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Improvements to Biomaterials Structure Used in Acrylic Prostheses

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Abstract. *Achievements in the field of biomaterials have as a basis three scientific domains: chemistry, biology and physics, then the technical application or " the putting up " culminating with clinical achievements. Dental prostheses, regardless of their type, replaced the lack of teeth. Although, mainly, many people that lost their teeth could continue life with the help of prostheses in a way pretty decent, dental prostheses shows some disadvantages that make them even unbearable for some people. The study aims at analyzing the biomechanical behavior of sandwich type structures that reunite the classic acrylate and a silicone layer, namely the Flexite type elastic acrylate. We used a silicone material, RUBBER 732 RTV, which is frequently used in mucous-bone support deficits, especially in oral maxillofacial surgery post interventions. The tensile strength was tested on **a** TEXTENSER traction test machine, in view of establishing the mechanical analysis of the 2 materials used. Regarding the maximum tensile strength for sandwich-type test samples, the flexible acrylate - silicone RUBBER 732 RTV structure broke at 1125N, while for the classic acrylate – silicone material a fracture value of 950N was recorded. The structure of the two biomaterials within the sandwich type test samples decisively influences the force and tension at which the fracture occurs, as well as the fracture route, which is linear, without the displacement of fragments, both the flexible acrylate and the silicone being affected, respectively a linear route at the level of the acrylic structure, affecting the acrylate – silicone interface for the classic acrylate – silicone test samples.*

***Keywords**: biomaterials, acrylic protheses, pattern.*

1.Introduction

By biomaterial one may comprehend a synthetic material used to replace a part of a living system, or for the work in close relation with an alive tissue; biomaterial is "an inert substance from the point of view of systematic and pharmacology, set to be implanted for the coexistence of it, together with the systems of living." On the contrary, the biological material is a material such as would be the structure of the bone or tooth enamel, produced by a biological system. The most customary and well-known are the metallic biomaterials which are polycrystalline compounds, usuallyinorganic: metal oxides (alumina), carbides, hydrides, refractory sulphides, selenides. The main bio ceramics are used, in particular in dentistry: crowns tooth, for a particular aesthetics, resistance higher to compression and lack of reaction in the fluids of the body human [1]. Composite biomaterials are formed from two or more phase distinct, with properties different from the homogeneous material. The material for addition of a composite can have the form of particles, fibres, or strips [2]. Dental biomaterials, in addition to the mechanical and chemical resistance, need not to contain toxic elements dispersed in the general movement, elements of potentially allergic, or the effect of carcinogenesis.

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From the point of view of mechanical resistance and the reaction of the neighbouring tissues, titanium meets the best requirements of the living organisms that come in contact. With the discovery of bioactive synthetic biomaterials, in 1970, particularlywith ceramics or phosphate glasses and use them as bone implants, the possibility has occurred that it can improve the quality of dental implant. Polymeric materials with improved durability have important applications as dental materials. Teeth bases and artificial teeth are two major areas in which polymeric materials are used. In addition to this, they are used in various applications such as facets of bridges and crowns, support structures, implants, waxing, abutments, temporary crowns, endodontic fillings, athletic protection of mouth and orthodontic devices for maintenance of the space between the teeth, etc.

The polymeric materials presented in dentistry are of the type of acrylic resins being used in waxing. These materials have an irritating effect on the mucosa and pulp, the polymerization contraction is high, the handling difficult and the cost high. Dental dentures are, usually, used if an entire tooth arch is missing [3]. If there are only a few teeth left, it is necessary a partial prosthesis. In general, dentures have a basis for fixing acrylic. The quality of the fastening base of the prosthesis with polymer or polymers, synthetic depends on the necessary temperature during the process of realization [4].

The process of polymerization is crucial for the properties of the prosthodontic device. Mechanical properties including an increasing resistance depend on the procedure of processing and the quality of the agent used. At an ambientaltemperature, the material is brittle and transparent. At the temperature higher than the transition temperature, the material tends to be softened and becomes viscoelastic. The presence of pores and the fissures of the surface as well as the internal defects, usually, affects the resistance to torsion of the material. The transfer material of prosthesis may be a consequence of shocks or usage. Failure impact is due to the effort of the material, and the failure to follow the usage is due to the flex ring of material that generates cracks. Partially acrylic prosthesis, from the point of view of the embodiment technology is very accessible. This accessibility justifies the frequency of the indication, of the manufacture. It has a low-cost price, because it is possible to be made in any dental technology laboratory, in a relatively short time and also from materials that do not require a cost too high [5].

