Aspects Regarding the use of Three Types of Polymers as Denture Base Materials

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Removable partial dentures (PDs) are an affordable and effective treatment option in patients with partial edentations.

This aim of this study is to evaluate the differences, in the terms of patient's compliance, in restoration of partial edentations through three types of PDs, achieved of Meliodent-Kulzer acrylic resin, Valplast® polyamide resin, respectively of BioDentaplast-Bredent acetal resin. Investigations were carried out on 78 patients (3 groups of 26 patients), to which were performed 101 PDs (35 of Meliodent-Kulzer, 33 of polyamide Valplast®, respectively 33 of BioDentaplast-Bredent) and after the accommodation period with the dentures, six assays of compliance have been conducted. The results of the research have demonstrated that PDs made of flexible materials were far more favourable than those made of Meliodent acrylic resin, and PDs with BioDentaplast framework presented the best impact. The ascertained differences are relevant in the treatment of partial edentation, for choice of the best option for one of these three polymeric denture base materials.

Keywords: Meliodent-Kulzer, Valplast, BioDentaplast, patient's compliance

Despite all the progresses in dental restorations, it is still necessary to use conventional acrylic removable partial dentures (PDs). Edentulism in the developed countries is in decline, but the number of patients suffering from partial tooth loss continues to rise [1,2]. In the countries with lower economic development the rates of edentulism remain high [3,4]. Movable dental restorations represent a temporary or, sometimes, a durable/permanent solution in total or partial tooth loss [5].

A classification of denture base materials is presented in figure 1.

Polymethyl methacrylate (PMMA) has been the most popular material used for denture fabrication since its introduction in 1937 [7].

PMMA, an ester of methacrylic acid ($CH_2=C[CH_3]CO_2H$), belongs to the important acrylic family of resins. In modern production it is obtained principally from propylene, a compound refined from the lighter fractions of crude oil. Propylene and benzene are reacted together to form cumene, or isopropylbenzene; the cumene is oxidized to cumene hydroperoxide, which is treated with acid to form acetone; the acetone is in turn converted in a three-step process to methyl methacrylate ($CH_2=C[CH_3]CO_2CH_3$), a flammable liquid. Methyl methacrylate, in bulk liquid form or suspended as fine droplets in water, is polymerized (its molecules linked together in large numbers) under the influence of free-radical initiators to form solid PMMA [8].

The structure of the polymer repeating unit is presented in figure 2.

Heat-cured acrylic resins are the most used materials for the production of partial or full dentures. Polymethyl methacrylate (PMMA) resin used in denture base manufacturing has lots of advantages: it is easy to apply and to repair, its low cost, acceptability by most of the patients, stability in the oral cavity, and aesthetical properties [9,10]. In figure 3 is presented a scanning electron micrograph of polymethyl methacrylate beads [11].

Polymethyl-methacrylate (PMMA) is synthetically obtained acrylic resins [12].

Meliodent-Heraeus Kulzer is a heat-curing polymer, with the presentation mode represented by powder (polymethyl-methacrylate) and liquid (methyl-methacrylate, di-methacrylate), used as dental resin for making dentures (fixed and removable prosthetic restorations) [13].

The aesthetic appearance of removable PDs with PMMA bases may be compromised by the visibility of metal clasps,

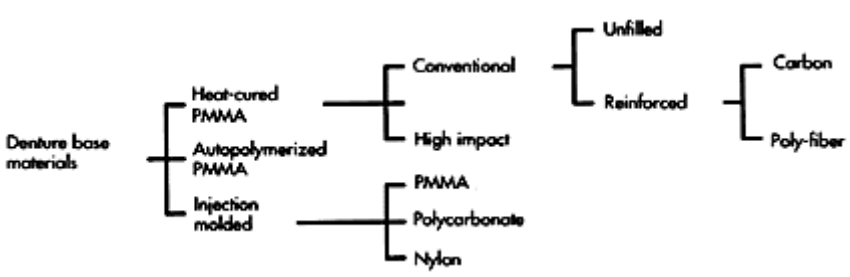

Fig. 1. A classification of denture base materials [6]

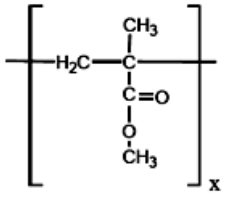

Fig. 2. The chemical structure of PMMA [8]

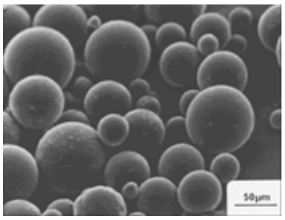

Fig. 3. Scanning electron micrograph of PMMA beads

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Fig.4. Manner of presenting of the used dental polymers in research: left - Meliodent; Center - Valplast; right - BioDentaplast

so that a feasible alternative to PMMA-based removable PDs may be the use of certain types of thermoplastic polymers from the class known as polyamides or nylons [14].

