

METAL-FREE REMOVABLE PARTIAL DENTURES MADE OF THERMOPLASTIC MATERIALS

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REZUMAT

Obiectiv: Acest studiu intenționează descrierea materialelor și tehnicii necesare obținerii unei proteze parțiale scheletate cu schelet și croșete realizate dintr-un material termoplastic. **Material și metodă:** S-a utilizat o rășină termoplastică acetalică (Bidentaplast[®]) pentru a obține o proteză parțială mobilizabilă fără schelet metalic. Întreaga tehnologie a respectat indicațiile producătorului. **Rezultate:** Proteza obținută nu a prezentat nici un defect macroscopic, chiar și în zonele cele mai subțiri. **Concluzii:** Rășinile acetice pot fi prelucrate prin tehnica injectării în laboratorul dentar pentru obținerea de proteze parțiale mobilizabile fără structură metalică, cu croșete estetice și flexibile.

Cuvinte cheie: proteză parțială mobilizabilă, croșet, schelet nemetalic

ABSTRACT

Objective: This study intended to describe the materials and technology needed to obtain a removable partial denture which has the framework and clasps made of a thermoplastic material. **Material and methods:** A thermoplastic acetal resin (Bidentaplast[®]) was used to obtain a metal-free removable partial denture with clasps. The technology followed the manufacturer recommendations. **Results:** The denture was obtained with no macroscopic defects even in the thinnest areas. **Conclusions:** Acetal resins are suitable for injection-molding technology and could be used in dental labs to obtain metal-free removable partial dentures with flexible, esthetic clasps.

Key Words: removable partial denture, clasp, thermoplastic, metal-free framework

INTRODUCTION

The introduction of acrylic resins in dentistry was revolutionary. They are synthetically obtained materials that can be modeled, packed or injected into molds during an initial plastic phase which turns into solid by chemical reaction (polymerization). Acrylic resins are better known as polymethylmethacrylate or PMMA. Thermal polymerized PMMA exhibits

high porosity, high water absorption, volumetric changes and residual monomer.¹ The development of polymer chemistry produced alternative materials to PMMA such as polyamides (nylon plastics), acetal resins (polyoxymethylen based materials), epoxy resins, polystyrene, polycarbonate resins etc. All of these new types of resins are suited for thermoplastic processing.

Usage of thermoplastic resins in medicine has significantly grown in the last decade. The technology is based on plasticizing the material using only thermal processing in the absence of any chemical reaction. The possibility of injecting the plasticized resin into a mold has opened a new perspective to full denture and removable partial denture technology. Thermoplastic resins could be used in dentistry to produce preformed clasps, metal-free removable dentures, temporary crowns and fixed partial prostheses, occlusal splints, implant abutments, orthodontic appliances etc. Most probably, further chemical development of elastomeric and polymeric materials will enlarge the domain of

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clinical applications of thermoplastics in dentistry.²

At present, there are several thermoplastic materials for dental use on the market, such as: Flexite® (The Flexite Company), Valplast® (Valplast Int. Corp.), PolyAress/PVS-H-Polyan® (Girrbach Dental), Flexiplast® (Bredent), Success FRS® (Dentsply), Proflex System® (DR Dental Resource Inc.), The.R.Mo.Free® (If Dental-Pressing Dental), Bio Dentaplast® (Bredent) etc.

Thermoplastic processing implies using complete polymerized or prepolymerized resins.³ These materials are presented as grains with low molecular weight (about 150,000). They have a low plasticizing temperature and exhibit a high rigidity in spite of the low molecular weight.⁴

Acetal resins have fracture strength, wear resistance and flexibility. However, they lack the natural translucency of thermoplastic acrylic and polycarbonate resins.⁵ These characteristics make them usable for preformed clasps, partial denture frameworks, provisional fixed partial dentures, artificial teeth for removable dentures, resin-bonded fixed partial dentures, orthodontic appliances.⁵⁻⁷

