

The Flexural Strength of Traditional and Modern Acrylic Prosthetic Bases

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Abstract: *The aim of this paper is to investigate the resistance to flexure of traditional and modern dental acrylic prosthetic bases. The practical utility of the laboratory studies carried out in this research is to apply the physical properties of plastic in medical technology, for improved clinical practice. The clinical utility of this research on prosthetic acrylic bases resistance is reflected in the quality of life of patients, the quality of mastication and durability of the prosthesis. Material and methods: experimental research, using a mechanical test machine. The results were analysed through quantitative methods. Statistical correlations were made in the final experimental part. In conclusion, the values obtained in our experiments are comparable with those found in scientific literature. This fact enables us to recommend the use of the injection molding technique in clinical practice in our country, as well as the abandonment of the traditional manual stuffingpressing process.*

Keywords: *acrylic prosthesis, traditional, modern dental materials, flexural strenght.*

1. Introduction

Clinical trials have shown that the basis of a dental prostheses must be rigid [1-5]. The more rigid it is, the more symmetrically the masticatory pressures will be transmitted to the underlying mucosa, respectively to the bone and / or the remaining teeth. In this sense, the use of polymers with a low modulus of elasticity (those that oppose a minimum resistance to the action of an arc force, which causes an elastic deformation) is not indicated. On the other hand, the hardness of the material must not be exaggerated, because it becomes breakable. It must have a sufficient shock resistance to prevent, for example, breakage of the prosthesis, if it is dropped down during sanitization. When choosing the technology for manufacturing mobile and mobilizable prostheses, it needs to know that each occlusal pressure during mastication or swallowing, gives birth to forces with different intensities, which act on the dentures, bending and arching the prosthesis [6-9]. After the end of the action of that force, depending on the quality of the material from which the prosthesis is made, it never completely returns to its original shape (size) [10-13]. These permanent stresses - long bending stresses - can lead after a period of time to the cracking and / or fracture of the prosthesis and to the loss of its adaptation on the prosthetic field, which takes turn also undergoes changes. The longevity of the prosthesis is evaluated for cost-efficiency in dental cabinets [14-16].

Properly processed poly-methyl methacrylate: PMMA-based resins can support different levels of stress. Experimentally, each prosthesis was alternately exposed to a number of approximately 106 bendings, at varying intensities.

Institute for Material Science, Körber and collaborators at Christian-Albrechts University of Kiel - Germany were tested in comparison to mechanical tear strength of specimens manufactured in several different ways and using different materials, as follows [17-21]:

- a. thermopolymerization technique with injection molding compensation Ivoclar;
- b. conventional polymerization technique, hot and under pressure;
- c. cold plastic injection molding and self-curing technique - Kulzer.

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Tests were produced on standard test specimens, using a unit for determining the resilience - Zwick pendulum system 5101. The resilience was calculated from the mechanical work absorbed by the shock, and expressed in J / mm². The experimental program mentioned refers to the three processes mentioned in each case using two different materials. For each material were carried out by 10 samples, under standard conditions. The results that Körber obtained and presented can draw the following conclusions:

a. the products made by the thermobaropolymerization technique with injection molding compensation have the highest values of the shock resistance: 10.92 ± 0.51 mJ / mm² for SR Ivocap Plus and 8.69 ± 0.29 mJ / mm² for SR Ivocap Universal;

b. the group of hot and pressurized polymerized materials (conventional process) has on average only 60% of the shock resistance to thermobaropolymers, respectively 7.02 ± 0.3 mJ / mm² for Paladon 65 and 7.05 ± 0.48 mJ / mm² for SR Base Hot;

c. the group of "cold" polymerized materials has on average 50% of the shock resistance compared to thermobaropolymers, ie 5.58 ± 0.8 mJ / mm² for PalaXpress and 4.79 ± 0.3 mJ / mm² for SR Pro Base Cold.

The tests performed and the results presented for the corresponding high technology materials show a very good reproducibility of the resilience in tangible limits for each process. Standard deviations indicate very low individual values of the mean deviation value for each of the three methods discussed above.

Another study, conducted by Takahashi et al. evaluates the bending strength of thermoplastic (poly-methyl methacrylate) PMMA-based prostheses after re-coating with different types of materials, applied in layers of different thicknesses [22]. All re-coating dental prosthetic bases showed significantly lower strength than the mass of the prosthetic bases. The flexural strength of denture bases reoptimize decreases with the thicknesses of the relining material layer [23]. Therefore, it is obvious that by the injection process, bending resistance values obtained is higher than values obtained by the classic manual compression-pressing technique [24, 25].