Polyamide (PA) was proposed as a prosthetic material by Lucar in 1950 and it is a flexible material suited for denture bases and for clasping [15,16].

Thermoplastic nylon is a polyamide resin derived from diamine and dibasic acid monomers, exhibits high flexibility, physical strength, heat and chemical resistance. It can be easily modified to increase stiffness and wear resistance. Because of its balance of strength, ductility and heat resistance, nylon is an outstanding candidate for metal replacement applications and it is used primarily for tissue supported removable dentures [17,18].

Valplast® is a polyamide resin developed from a type of nylon material, with 99.9% of its content consisting of polylaurolactam (nylon 12, chemical formula $\{CO(OH_2)_{11}NH\}_n$). It is a heat-cured polyamide, used for flexible, lightweight and esthetic denture base resin, so that it is a biocompatible thermoplastic nylon [19,20].

BioDentaplast is a semi-crystalline thermoplastic polyoxymethylen based material (acetal resin) that features a linear structure and a high crystallinity. The material exhibits good physical and chemical properties such as high hardness, considerable rigidity, no cracking under stress, high restoring capacity and high dimensional stability. BioDentaplast has an opaque colour and allows the fabrication of tooth-colour frameworks with a layer thickness that is suitable for the injection-moulding technology [21].

The manner of presenting of the dental polymers used in our research is visualized in figure 4.

The purpose of our study was to emphasize the differences between these three types of polymeric denture base materials, differences considered relevant for opting for one of the treatment variants in partial edentation cases.

Experimental part

Materials and methods

The researches were conducted in the Dental Medicine Faculties of Oradea and Bucharest Universities.

This study aims to evaluate the differences, in terms of patients compliance, of three types of PD, Meliodent-Kulzer acrylic resin (26 patients), Valplast® polyamide (26 patients), respectively BioDentaplast-Bredent acetal resin (26 patients).

For achieving dentures from Meliodent-Kulzer resin, it is necessary to realise the impressions, plaster models/casts, the determination of jaw relations, then the wax dentures with casts are invested/flasked and dewaxed to obtain the mold, the polymer-power is mixed with the liquid monomer and inserted into the moulds during their plastic phase, the heat-curing process, then devesting, finishing and polishing.

Production of the Valplast® PDs in the dental laboratory is realised by following the same technical steps as for the Meliodent-Kulzer denture base material, the difference consisting in the duplication of plaster casts, in specific attachment of spruing system and in a special flask (resistant to pressure), achievement of mould by dewaxing, preliminary heating, injection of the melted polyamide material into the mould, devesting, finishing and polishing of PD.

BioDentaplast is used for the framework of PDs. It is a semi-crystalline thermoplastic polyoxymethylen based material and features a linear structure, suitable for the injection-moulding technology. It has a low melting temperature, between 200-230°C, with good flow characteristics and it is processed at a pressure of 7.2 to 7.5 bars, in a Thermopress 400 injection unit. The high pressure reduces shrinkage, ensures dimensional accuracy and the precision-fit dental framework. The acrylic artificial teeth are fitted on the saddle of the BioDentaplast framework by using an Enigma Color Tone System.

Valplast and BioDentaplast resins are supplied in the form of granules, in cartridges of varying sizes.

From 105 examined patients, we selected 78 patients (48 females and 30 males), which presented edentations with more than 3 missing neighbouring teeth, with healthy remaining teeth or with minor odontal injuries, and without periodontal affections. The patients were selected after a detailed anamnesis and were attended only by those that have expressed their desire to be part in the research. The age range of the patients was similar, between 50-61 years, with a median age of 55.5 years and a mean of 55.5 ± 5.5 years (fig. 5).

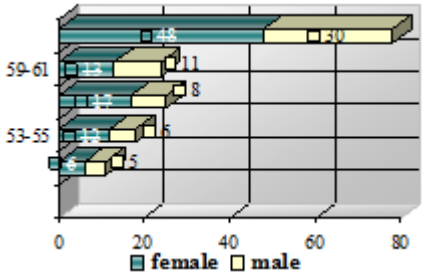

Fig. 5. Distribution of patients after age and gender

The majority of the patients were female (48 female patients = 61.53%, 30 males = 38.46%).