Another group of thermoplastic materials used in dentistry are polyester resins. These resins melt between 230-290°C and the technology implies casting into molds.⁸ Polycarbonate resins are particular polyester materials. They exhibit fracture strength and flexibility, but the wear resistance is lower when compared to acetal resins. However, polycarbonates have a natural translucency and finishes very well, which make them proper for producing temporary restorations. They are not suitable for partial denture frameworks.⁵

Polyamide resins used in dentistry exhibit high flexibility, physical strength, heat and chemical resistance. They are used primarily for tissue supported removable dentures because the stiffness is not enough for usage as occlusal rests or prostheses parts that need to be rigid.⁵

All these materials are suited for thermoplastic processing by injection, the technology being conceived especially for industrial productions. The metallic cartridges containing thermoplastic grains are heated to plasticize the resin. The cartridges are set in place into the injecting unit and pressure of 6-8 Barr is used to force the plasticized resin to fill the mold. Pressure, temperature and injecting time are automatically controlled by the injecting unit.⁹

Injecting thermoplastic resins into molds is not a common technology in dental laboratories because the need of expensive equipment and this could be a disadvantage.

The purpose of this study was to describe the technology of manufacturing a removable partial denture made of an acetal thermoplastic material – Bio Dentaplast® (Bredent, Senden/Witzighausen, Germany), which was provided with Akers-like flexible clasps.

MATERIAL AND METHODS

The master cast represented a class III Kennedy partial edentation with missing teeth 3.5, 3.6, 3.7, 4.6, 4.7. (Fig. 1)

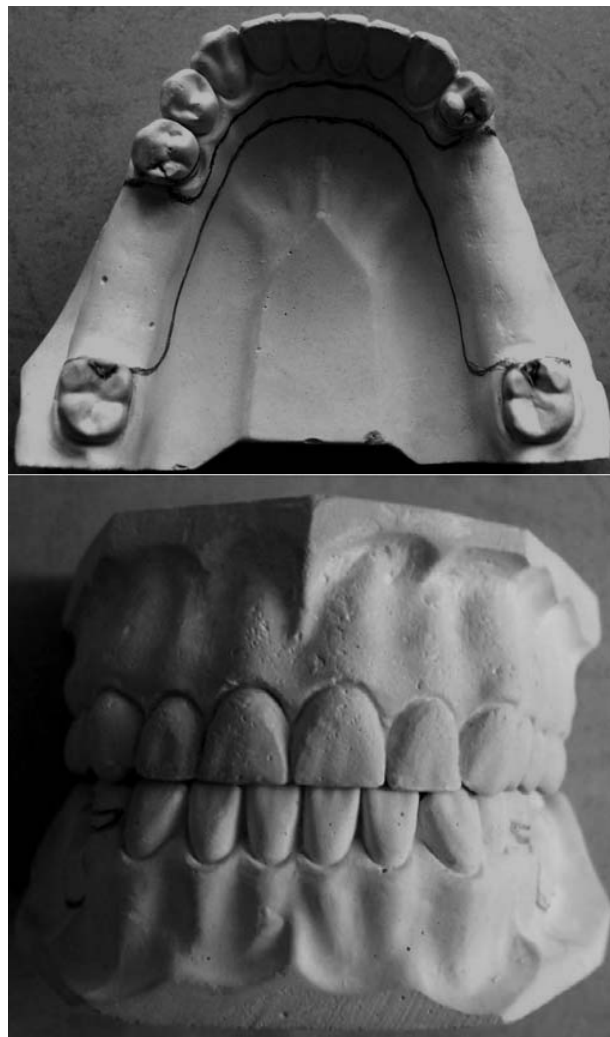


Figure 1. Master casts.

In order to obtain the master cast, the impression was poured with type III dental die stone (Moldano®, Bayer Dental, Leverkusen, Germany) using a vibrating table. Once the master cast was ready, it was analyzed using a surveyor (Dentalfarm, Torino, Italy). The teeth 3.4, 3.8, 4.5, 4.8 were selected as abutments and a position of the cast was chosen and recorded so that a favorable path of insertion was obtained. Tripod marks were used to record the position of the cast.