2. Materials and methods

In the present study we tested the bending strength on PMMA specimens made by two different technologies: manual compression-pressing and injection molding. In order to determine the influence of the technology of making the bases of mobile and mobilizable prostheses on their bending resistance, we manufactured specimens with dimensions of 60 x 60 x 3 mm (length - width - thickness), as follows:

- Eight specimens made by the classic technique (of compaction - manual pressing) for making mobile and mobilizable prostheses bases.
- Eight specimens made by the Polyapress process - injection molding process developed by Bredent and using a thermoplastic copolymer based on PMMA - PVS-H / Polyan - Girschbach-Dental.

A more accurate filling pattern was obtained after the union of the sprue is funnel-shaped at its upper pole, while the outlet channel is attached to the pole by a lower delta layout. (Figure 1).

Conditions of the polymerization heat was in part according to a protocol of each technique. After removing the test pieces, they were processed and finished in the usual manner. Prior to testing, the samples were kept in distilled water at 37°C for 50 h. Samples were cut 60 x 8 x 3 mm to be tested for mechanical tensile testing machine (Figure 2). Finally, 16 samples were obtained from acrylate, 8 by each process.

The testing was performed with a universal machine Type RM - 101 from the endowment of the Faculty of Engineering within the 'Aurel Vlaicu' University of Arad (Figure 3).

The machine has a frame made with a single vertical column, it is electrically operated and the force measuring device is with a pendulum (Figure 3). There are three load ranges on the power dial: A - 100 daN B - 250 daN C - 500 daN. The loading force is achieved with a speed motor. The specimens are fixed between the two tanks, one fixed and one mobile.



Figure 1. Model specimens in the sink



Figure 2. Special bending device



Figure 3. Tensile testing machine (500 daN)

3. Results and discussions

After performing the test, the samples were visually examined in an attempt to differentiate the origin and type of fracture. Macroscopic examination of the samples showed that all 16 samples were completely fractured - all 8 samples obtained by the classic manual compression-pressing process and all 8 samples obtained by the modern thermoplastic injection molding process.

Under the action of a certain force (specific for each sample), the samples fractures pattern corresponding with rigid material (breaking), rather than flow material (stretch) characteristic of plastic materials. The fracture surfaces obtained for all 16 samples are clean, which shows that, regardless of the processing and polymerization technology (thermoplastic denture base resins), the material used to make the prostheses is breakable.

The flexural strength of the test specimens σ (N / mm) was determined using the equation (1):

$$\sigma = 3Fl / 2bh^2 \tag{1}$$

where:

F - represents the maximum force (N) exerted on the sample

l - distance between the supports (± 1 mm)

b - width of the test piece (mm)

h - height (thickness) of the test piece (mm).

This equation was determined from the formula (2, 3, 4):

$$\sigma = Mi / Wz \tag{2}$$

$$Mi = Fl / 4 \tag{3}$$

$$Wz = bh^2 / 6 \tag{4}$$

The flexural strength of the test specimens obtained by the classic manual compaction and pressing (Superpont) was calculated by the formula shown above (formula 1). Thus, for the test pieces made by the classical technique, the bending resistance obtained has values between 73.287 - 109.116 N / mm², with an average of 92.558 N / mm², the results being centralized in Table 1, with the same caption of the formulas above.

Table 1. Bending test of classic PMMA - Superpont

Sample	Parameter					
	L (mm)	b (mm)	h (mm)	l (mm)	F (N)	σ (N/mm ²)
1	60	7.9	3	39	120.1	98.816
2	60	8	3.1	39	143.4	109.116
3	60	8.3	3.2	39	129.4	89.066
4	60	8	3	39	90.2	73.287
5	60	7.9	3.1	39	102.4	78.905
6	60	8	3.1	39	135.9	103.409
7	60	8	3	39	113.5	92.218
8	60	8.1	3	39	119.2	95.654

In the case of the modern process, the bending resistance obtained has values between 110.029 - 136.5 N / mm², with an average of 125.523 N / mm², the results being centralized in Table 2.

