POLYMERIC PARTIAL DENTURE FRAMEWORKS- A REVIEW

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Abstract

Since the 1930's, partial denture frameworks have generally been made from metallic alloys such as Cobalt-Chromium (Co-Cr). However, the main limitations of these materials are related to their aesthetics, due to which there is a lack of patient acceptance. The introduction of thermoplastic polymers like polyamide, polyoxymethylene, and the aryl ketone family has been revolutionary due to their good mechanical properties, excellent aesthetics, and adequate biocompatibility. While their usage has seen an exponential increase in recent times, adequate research regarding their long-term clinical success is limited, especially regarding the recently introduced PEEK and PEKK. The current review aims to briefly discuss the types of polymeric partial denture frameworks along with their advantages and disadvantages.

Key words: *Flexible dentures, Thermoplastic resins, PEEK, PEKK, PAEK*

With the advent of modern technologies and healthcare systems, the life expectancy of an average individual has increased substantially. A longer life span with better healthcare has led to improved awareness of the importance of oral healthcare practices as well. Thus, the prospect of complete edentulism has extended well into the latter years of an individual and there is an increased scope for partial dentures.

In the current scenario, partial edentulism is often corrected with the use of dental implants or by the fabrication of crowns and bridges. However, the patient might require an alternate option in the form of Removable Partial Dentures (RPDs); primarily, due to financial constraints along with other factors such as excessive ridge-resorption, oral hygiene concerns, and in cases where there is a requirement for cross-arch stabilization.[1] It also helps that the delivery of RPDs can be carried out much more quickly in comparison to the case of an implant fixture.

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A partial denture framework is a substructure onto which the teeth are placed. It provides features such as support, stability, and rigidity. Traditionally, they have been made using various metals. RPDs made of metals, however, are not in line with the current aesthetic standards of metal-free restorations. Therefore, the trend is shifting toward materials such as polymers. These materials are beneficial as they provide high stability, and the colour aesthetically matches the teeth and/or mucosal tissue.

Flexible Denture Base Materials

When fabricating a removable partial denture prosthesis, certain rules are followed to provide optimal support, retention, and stability. Traditionally, the rigidity provided by a metal major connector is the primary requirement to ensure that the other components of the partial denture (such as rests and indirect retainers) function as they should and that applied forces are distributed broadly. Even so, the level of patient satisfaction with an RPD does not always equate to its overall quality or precision of fit. The use of a nonrigid material for the major connector or other components of an RPD, while a change from traditional thinking, may prove to be beneficial for certain patients.

The flexible materials employed for RPD fabrication are thermoplastic resins. Thermoplastic resins do not undergo any kind of chemical reactions and are subject only to physical changes when heated, as they become soft and can be injected under

pressure into a preheated refractory mould, where it solidifies as it cools. Flexible thermoplastic resins that are commonly used for RPD fabrication include polyamides or nylons, and acetate or polyoxymethylene resins.[3]

Polyamide or Nylon

Nylon (a generic name for a specific group of thermoplastic polyamides) was considered particularly useful for patients who had repeatedly experienced denture fractures or demonstrated a known sensitivity to polymethyl methacrylate (PMMA).

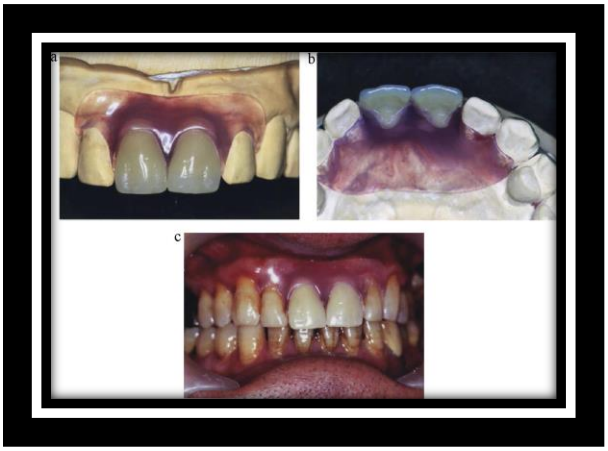

Fig 1: A non-metal clasp denture without a metal framework (Valplast)

Polyamide derives from diamine and dibasic monomer acids. It has a high chemical, thermal, and physical resistance, is clinically unbreakable, and absorbs little water. After the polymerisation process is completed, various additives and pigments are added which can change the physical properties of the polymer.

After this, the molten polyamide nylon is extruded through holes to form long laces of nylon. The laces are allowed to cool and solidify by extruding them into a water bath. Afterward, they are cut into granules with a length of 3 to 4 millimeters. These granules are then packaged and shipped to processing plants where they are subsequently re-melted and extruded through dies to create fibres and various extruded shapes or castings.

Currently, available commercial products include Valplast (Valplast International Corp.), Lucitone FRS (flexible resin system, DENTSPLY International), Ultimate, Flexiplast (Bredent, Germany), Flexite, etc.

The major advantage of nylon lies in its exceptional mechanical properties such as resistance to shock and repeated stress. Nylon is said to have higher fatigue resistance than polymethyl methacrylate; although the data has not been corroborated under intraoral conditions. Though nylon has superior mechanical properties than any other non-metallic base, there are still some major drawbacks such as processing difficulties and dimensional changes.