Carbon graphite rod was used to mark the heights of contour on the abutment teeth and the retentive mucososeous tissues. Undercut gauges were used to measure the abutments undercuts. Engagement of the terminal third of the retentive arms of the clasps was established at 0.25 mm below the greatest convexities for each abutment.



Figure 2. Design of the framework.

After the cast was analyzed with the surveyor, a soft tip black pencil was used to draw the framework design on the cast. The design included all extensions of saddles, major connector (lingual bar), retentive and bracing arms of the clasps, occlusal rests and minor connectors of Akers circumferential clasps on abutment teeth 3.4, 3.8, 4.5 and 4.8. (Fig.2)

After designing the framework, the master cast was prepared for duplication. At the beginning, blue wax plates (Öntóviasz®, Fertisol, Budapest, Hungary) were used as spacers in regions where the framework had to be away from the gingival tissue. The residual ridges were covered with 1-mm-thick wax along the 2/3 of the mesio-distal length and the 2/3 of the lingual slope height. The wax crossed the edge of the ridge and covered a short portion of the buccal slope too. The same thickness of the spacer was used along the mucosal region of the major connector where the wax was applied between gingival margin and bottom of the alveololingual sulcus. Wax spacer of 0.3 mm was placed along the ways of minor connectors.

The next step was the block-out procedure. Block-out wax was applied between teeth cervices and gingival margin of the drawing representing the clasps arms. Smooth joint was made between block-out wax and spacing wax.

Duplication of the master cast was made in usual manner. A stock tray and a condensation silicone (Zeta Plus®, Zhermack SpA, Badia Polesine, Italy) were used to make an impression of the prepared cast. The duplicated cast was poured using a class III plaster (Moldano®).

The duplicated cast was used to wax-up the pattern of the removable partial denture framework. Because the wax pattern of the metal-free framework has to be 50% thicker than that of a metallic framework, pink wax (Modellviasz®, Fertisol, Budapest, Hungary) was used for wax-up. In order to produce patterns of the saddles, wax plates were adapted on the cast according to the hallmarks and circular retentive holes were cut along them. The lingual bar was made by the same wax, achieving a half-pear shape with an optimal dimension. Wax-up of the saddles and lingual bar was made using a special wax (Finowax®, Fino, Bad Kissingen, Germany), easy to wash away, following the hallmarks. Preformed wax patterns were adapted to the hallmarks with an adhesive solution (Protek Wachsleber®, Bredent, Senden/Witzighausen, Germany). (Fig.3) Blue wax (Koronaviasz®, Fertisol, Budapest, Hungary) was used to drop wax-up the patterns of the circumferential clasps. Unlike the pattern of a metallic framework, the patterns of the clasps, occlusal rests and lingual

bar were made 50% thicker. Once the pattern of the framework was ready, it was stabilized by sticking the margins to the cast. (Fig.4)

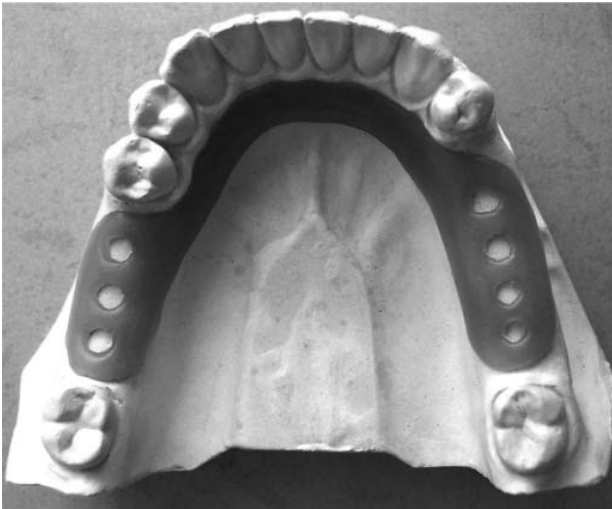


Figure 3. Wax pattern of saddles and major connector.

