22 July 1946.
8. Preoteasa C.T., Ionescu E., Preoteasa E., Comes C.A., Buzea M.C., Grănescu A., Orthodontically induced root resorption correlated with morphological characteristics, *Rom. J. Morphol. Embryol.* 2009; 50(2):257-62.
9. Preoteasa E., Preoteasa C.T., Meleşcanu-Imre M., Iosif L., Tancu A.M., Nabil Sultan A., Influența statusului general asupra stării de sănătate orală la edentatul total, *Rev. Med. Milit.*, 2010; CXIII (4), 11-18.
10. Preoteasa E., Iosif L., Amza O., Preoteasa C., Dumitrașcu C. Thermography, an imagistic method in investigation of the oral mucosa status in complete denture wearers, *J. Optoelectron. Adv. Materials*, 2010; 12 (11) : 2333-2340.

11. Preoteasa E., Ionescu E., Bencze A., Preoteasa C.T., Considerations regarding the treatment with total dentures for patients with hyposalivation. A clinical case, *Rev. Med. Chir. Soc. Med. Nat. Iași*, 2006; 110(2):449-55.
12. Preoteasa E., Ionescu E., Băncescu G., Băncescu A., Preoteasa C.T. Epidemiologic aspects of the edentulous mouth (II). General and local features of the totally edentulous mouth, *Bacteriol. Virusol. Parazitol. Epidemiol.* 2005; 50 (1-2):27-34.
13. Preoteasa E., Meleşcanu Imre M., Preoteasa C.T., Marin M., Lerner H. Aspects of Oral Morphology as Decision Factors in Mini-Implant Supported Overdenture, *Rom. J. Morphol. Embryol.* 2010; 51(2):309-314.
14. Popa L, Negrei C, Neagoe IV, Albulescu L, Preoteasa V., Bălănescu A.R., Ghica M.V., Manda G., Pro-inflammatory signal delivered *in vitro* by leflunomide active metabolite A77 1726 on abnormal peripheral monocytes in rheumatoid arthritis, *Farmacia*, 2010, 58(5): 546-558.
15. Zissis A.J., Polyzois G.L., Jagger R.G., Waters M.G. Wettability of visible light-curing denture lining materials, *Int. J. Prosthodont.*, 2001; 14(3):250-4.
16. Zissis A., Yannikakis S., Jagger R.G., Waters M.G., Wettability of denture materials, *Quintessence Int.* 2001; 32(6):457-62.
17. Waters M.G., Jagger R.G., Polyzois G.L., Wettability of silicone rubber maxillofacial prosthetic materials, *J. Prosthet. Dent.*, 1999; 81(4):439-43.

Manuscript received: March 12th 2011