Acetate or Polyoxymethylene Resin

Polyoxymethylene (POM), formed by polymerizing formaldehyde, is an alternative denture clasp material. The homopolymer POM is a chain of alternating methyl groups linked by an oxygen molecule. Acetal resin is quite strong, resists wear and fracture, and is very flexible. This material is hydrophobic in nature, which means that the material is resistant to water or saliva. It also exhibits high creep resistance and high fatigue endurance as well. It is monomer free and offers a convenient and safe treatment alternative for patients who are allergic to conventional resins. It has little to no porosity, thereby reducing the accumulation of biological material like plaque, which in turn resists odour and stains. Owing to these characteristics, it is an ideal material for pre-formed clasps for partial dentures, single-pressed unilateral partial dentures, partial denture frameworks, provisional bridges, occlusal splints, and even implant abutments. Because of its superior biocompatibility, it is considered an RPD framework material for patients who may be allergic to cobalt-chromium materials. The material was promoted primarily based on superior aesthetics, which allowed the clasp to better match the colour of the abutment tooth.

Contraindications of flexible partial dentures include patients who simply should not or would not wear any type of removable appliance. However, flexible partials specifically are not advisable in patients with insufficient inter arch space (<4mm space for placement of teeth), prominent residual ridges; where there is less space for labial placement of teeth because, T–shaped holes are necessary for mechanical retention of teeth to the denture bases, and flat- flabby ridges with poor soft tissue support,

which require more rigid prosthesis.[4]

Fig 2: Acetal resin flexible RPDs with conventionally styled frameworks

Polyaryletherketone Dentures

Polyaryletherketone (PAEK) is a family of semi-crystalline thermoplastics that has features like high-temperature stability and high mechanical strength. Its chemical structure includes a molecular backbone consisting of ketone (R-CO-R) and ether groups (R-O-R) arranged alternately.[5]

Polyether Ether Ketone (PEEK)

Polyether ether ketone is a colourless organic thermoplastic polymer.[6] PEEK is a type of polyaryletherketone that boasts of excellent mechanical and chemical resistance properties, that are retained even at high temperatures. These properties are related to its crystalline structure which in turn is related to the processing conditions used to mould the material. It can withstand not only thermal degradation but also the presence of both organic and aqueous environments which is the case in the oral cavity. In comparison to most other thermoplastics, PEEK has a relatively high melting point. It is processed using methods such as injection moulding or extrusion within the range of its melting temperature.[7]

The major application of PEEK in dentistry is as an alternate option to metal connectors and clasps in removable partial prostheses. Apart from this, PEEK can be used with acrylic teeth as an alternative material for the fabrication of removable partial prostheses. They could play an important role in distal extension cases, as it is thought that prostheses with a PEEK substructure could aid in the health of the abutment teeth. This is to be expected, as the elasticity of the material is thought to reduce the torque on the abutment. Consequently, lighter prostheses can be obtained which increases patient satisfaction and comfort.

They help in the elimination of metallic taste and allergic reactions. Also, this material can be well polished and therefore, has low plaque retention. As PEEK is white in colour and has high resistance, it can be used to place clasps in aesthetic areas.

PEEK has been observed to be more colour stable compared to other prosthetic resin materials. The effects of polishing methods on the surface roughness and free surface energy have been compared among PEEK, PMMA, and a composite resin and it was seen that lower surface roughness and free surface energy among the three, were obtained in PEEK, which is a harder material.

BioHPP (Bredent GmbH, Senden, Germany) is a modified PEEK material containing 20% ceramic fillers and is marketed as a high-performance polymer. It presents with high biocompatibility, good mechanical properties, high-temperature resistance, and chemical stability. Also, due to its modulus of elasticity of 4 GPa, it is as elastic as the bone itself and can, therefore, reduce the stresses transferred to the abutment teeth. Furthermore, the white colour of BioHPP frameworks provides a different esthetic approach than the conventional metal framework display does and is thus, considered to be superior in aesthetics. This material also provides additional advantages such as the elimination of allergic reactions and metallic taste, high polishing qualities, low plaque affinity, and good wear resistance.[8, 9]

Polyetherketoneketone (PEKK)

Polyetherketoneketone (PEKK) is a new polymeric material that has attracted the attention of researchers due to its excellent properties that can be used in many applications. PEKK is a methacrylate-free, high-performance thermoplastic material. PEKK was first introduced by Bonner in 1962 and has since been used for various industrial and military purposes.

Fig 3: BioHPP intraoral view

Recently, PEKK has been increasingly used as a biomaterial with properties suitable for both dental and medical applications. Its wide biomedical application is possible due to its higher mechanical strength and the presence of the second ketone group, which allows greater surface modification.

Recently, PEKK has been used in removable partial dentures (RPD) as dental clasps and frameworks using digital technology. Sun et al., presented a digital workflow for the application of PEKK in speech bulb prostheses as well.

Conclusion

In the coming years, the number of patients with partial edentulism will increase, and with it, the need for cost-effective treatments such as RPDs. As with any other treatment protocol, complications and treatment failures can occur with RPDs. Therefore, thorough research is needed to investigate the strengths and weaknesses of the various RPD designs, as well as the newer techniques and materials that are available. Proper assessment of the dental condition, tooth position, abutment preparation, fitting of structures within the RPD, patient education, timely recall, and maintenance are some of the steps that are essential for success. Ideally, treatment with RPDs should result in improved overall oral health, patient satisfaction, and compliance.

Research and advances in the application of digital technologies and improved materials such as biocompatible metals and polymers have the potential to address many of the issues associated with the use of RPDs and oral health. Digital strategies are expanding the range of therapeutic applications for partial dentures due to their improved design and production control, which will likely improve patient outcomes and experiences. As the need for RPDs is expected to increase, the strategies must continue to evolve and improve to accommodate the growing number of partially edentulous patients. The combination of improved materials, digital design, research, and education, promises to improve the quality of life for our patients.

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Conflict of Interest: *None Decl*ared