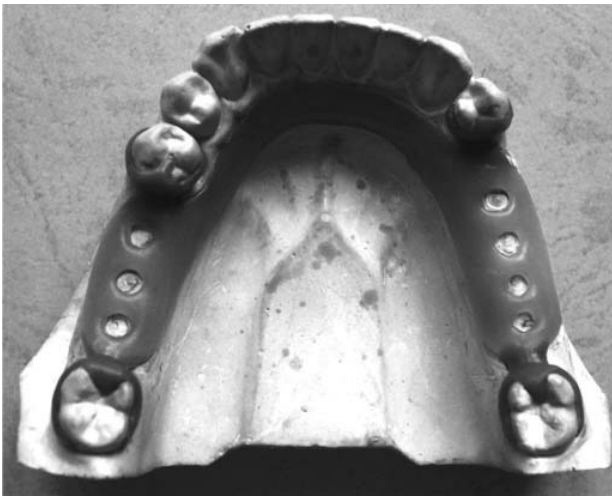


Figure 4. Final wax pattern of framework and clasps.

Spruing the framework was made using five minor sprues of 2.5 mm calibrated wax (Biotec®, Bredent, Senden/Witzighausen Germany) connected to one major sprue. (Fig.5)



Figure 5. Spruing of framework wax pattern.

After surface-tension reducing solution (Debubblizer®, Kerr, West Collins Orange, CA) was applied to the wax pattern, it was invested in a vaseline insulated aluminum flask. Hard stone class III (Moldano®) was used as investment. About 250 g gypsum paste was poured into one of the two halves of the flask and the duplicated cast containing the spruing of the framework pattern was centrally dipped base-face down. (Fig.6)

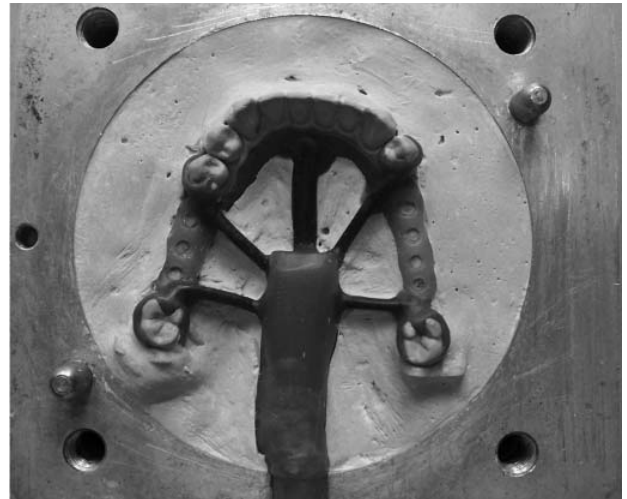


Figure 6. Embedment of the framework wax pattern.



Figure 7. Mold of the framework.

When the investment set, the gypsum surface was insulated and the second half of the flask was assembled. About 400 g of the same hard stone was prepared and poured into the upper chamber of the flask, covering thoroughly the wax pattern and sprues. After the gypsum set, the flask was submerged in warm water in a thermostatic container. The two halves of the flask were then disassembled and the wax was boiled out using clean hot water. (Fig. 7) The mold was then insulated using a special agent (Acrylic Sep®, Bredent, Senden/Witzighausen Germany) which was applied in a single layer on the gypsum surface. The surface of the mold was given a shining aspect by treating the gypsum surface with light curing transparent varnish.

Before the injection procedure, the valves of carbon dioxide tank were checked to make sure the injecting pressure was according to procedure demands (7.2-7.5 Bar). Preheating temperature and time were also checked (15 minutes at 220°C). The corresponding cartridge of injecting material (quantity and color) was selected. (Fig. 8) The cartridge was introduced into one of the two heating cylinders after vaseline had been applied at its closed end. The cartridge membrane was pointed to the flask chamber.