Table 2. Bending testing of thermoplastic PMMA - Polyan

Sample	Parameter					
	L (mm)	b (mm)	h (mm)	l (mm)	F (N)	σ (N/mm ²)
1	60	8	3.1	39	114.6	110.029
2	60	8.1	3	39	167.4	134.333
3	60	8	3	39	168	136.5
4	60	8	3	39	143.2	116.35
5	60	7.9	3.2	39	183.3	132.553
6	60	8	3.1	39	168.3	128.063
7	60	7.9	3	39	141	116.012
8	60	8	3.1	39	171.3	130.346

The test pieces made by the classic manual compression-pressing technique have low bending strengths, the maximum value recorded being below the minimum value obtained by the injection molding process. It also has the largest variations in bending strength ($\pm 20\%$), which is more than likely due to the manual thickening and pressing of the acrylate paste in the mold, at this level, human error occurs in a fairly high percentage, as well as the empirically controlled thermal polymerization regime, as well as the lack of shrinkage compensation in the polymerization of the material.

The higher values obtained in the case of specimens obtained by the thermoplastic injection molding technique are due to the uniformity of the mass of the polymer that is injected under pressure and the permanent verification of the thermal regime.

It is therefore observed that through the injection molding process (series 2), were obtained much higher values of bending resistance than those obtained by the classic manual compression-pressing technique (series 1), (Figure 4).

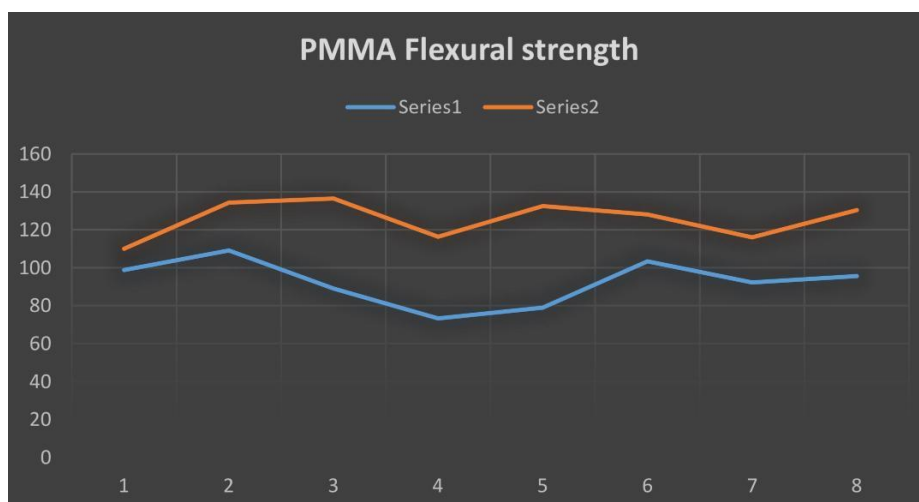


Figure 4. Comparative diagrams of the flexural strength of the samples by the classical method versus injection molding

Discussions

Dental polymers are not allowed to change their shape, size, qualities in the oral environment.

Dental plastics must have sufficient abrasion resistance not to change their shape and size under the action of foods of high consistency or sanitizing brush. Only a material with high abrasion resistance can keep its surface smooth, preventing the bacterial plaque from adhering to this level.



The polymers for manufacturing mobile prostheses must have an increased abrasion resistance in order to maintain a constant occlusal vertical dimension DVO and implicitly the occlusal stops.

Therefore, the stability - chemical and mechanical - in the oral environment of dental polymers is a very important property, which must be taken into account when choosing a material or a procedure for manufacturing a dental prosthesis.

4. Conclusions

Following the study that we tested the bending strength on specimens made of classic and modern polymer to achieve the bases of mobile prostheses, the following conclusions can be drawn:

a. In the case of test pieces made by the injection molding technique, values of resistance to bending were much higher than those obtained by the classic manual compression-pressing technique, probably due to the thermoplastic material used and the polymer pressure injection molding system with permanent verification of the thermal regime.

b. The static mechanical bending test must be supplemented by a dynamic test to obtain results that allow useful clinical data to be obtained.

c. In relation to similar research conducted in this field and reported in the literature, our values are comparable. This fact entitles us to recommend the extension in the current practice in our country of the injection molding technique and the abandonment of the traditional manual stuffing pressing process.

In conclusion, the values obtained in our experiments are comparable with those found in scientific literature. This fact enables us to recommend the use of the injection molding technique in clinical practice in our country, as well as the abandonment of the traditional manual stuffingpressing process.

Acknowledgments: I declare that, there is no conflict of interest regarding the publication of this paper. For any experiments on humans, all work was conducted in accordance with the Declaration of Helsinki (1964). Papers describing experimental work which carries a risk of harm to human subjects include a statement that the experiment was conducted with the human subjects' understanding and consent.

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Manuscript received: 01.05.2020