The total sum of achieved PDs was 101 (35 of Meliodent =34.65 %, 33 of Valplast polyamide = 32.67% and 33 of BioDentaplast = 32.67%).

Fig.6. Achieved PDs: Meliodent - left; Valplast - center; BiDentaplast - right

In figure 6 are presented images with three PDs, achieved of these three polymeric dental materials.

After the completion of the habituation period to PDs (4 weeks), we conducted the monitoring of the results. A total of six assays of compliance have been conducted, the first at four weeks after the insertion of the PDs, the second after 6 months, the third after one year, the fourth

after 1 year and six months, the fifth after 2 years and the sixth after two years and six months. In every monitoring session, patients and dental practitioners completed questionnaires containing questions regarding the subjective symptomatology (reported by patients = criteria 1 and 2) and objective symptomatology (determined by clinical examination = criteria 3-8).

The used criteria's in the questionnaire were:

Criterion 1 = discomfort of PDs wearer patients;
Criterion 2 = existence of unpleasant taste of the prosthesis;
Criterion 3 = existence of allergic reactions in soft tissues of oral mucosa in contact with the PDs base;
Criterion 4 = patients who experienced fractures/cracks of the PD;
Criterion 5 = altered colour shade in PDs;
Criterion 6 = the degree of plaque accumulation on the PDs;
Criterion 7 = occurrence of halitosis;
Criterion 8 = existence of decubitus lesions of the soft tissues in the oral cavity.

Investigations were carried out on all 3 groups of patients.

Results and discussions

We note that in all the monitoring sessions there were cases where the same patient asserted that he/she presents more than one of the stated criteria.

Criterion 1 = discomfort: Patients with Meliodent dentures presented on average a higher discomfort than the other patients. PDs with BioDentaplast framework were considered more comfortable and were more easily integrated by patients in comparison with Valplast and Meliodent dentures. Meliodent PDs carrier patients presented same degree of discomfort at first, fifth and sixth monitoring session (6 patients = 23.07% presented discomfort) and at second and fourth monitoring sessions (5 patients =19.23%). The discomfort decreased in flexible PDs carrier patients at each monitoring session: in Valplast polymer PDs bearer patients, from 8 (=30.76%) at the first monitoring session to 2 patients (=7.69%) at the last monitoring session; in BioDentaplast, from 3 patients (=11.53%) at the first monitoring session, to 1 patient (=3.84%) at the last monitoring session.

Criterion 2 = unpleasant taste: Patients wearing Meliodent PDs presented a higher degree of unpleasant taste in their mouth than the patients with Valplast and BioDentaplast PDs. 2 patients (=7.69%) with Meliodent PDs have complained of unpleasant taste of their PDs at the second, 3 (=11.53%) at the third, 5 (=19.23%) at the fourth, and 6 (=23.07%) at the fifth and sixth monitoring session. The unpleasant taste increased in Valplast flexible PDs from 1 patient (=3.84%) at the fourth monitoring session to 2 patients (=7.69%) at the last monitoring session; in BioDentaplast PDs, the unpleasant taste of dentures appeared in 1 single patient (=3.84%), in fifth and sixth monitoring sessions. We should mention that meanwhile this patient with BioDentaplast framework PDs became diabetic, and presented dental plaque including on the internal surface of denture.

Criterion 3 = allergic reactions: Only patients wearing Meliodent PDs presented allergic reactions. Of 26 patients, 4 (=15.38%) presented allergic reaction, in 3 patients at the first monitoring session (=11.53%) and in 1 case at the second monitoring session (=3.84%). Patient's wearing BioDentaplast and Valplast PDs have not experienced allergic reactions at all.

Criterion 4 = fractures/cracks: Only PDs achieved of Meliodent polymer presented cracks and fractures. From 26 patients with Meliodent PDs, in 1 patient (=3.84%) we found a crack at the third monitoring session, 2 patients complained about fracture of PDs at the fourth monitoring session (=7.69%), 5 at the fifth session (=19.23%) and 6 at the sixth session (=23.07%). No fractures/cracks occurred in any flexible PDs.