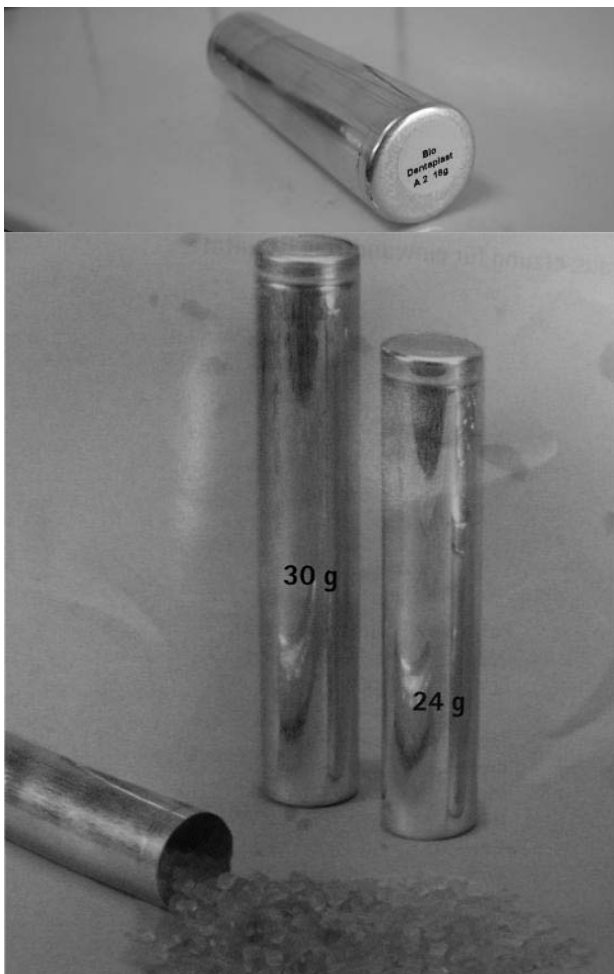


Figure 8. Cartridges with injectable resin material.



Figure 9. Polyapress injection unit.

The excess of silicone vaseline on the margin of the heating cylinder was wiped out using a highly absorbent paper. Preheating process was then activated by pushing the key on the front control panel. (Fig. 9) When the programmed preheating time elapsed, an audible signal was heard. The two halves of the flask were assembled and fastened with screws. If the flask had been assembled earlier, water vapor condensation might have occurred inside the mold, which would have had a negative effect on the quality of the injected material. The flask was inserted and secured in the corresponding place of the injecting unit. The opening of the flask was set in a straight line with the heating cylinder and cartridge.

The heating cylinder containing the material cartridge was brought near to the flask and the injecting procedure was initiated by pressing the key on the control panel. The injection process took 0.25 seconds. The pressure was automatically kept constant for one minute so that setting contraction was compensated. This stage was indicated with the sign “----“ on the screen of the heating cylinder. The cylinder was then moved about 3 mm away from the flask so that the cartridge could be separated using a trowel and a mallet. The flask was then released and pulled out. The used cartridge was automatically pushed out pressing the evacuation key.

In order to achieve optimal quality of the material, the flask was left to slowly cool for 8 hours.

Before investment removal, screws were loosened and the flask was gently disassembled. The stone blocking the vents in the upper side of the flask was removed using the hook and a mallet. Any excess of vaseline in the injecting canal was removed so that the injected material wouldn't involve such remains during subsequent usage.

The sprues were cut off using carbide and diamond burs using low pressure to avoid overheating the material. (Fig. 10) Finishing and polishing was made using soft brushes, ragwheel and polishing paste (Abraso-Star K 50®, Bredent, Senden/Witzighausen Germany).



Figure 10. Resin framework after investment removal.