The partially acrylic prosthesis is composed of several elements, each having a well-defined function. All the component elements are intimately solidified and form a solid, rigid, non-deformable body, resistant to masticatory pressures. The component elements are only theoretically individualized, in order to be described schematically, to follow a certain order.

The elaboration of a dental prosthesis, in particular a partially attached dental prosthesis, must take into account all the morphological particularities of the prosthetic field, the quality of the dental-periodontal support, of the bone and muco-periosteum, of the local and distance changes caused by the state of unimaxilar or bimaxilaredentation, the functional changes, the state of the patient and also his psychic [6].The degree of mouth opening is another factor that must be considered, particularly when designing an acrylic prosthesis for patients with a history of head and neck cancer. In such cases, the approach used for tumor removal, the method of reconstruction, as well as the postoperative radiotherapy often result in a degree of limited mouth opening [7], anatomical local changes influencing the retentivity of the prosthetic field, as well as changes in the quality of the oral mucosa. All those factors will interfere with impression taking, the insertion and removal of the prosthesis, as well as the actual wear. Thus, the technological phase of obtaining an acrylic prosthesis must be as accurate as possible, for reducing the occurrence of errors that may result in a poor adaptation of the prosthesis on the already challenging and deficient prosthetic field.

2. Materials and methods

The study aims at analyzing the biomechanical behavior of sandwich type structures that reunite the classic acrylate and a silicone layer, namely the Flexite type elastic acrylate. We used a silicone material, RUBBER 732 RTV, which is frequently used in mucous-bone support deficits, especially in oral maxillofacial surgery post interventions. The tensile strength was tested on **a** TEXTENSER traction test machine, in view of establishing the mechanical analysis of the 2 materials used.The creation of the test

samples of classic acrylate plus RUBBER 732 RTVsilicone, namely flexible acrylate and silicone followed the classic laboratory stages, special attention being paid to the proper choice of packing sinks, namely the mold.Their size($\alpha_{1,}\alpha_{2)}$ had the following parameters: (thickness 0.5cm, length 10cm, width 2 cm).In view of conducting the comparative analysis of the tensile strength, classic and flexible acrylate test samples were used, respectively (Figure 1).

Figure 1. Aspects of making samples

The manufacturing algorithm aimed at packing the wax molds which in a first stage were packed in Moldano type gypsum and in the second stage of packing – the molds were packed in lab sinks, followed by the preparation of the mold and its isolation with IsoplastIp. In the last stage the component materials are injected, namely polymerized.

3. Results and discussions

The experimental determination of the material elasticity constants. The shearing trials to determine the G transversal elasticity module led to the following results (Table 1).

Table1. Results regarding the elasticity module for analyzed samples

	α_1	α_2
b(mm)=the width of the sample	3	2.8
h(mm)=the height of the sample	13.4	12.6
S_0(mm^2)=the section where the sample fracture occurs	40.2	35.28
$\sigma_{max}=F_{max}/S_0=500N/S_0$ (N/mm^2) maximum force	12.43	14.172

The load on test sample 1 was limited at F_{max}=210N since the creeping phenomenon was observed (the increase of deformation at constant load): when the machine was stopped to read the deformation (at the high value of force: at 150 and 200N) the load showed a decrease with a speed of approximately 5B/sec, which shows that the test sample was elongating (Figure 2).

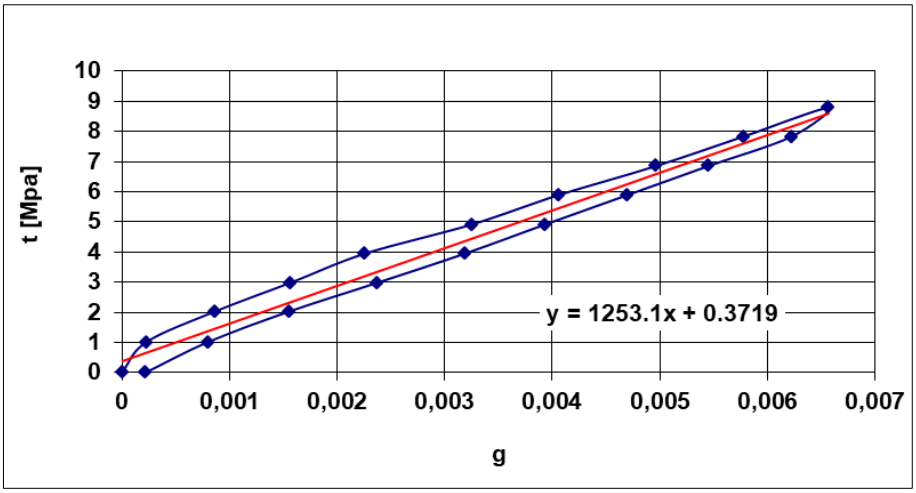

Figure 2. The deformation characteristics of Sample α_1

Regarding the load on test sample 2, we observed a relatively slow creeping speed and it decreases if the material is stressed repeatedly. A strain hardness is observed, similar to metallic materials.