Criterion 5 = altered colour shade: Patients wearing Meliodent PDs presented a higher degree of altered colour shades of their dentures than patients with Valplast and BioDentaplast PDs. In Meliodent base PDs, 2 patients (=7.69%), presented altered colour shades in the third session, 4 patients (=15.38%) in the fourth, 5 patients (=19.23%) in the fifth and 6 patients (=23.07%) in the sixth monitoring session. 1 patient (3.84=%) with Valplast PDs in the fourth, 2 (=7.69%) in the fifth and 3 (=11.53%) in the sixth monitoring session presented altered colour shades of their dentures. 1 patient (3.84=%) with BioDentaplast PDs in the fourth and in the fifth session and 2 patients (=7.69%) in the sixth monitoring session presented altered colour shades.

Criterion 6 = plaque accumulation: We considered this criterion positive if the PDs presented soft debris which covered at least the cervical area of artificial teeth, or presented prosthesis stains, without other debris, regardless of the denture area. Plaque accumulation was higher in Meliodent PDs (2 patients at the first session, 3 in the second and the third sessions, 5 in the fourth and 6 in the fifth and sixth sessions) than in Valplast PDs (1 patient in the third monitoring session, 2 patients in the fifth and 3 in the sixth monitoring session). The lowest plaque accumulation was found in BioDentaplast PDs (1 patient in the third, fourth, fifth and sixth monitoring sessions).

Criterion 7 = halitosis: Patients with Meliodent PDs presented increasing frequency of halitosis in time (1 patient at the second session, 3 in the third and 6 in the four, fifth and sixth monitoring sessions) and in comparison to the flexible PDs. In Valplast PDs, halitosis appeared at 1 patient in the fifth and sixth monitoring session. The lowest number of halitosis presence was in the patients with BioDentaplast PDs (1 patient in the sixth monitoring session).

Criterion 8 = decubitus lesions: The patients with all three types of polymeric PDs presented in time a decreasing number of decubitus lesions. In Meliodent PDs, the number of these lesions decreased from 15 patients (=57.69%) at the first monitoring session, to 12 patients (=46.15%) in the second, 11 (=42.3%) in the third, 8 (=30.76%) in the fourth, respectively 4 (=15.38%) in the fifth and sixth monitoring sessions. Because Valplast and BioDentaplast polymers present a high degree of flexibility, patients with these PDs complained about a lower number of decubitus lesions. 10 patients (=38.43%) with Valplast PDs presented decubitus lesion at the first monitoring session, 9 (=34.61%) at the second, 6 (=23.07%) at the third, 5 (=19.23%) at the fourth, 2 (=7.69%) at the fifth and 1 (=3.84%) at the sixth monitoring session. Only 2 patients (=7.69%) with BioDentaplast PDs presented decubitus lesions at the first monitoring session and 1 patient (=3.84%) at the second and third sessions.

Figure 7 presents the obtained results after processing the data, referring to the criteria set of the three denture base materials used in our research (Meliodent-Kulzer, Valplast and BioDentaplast-Bredent).

The research proved that an adequate oral hygiene and professional care can substantially reduce the problem regarding the colour stability and staining in all used dental polymers.

Determination / Criteria	78 patients, 101 PDs (partial dentures)																	
	Meliodent (26 patients, 35 PDs)						*Valplast* (26 patients, 33 PDs)						*BioDentaplast* (26 patients, 33 PDs)					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Criterion 1: discomfort	6	5	5	5	6	6	8	6	3	2	2	2	3	2	1	1	1	1
Criterion 2: unpleasant taste	-	2	3	5	6	6	-	-	-	1	2	2	-	-	-	-	1	1
Criterion 3: allergic reactions	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Criterion 4: fractures/cracks	-	-	1	2	5	6	-	-	-	-	-	-	-	-	-	-	-	-
Criterion 5: altered colour shade	-	-	2	4	5	6	-	-	-	1	2	3	-	-	-	1	1	2
Criterion 6: plaque accumulation	2	3	3	5	6	6	-	-	-	1	2	3	-	-	1	1	1	1
Criterion 7: halitosis	-	1	3	6	6	6	-	-	-	-	1	1	-	-	-	-	-	1
Criterion 8: decubitus lesions	15	12	11	8	4	5	10	9	6	5	2	-	2	1	1	-	-	-

Fig. 7. The obtained results after processing of data, in reference to the criteria set

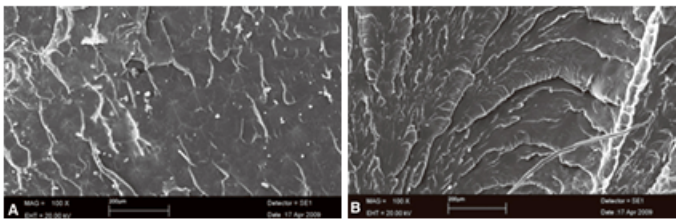

Fig. 8. A: PMMA specimen without fiber (original magnifications x 100), B: Valplast specimen (original magnifications x 100) [32]

Results of the research have demonstrated that PDs achieved from flexible materials were far more favourable than those made of Meliodent acrylic resin.