Once the framework was ready, the artificial teeth were set up. (Fig. 11) Wax patterns of the saddles were constructed dropping pink wax over the framework which was set in place on the master cast. The wax was extended to the bottom of the buccal and alveololingual sulci. Teeth set-up started with the most mesial tooth, which was the second premolar. (Fig. 12)

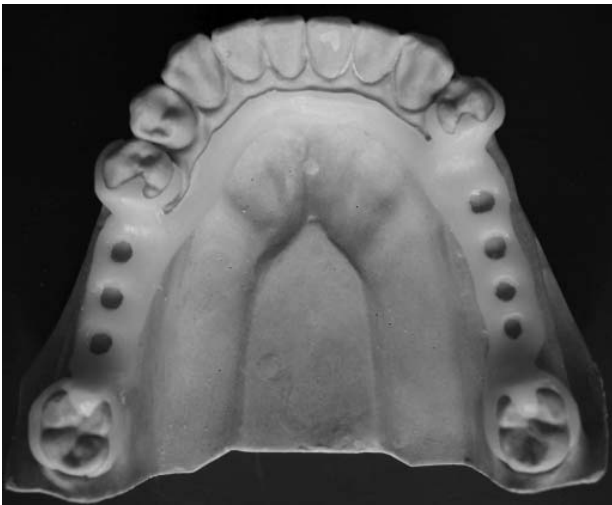


Figure 11. Resin framework set on the master cast.

When all the teeth were properly set, an investing procedure was used to turn the wax pattern into acrylic resin. Putty condensation silicone (Zeta Plus®) was used to make an impression of the wax pattern placed on the master cast. (Fig. 13)

When silicone was set, impression was detached, wax was removed, and teeth, framework and the master cast were thoroughly cleaned. Openings were cut on the lateral sides of the impression and the teeth were set in the corresponding places inside the impression. The master cast was insulated. The framework was placed on the cast and the impression was set in its original place.



Figure 12. Wax pattern of the removable partial denture after teeth set-up.

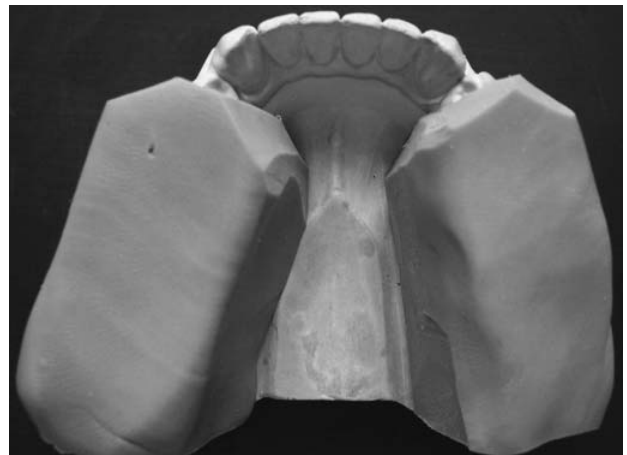


Figure 13. Impression of the wax pattern in order to obtain a mold for packing acrylic resin.

Self curing acrylic resin (Wipo-Dur[®], Bredent, Senden/Witzighausen Germany) was prepared and poured inside the impression through the lateral openings. The cast was introduced into a heat-pressure curing unit setting a temperature of 50°C and a pressure of 6 bar for 10 minutes to avoid bubbles occurrence. Once the resin was cured, the impression was removed. Burs, brushes, ragwheel and pumice was used to remove the excess, polish and finish the removable partial denture. (Fig. 14)



Figure 14. The final removable partial denture with thermoplastic resin framework.

RESULTS

The article intended to present a new technology which was actually tested. The result was a consistent removable partial denture with no macroscopic deficiency even in the thinnest 0.3-0.5 mm areas of clasps, which means the technology was effective.

DISCUSSION

Thermoplastics used in dentistry have known a great diversification in the last years. Processing principles are similar to the injecting technology of chemoplastics. However, the main difference consists in chemical composition, liquefying temperature of grains, injecting pressure and the fact that thermoplastic resins are monocomponent.¹⁰

Before clinical use, new technologies always need preliminary *in vitro* tests for both the methods and materials, which is the responsibility of preclinical research departments. This study proved that metal-free removable partial dentures could be obtained using the technology of injecting acetal resin into molds. The next step in testing the reliability of this technology would be the assessment of physical, chemical and biological properties of the injected acetal resin, as well as the *in vivo* behavior of such a denture.

