

# THE DEVELOPMENT OF FLEXIBLE DENTURE MATERIALS AND CONCEPT: A NARRATIVE REVIEW

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## **Abstract**

**Introduction:** Flexible denture is an alternative treatment modality for removable partial denture (RPD) that aid the retention by ensuring seal around the entire border of the denture. It is also referred as hypoallergenic denture especially for those who are allergic towards conventional acrylic denture which is the poly-methyl-methacrylate monomer (PMMA) and metal (cobalt chromium). The flexible material exhibits lower flexural modulus than conventional type of baseplate material denture that makes it nearly unbreakable. Nowadays, there are a handful of different flexible materials in the dental market for the general dental practitioners to choose but somehow the studies on the properties of these different types of flexible materials are sparse.

**Objectives:** The present study is to study the development of the flexible materials, the different type of flexible materials and their physical properties.

**Methods:** From the limited article journals available, the authors have summarized the history, development and constituents of different type of flexible materials used in fabricating denture. Besides that, the authors also discussed about the indications, contraindications, advantages and disadvantages of the materials in denture constructions based on all the published researches available on this topic using published materials available in the dental library, University of Malaya and the databases (Science Direct, PubMed).

**Conclusion:** Each flexible material has its pros and cons. Therefore, careful selection of material and understanding of the flexible dentures' indications and contraindications are utmost importance to make sure the best treatment outcome. Hence, patients' best interest and quality of life can be upheld.

**Keywords:** *Flexible Denture Material, Physical Properties, Indications, Contraindications*

## **Introduction**

For the past century, denture base material had undergone various phases of development and improvisation. It started in year 1855 where vulcanized rubber (vulcanite) was first introduced and dentists faced many difficulties in achieving good aesthetic and the technique in fabrication using this material. This is when polymethyl metacrylate (PMMA) was introduced in 1937 by Dr Walter Wright to improve the physical and aesthetic properties of denture. Since then, PMMA has been the most commonly used material for complete or partial denture construction due to inexpensiveness and the advantageous properties of material. Some bonus points of PMMA include easy application and repair, stability in oral cavity, patient's acceptability and aesthetical properties. However, PMMA

exhibits weak flexural and impact strength as well as low fatigue resistance that may lead to fracture (1). Other than that, PMMA has difficulty in insertion when there is presence of undercut areas and it would not be recommended for those patients with allergy to methyl metacrylate monomer (2).

In order to overcome the downside of the PMMA, base metal alloys, such as cobalt chromium (Co-Cr) was introduced in 1929 as an alternative to be used in fabrication of removable partial denture. Co-Cr exhibit lower density and a modulus of elasticity that is nearly twice that of gold alloys. These features improved denture in term of aesthetics and physiological contouring as well as the development of a suitable occlusion with less tooth structure reduction (3). Although the combination of Co-

Cr and PMMA in denture construction seems successful, they are still not able to provide patients with acceptable aesthetic property and are not suitable for patients who are allergic to metal and methyl methacrylate monomers. Providing cobalt chromium denture to patients with a history of eczematous dermatitis could exacerbate their systemic lesions, in addition to a localised lesion under the denture (4,5).

Similarly, the unreacted acrylic resin monomer residual could cause toxic side effects in some wearers (6), despite of the measures taken to reduce the monomer, like immersing denture in hot water before issuing, and asking the patient to keep it out of the mouth. Yet, patient might suffer from denture stomatitis (7,8) and extensive systemic symptoms because of denture wearing (9). Besides that, the dental clinicians and dental technicians can get allergic contact dermatitis primarily because of the contact with acrylic monomer (10).

A light-polymerised denture base resins which is composed of urethane acrylate oligomers was introduced in the early 1980s. Eclipse is the most common brand of urethane-based denture material, and (11) uses visible light as activator and camphorquinone as initiator.

Recently, flexible dentures have gained popularity as an alternative to the PMMA among dentists and patients in denture construction as it offers twin advantages of aesthetic and flexibility. Flexible denture materials referred as hypoallergenic are used to make removable partial denture (RPD) for patients who exhibits allergic reaction to acrylic resin or cobalt chromium dentures. The flexible material exhibits lower flexural modulus than conventional type of denture material making it nearly unbreakable. In addition, PMMA has difficulty in insertion when there is presence of undercut areas and it would not be recommended for those patients with allergy to methyl methacrylate monomer (2).