An important aspect is represented by the resistance of the test sample which represents the sandwich type structure, explained by the very good adherence of the silicone component to the acrylate, an outcome to which the coupling agent contributes significantly. For test sample 2, the chemical-silicone bond is very stable due to the technological similarities between the 2 materials (Figure 3).

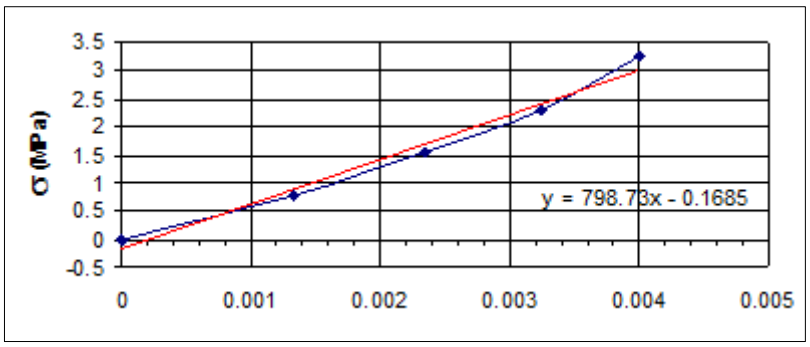

Figure 3. The deformation characteristics of Sample α_2

The association of the silicone material with elastic materials shows good tensile strength and a high elasticity module, which recommends their use for the bone support covered by a brittle mucosa or for the defects associated to post surgery substance losses. The association of the classic acrylic material with a silicone material leads to longer-term prosthetic constructions, with a reduced deformation degree and good adhesion between the two components.

These structural changes are applied according to the particularity of the clinical case and the biologicall clinical algorithm of realization.

Regarding the maximum force at which the fracture of the test samples occurred, we recorded a force value of 1750N for test samples made of flexible acrylate, followed by the test samples made of classic acrylate, with a fracture value of 1559N. Regarding the maximum tensile strength for sandwich-type test samples, the flexible acrylate - silicone RUBBER 732 RTV structure broke at 1125N, while for the classic acrylate – silicone material a fracture value of 950N was recorded (Figure 4).

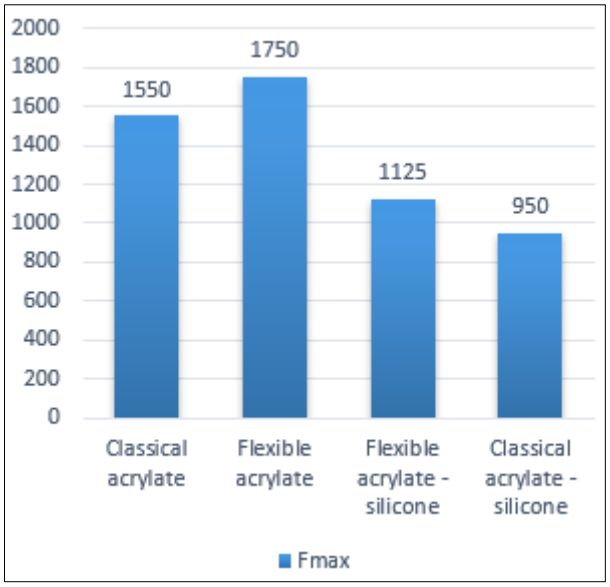

Figure 4. The maximum force for fracture of the test samples

Other calculated parameters included maximum (normal) strength ($\sigma_{max}=F_{max}/S_0$), where $S_0=b\cdot g$ is the section where the fracture occurs (or the initial section of the test sample study area), namely of $(\sigma_{max})_{real}$= real maximum normal strength, calculated in the section where the fracture actually occurred, the traction force being eccentric due to the asymmetric structure and the manner of taking over of the load by the structure.

We recorded the fracture of acrylate test samples at a maximum force of 57.47, of the sandwich type structure that combined flexible acrylate and silicone structure at a maximum force of 31.51 and at a real maximum force of 82.72 and the sandwich structure based on the combination of the classic acrylate with the RUBBER 732 RTV silicone material fractured at a maximum force of 37.88 and a real maximum force of 65.97 (Figure 5).

