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 (CH₂=C[CH₃]CO₂H), 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 (CH₂=C[CH₃]CO₂CH₃), 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,
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 clamping [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 poly(laurolactam) (nylon 12, chemical formula \( \text{C}_2\text{H}_4\text{O} \text{(OH}2\text{)}\text{(NH)}\)). 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, plastic 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).

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%).

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
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 Bio-
Dentaplast 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 (=42.32%) 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.
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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