The ascertained differences are relevant in the treatment of partial edentation, for choice of the best option between one of these three polymeric denture base materials.

Continuous development and progress of the polymer's industry with application in general and dental medicine has its ground in the importance of these biomaterials in the health domain [22].

Acrylic resins dominated dentures technology for several decades, being used for denture and removable orthodontic bases, artificial teeth, veneering materials, dental restorations [23].

Polymethyl-methacrylate (PMMA) are synthetically obtained acrylic resins, which can be modelled, packed or injected into moulds during an initial plastic phase, and solidified through a thermo-polymerization chemical reaction [24,25].

PMMA is commonly used to fabricate removable dentures, but the disadvantages, such as polymerization shrinkage and modest mechanical strength (which causes fractures of the denture bases at impacts), low flexural fatigue (which causes failures in these types of movable restorations), and increasing rate of intolerance to monomers present in acrylic materials among patients and medical staff [26,27].

To improve the properties of PMMA, there were added metallic threads, plates, fibers, inserts or the chemical structure was modified [28].

Thermoplastics used in dentistry have known a great diversification in the last years. Processing principles are similar to the injecting technology of chemoplastics, the main difference consisting in their chemical composition, liquefying temperature of grains, injecting pressure and the fact that thermoplastic resins are monocomponent [29].

The smooth surface of casted by injection dentures avoids the adhesion of plaque [30].

More recent work on glass-reinforced nylons with much lower water absorptions (e.g., nylon 66) has produced more encouraging results. These nylons are either filled with specially coated glass beads or chopped glass fibers. The glass fibers increase the stiffness of the nylon to about that of a conventional heat-cured denture base from a stiffness of half that when only glass-bead reinforcement is used. Glass-fiber reinforcement should be used with care, and patients should be warned not to abrade the fitting surface so as to avoid exposing irritation-causing fibers [31].

The researches of Soygun and al [32] regarding the structural images of the PMMA and Valplast resin specimens, by using a surface scanning electron microscope, shows that both groups displayed smoother structure (figure 8).

After Durkan and al [33], conventional PMMA resin had higher hardness than polyamide-based resins. This difference stems from the differing structural properties of the materials. According to the manufacturers, polyamide resins had higher fibrous content and lower modulus of elasticity.

After the researches of Singh and al [14], the flexible dentures were found to fare significantly better as compared to the conventional PMMA dentures, and the preference among the two types of denture base material, were preferred the flexible dentures over customary methyl methacrylate dentures.

The scientific review of Vojdani M [34], of revealed that currently, thermo-injectable flexible polyamide represent an alternative to the conventional acrylic resins, due to its esthetic and functional characteristics and physico-chemical qualities.

Pinto and al [35] reported that polyamide resins had a higher mechanical resistance than acrylic resins.

Dental materials should not contain toxic, leachable, or diffusible substances that can be absorbed into the circulatory system, causing systemic responses, including allergic reactions, respectively teratogenic or carcinogenic effects [36].

Currently, the researchers are targeted for the improvement and the increasing of the biocompatibility in dental materials, and, at same time, for the increasing of the corrosion resistance of the materials that are in direct contact with the biological tissues. Biocompatibility of dental materials is an important consideration for the patient, clinician, laboratory technician, and manufacturer [37].

Conclusions

Within the limitations of this study, we conclude that each of these three types of partial denture has their advantages and disadvantages.

Achievement of flexible PDs requires the purchase of expensive devices, which is the reason that the price of flexible dentures are higher, unlike the classical acrylic prostheses, which are considered *social prosthesis* and pensioner patients prefer them due to financial reasons.

Flexible Valplast and BioDentaplast PDs were more quickly and easily integrated by the patients, being considered more comfortable.

Flexible dentures are not allergens, reason for which constitutes favourable alternative for classical acrylic resins dentures.

An adequate oral hygiene and professional care can reduce the problems regarding the colour stability, halitosis and plaque deposition in both type, acrylic and flexible denture base resins.

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