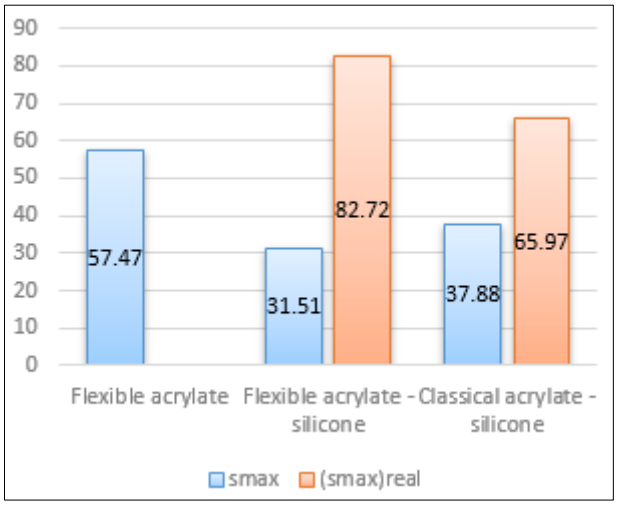

Figure 5. The maximum normal and real strength for fracture of the test samples

Upon examination of the breaking routes of the tensile test samples, the following aspects were recorded: the fracture at a low force of classic acrylate test samples, with the displacement of fragments, the difficult fracture of flexible acrylate test samples, with the presence of the fracture line but without the displacement of fragments.

In the case of the flexible acrylate – silicone sandwich structure, a linear fracture route is recorded, both biomaterials being damaged, which can be explained by the structure of the 2 materials, as the elasticity of the flexible acrylate is due to the dibutyl phthalate or the dioctylsulphate compatible with the organic structures from the structure of the silicone material. For the classic acrylate – silicone sandwich type test sample, a linear route is recorded at the level of the acrylic structure, affecting the acrylate – silicone interface.

Another particular case, using this type of sandwich structure is the manufacturing of an obturator prosthesis for defects following the resection of midface malignancies. The dimensions and volume of the obturator prosthesis influence the choice of material and the design of the prosthesis with the purpose of achieving a decreased weight, optimal stability, as well as an easy insertion in the presence of a decreased mouth opening [8], which sometimes dictates a two-piece design, complicating the technological manufacturing process. The presence of additional reconstructive methods, such as titanium mesh reconstruction, local, regional, or free flap reconstruction, further complicate the local anatomy and the possibilities of achieving good marginal closure and stability. The accuracy of such a prosthesis must be high since an optimal adaptation is needed for closing the resulting postoperative communication between the oral cavity and the maxillary sinus and nasal cavity. A lack of stability leads to the reflux of liquids and functional disturbances including impaired phonation, mastication and deglutition. The associated laryngopharyngeal reflux may exacerbate the already existing mucosal changes determined by the performed treatment [10], but also due to the presence of associated risk factors frequently found in head and neck oncologic patients, such as smoking, alcohol and HPV infection [11,12]. Therefore, ensuring an accurate construction and adaptation of the acrylic prosthesis in head and neck cancer cases, starting from the technological phase, contributes to increasing the quality of life of those patients.

The usual clamping materials used are the elastic ones such as alginates, silicones and thiorubber. The functional (definitive) model reproduces with great accuracy all the elements of the prosthetic field (the support area and the peripheral area of marginal extension). The accuracy of the future prosthesis depends on a large extent on the quality of the prosthesis.

The prosthetic fields in the partial edentation are marked by the presence of remaining teeth and the retentive spaces, elements that determine the limitation of the use of the clamping materials to semi-rigid and elastic materials.Semi-rigid materials are thermoplastic, oroplastic and zinc oxide and eugenol pastes.Elastic materials include materials of different composition but having similar characteristics. They are represented by reversible and irreversible hydrocolloids, synthetic elastomers → silicones, thiorubbers and polyesters.The definitive or working model, represents the positive copy of the partially edented prosthetic field, obtained by pouring the hard gypsum fluid into the impressions of the imprint.The occlusion template is an intermediate piece required by the physician to determine intermaxillary reports. The intermaxillary reports are recorded on the occlusion pattern in the centric relation with maximum intercuspidation (if sufficient dental-dental contacts exist); to be transferred to the laboratory [13].