Because the technology is quite new for dentistry, the literature is poor. Only few data on the subject were published to date.

Fitton et al tested some physical characteristics of polyoxymethylene (acetal resin) with dental use: the modulus of elasticity in compression, extension and flexure, stress relaxation, the force displacement behavior of clasp forms, impact strength and glass transition temperature.¹¹ Results showed that resin clasps may be resilient enough to engage undercuts for the retention of removable partial dentures but the low flexural modulus requires that the resin be used in greater cross-sectional area than metal alloys in order to gain useful retention. This greater bulk has implications for plaque accumulation and maintenance of periodontal health.

Physical properties of the acetal resin were also tested by Martinez-Gonzalez et al.¹² Metal, porcelain and acetal posts and cores were used to restore extracted teeth and oblique loaded to fracture of the teeth. The sample restored with acetal resin posts and cores showed the greatest resistance, statistically comparable to the metallic posts and cores sample. Moreover, the acetal resin posts and cores presented no fractures while metallic posts and cores exhibited different angulations and the ceramic restorations showed cracks.

Arda and Arikan simulated a 36-month clinical use of removable partial denture clasps made of acetal resin and assessed their retentive force and deformation by comparison with similar clasps cast of cobalt-chromium.¹³ The results showed no deformation for the acetal resin clasps after 36 months of simulated

clinical use unlike the cobalt-chromium clasps which presented an increase of the distance between the tips. However, the acetal resin clasps required less force for insertion and removal than Co-Cr clasps even after the simulated period.

The flexural properties of acetal resin clasps were also investigated by Turner et al.⁶ The conclusion was that to have stiffness similar to a 15-mm-long and 1-mm-diameter cast cobalt-chromium clasp, an acetal resin clasp must be about 5 mm shorter and with greater cross-sectional diameter (about 1.4 mm).

Another study compared the color stability of pigments in acetal resin with one conventional polymethylmethacrylate resin.¹⁴ The results showed slight color changes for both materials after 4000 thermal cycles. The discoloration of both materials was significant ($p=0.0001$) after 12000 thermal cycles. However, the discoloration values were clinically acceptable.

Regarding the color of metal-free removable partial dentures made of acetal resin, Chu and Chow show that acetal resin clasps are simple and effective means of improving RPD esthetics.¹⁵

Water sorption and water solubility of pink and white acetal resins were also investigated.¹⁶ Pink acetal resin showed significantly lower water sorption than heat-polymerized acrylic resin and white acetal resin. Polymethylmethacrylate showed significantly higher solubility than pink and white acetal resin. Water sorption and solubility of acetal resin were within the ISO specification limit.

A particular advantage of a removable partial denture made of acetal resin applies to the patients with large oral defects as a result of a maxillectomy procedure, who are due to have postoperative radiotherapy and need to have the density of the defect restored to ensure standardized radiation distribution.¹⁷ Different types of boluses may be used for restoration but a stent is usually needed as a support. Traditional metal-clasp retained stents are discarded in such cases as the clasps cause backscatter of the radiation beams. Acetal resin is a radiolucent material suitable for making a stent with clasps or even a RPD to retain the bolus.

A removable partial denture with the framework made of acetal resin should be quickly integrated into the dento-maxillary system and accepted by the patient due to its reduced volume, esthetic and flexible clasps. Such a removable denture is a comfortable solution for partial edentulous patient, achieving the principles of static and dynamic maintenance and stability.

CONCLUSIONS

1. Bio Dentaplast[®] is a thermoplastic polyoxymethylen based material (acetal resin) suitable for the injection-molding technology
2. Acetal resin frameworks may be as thin as 0.3-0.5 mm so that the material is suitable for removable partial dentures with flexible, esthetic clasps.

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