The recording of the mandibulo-cranial relations is a clinical stage in which the physiological position of the mandible is detected with respect to the maxilla (the centric relation and the vertical dimension of occlusion). With the help of occlusion patterns, the doctor records these positions intraoral and transfers them to the occlusal or articulator models.For the purpose of making the partially acrylic prosthesis, the working models are fixed with the help of templates in an instrument similar to the dental-maxillary apparatus; this instrument can be the occlusor or the articulator.The preliminary model of the partial prosthesis aims at the sample in the oral cavity of the patient, being a clinical stage in which the doctor checks whether the references transmitted to the laboratory have contributed to the correct choice and fitting of the artificial teeth.The preparation of the model for packaging and the packaging of the model includes two important objectives: the preparation of the model for packaging (final model), the packaging of the model.The final modelling of the pattern follows some objectives, namely: physiognomic, hygienic, phonetic, mechanical resistance and stabiliser.The shape and dimensions of the

acrylic base of the prosthesis designed by the doctor on the working model are faithfully reproduced, in negative, by the shape and dimensions of the pattern.Polymerization is the chemical process by which polymethyl methacrylate (acrylic paste) is transformed from plastic to solid, hard and non-deformable. The polymerization is initiated, is carried out and is finalized under the action of a thermal regime.

Partial acrylic prosthesis, unpacked and cleaned of all traces of gypsum, will be examined for possible defects caused during the introduction of acrylate in its printing and polymerization, disassembly or cleaning of gypsum. The prostheses are polished to the horizontal motor under the action of the polishing instrument. of abrasive materials. The insertion of partial prostheses on the prosthetic field depends on the form of edentation and the preparation of the working model for the final model stage. For rapid biological integration, the prostheses are adapted to the structural elements of the prosthetic field [14]. Acrylic resins - the variety of forms used in dentistry requires their classification according to different criteria: one of them is the moment of polymerization, depending on their delivery: industrially polymerized acrylics in finite forms, industrially polymerized acrylics in pre-defined forms; polymerized acrylics in the dental office or dental technology laboratory.Polymethyl methacrylate (PMMA) is the esterification product between methacrylic acid and methyl alcohol; it is obtained from acetone. (CH_3-CO-CH_3). It has a necrotic effect on odontoblastic extensions and nerve endings in the hard-dental tissues, producing local analgesia. Under the action of heat or a chemical initiator, the polymerization reaction is triggered. Polymethyl methacrylate (PMMA) is solid at normal temperature. It is thermoplastic, the softening temperature is around 125^{o}C. At a higher temperature depolymerization occurs, reaching 490^{o}C.The polymethacrylic acid possesses a very high affinity for water, due to the hydrophilic carboxy groups. This affinity also leads to a decrease of the resistance. Thus, in order to remedy this disadvantage, the esterification of the carboxy groups is practiced. Thermopolymerizable resins: although most of the products are presented in powder and liquid bicomponent system, PMMA pastes with a short shelf life have been launched on the market [15]. The great advantage of PMMA in the form of paste is that the powder and the liquid is predosed, the mixing ratio being optimal, ensuring superior qualities to the finished polymerization product. Hydrophilic polyacrylates have been used as materials for the basis of prostheses and permanent soft lining materials. The polymer absorbs water in a proportion of 20% by weight, thus becoming softer.Self-curing resins (chemopolymerizable) - used in clinics or laboratories for the immediate manufacture or repair of dental prostheses, especially their light handling .The great advantage of thermopolymerizable acrylic resins over the self-curing ones is the strong diffusion of the monomer and the cross-linking agent. polymerization beads. This ensures a low coefficient of residual monomer, a higher hardness, rigidity and fracture resistance. Self -polymerizing resins of" FLUID TYPE " - The chemical composition of fluid acrylates is similar to that of self-polymerizing methyl methacrylates.

4.Conclusions

Based on the results we can draw the following conclusions:

1. The test sample made of flexible acrylate has the highest value of tensile strength.
2. The test samples made of classic acrylate fractured, with the displacement of fragments.
3. The structure of the two biomaterials within the sandwich type test samples decisively influences the force and tension at which the fracture occurs, as well as the fracture route, which is linear, without the displacement of fragments, both the flexible acrylate and the silicone being affected, respectively a linear route at the level of the acrylic structure, affecting the acrylate – silicone interface for the classic acrylate – silicone test samples.
4. With all of the system of tissues which form the oral cavity it has the capacity of a remarkable adaptation, its inserting prosthesis and the implant can disturb the balance the oral environment, generating effects often resulting with damage to the integrity of the oral tissue.
5. The partial protheses -essential dental removable acrylic are very commonly used, andthe standards must be observed about the quality in achieving their technology and the improvement of structure by sandwich combination is dictated by clinical case particularity .

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