Nowadays, there are a handful of different flexible materials in the dental market for the general dental practitioners to choose from. However, researches showing the physical properties of different types of flexible materials are sparse. Therefore, the purpose of the present study is to give an overview of the development of the flexible materials and understand the different types of flexible materials and their physical properties.

### ***What is a flexible denture?***

It is a metal-free removable partial denture constructed from ISO 1567 thermoplastic resins that could be either polycarbonates (polyesters) acrylic resins or polyamides (nylons) polyaryletherketones, (GPT 9). It exhibits lower flexural modulus than the conventional type of baseplate material denture that makes it nearly unbreakable. The flexibility of these materials allow incorporation of denture flanges in undercut area of buccal vestibule (12). Like conventional PMMA denture, retention is by creating peripheral seal around the entire denture border. It is also

referred as hypoallergenic denture especially for those who are allergic towards methyl methacrylate monomer and metal. However, flexible dentures are intended for provisional and temporary applications and not to be used for long term.

### ***Materials development history***

In 1953, Valplast introduced a flexible semi-translucent thermoplastic resin to create flexible tissue-born partial dentures. Similarly, a New York-based company provided another variant of flexible material, Flexite thermoplastic which was a fluoropolymer (Teflon type plastic) in 1962. With an increase in aesthetic demands during the 80s, it was possible to hide the visible clasp by incorporating resin into the partial denture (13), or using injection method to make the whole denture including invisible clasp from Acetal resin dentures which provide clasp from the same material (14,15). In 1992, The Flexite Company developed and patented the first pre-formed tooth coloured clasps 'Clasp-Eze', in both pink and clear colour. Flexite demonstrated colour stability in air and water (16). Currently, there are three types of thermoplastic resins available which are Polyamide (PA-type) resins, Polycarbonate (PC-type) resins and Polyethylene terephthalate (PET-type) resins. All of them exhibit their own strength and weaknesses.

### ***Polyamide (Nylon)***

Polyamide (PA) was invented in 1928 by Wallace Carothers and was commercially available in 1938 as Nylon. It is produced by the condensation reactions between a diamine  $\text{NH}_2\text{-(CH}_2\text{)}_6\text{-NH}_2$  and a dibasic acid,  $\text{CO}_2\text{H-(CH}_2\text{)}_4\text{-COOH}$  (17), reaction of co-amino acids and hydrolytic polymerization of lactams, or reaction of lactams (18). In 1950s, polyamide resin (nylon) was proposed as a denture base material. Some of the commercial brands that used polyamide resins include Valplast, Lucitone FRS and Flexiplast. Dentures made of PA were flexible, fabricated by injection of molten material at  $274\text{ }^\circ\text{C}$ - $300\text{ }^\circ\text{C}$  into flask under pressure. Flexural strength and modulus of elasticity of polyamide type materials are lower than that of the conventional PMMA. According to the ISO standard (Type 3 denture base materials require more than 65 Mpa of flexural strength and a modulus elasticity of 2000 Mpa). Hence, the PA denture is more flexible when compared to conventional PMMA. Besides, it has the flexibility to disengage forces on individual teeth. Thus, transfer of forces to the remaining natural teeth and the contralateral side of the jaw can be avoided (2). However, despite of the low flexural modulus, they demonstrated strong resistance to fracture (17). Numerous amide bonds form the main chain of the polyamide resin. PA tended to have high water sorption values. Compared with PMMA, polyamide has higher fatigue resistance and produces rougher surface before and after polishing by using the conventional polishing technique. There are several polyamide materials available, which are Lucitone FRS, Valplast, Flexite and Vertex thermosens.

Lucitone FRS material is made by Dentsply, exhibits flexibility, high impact strength and excellent retention. In addition to that it enhances patient's aesthetic by providing a selection of shades to customize the denture base and clasp. Also, it offers a range of thickness which indicates its flexibility. The Lucitone FRS material is available in the form of pre-packaged cartridges that are heated prior to precision injection.

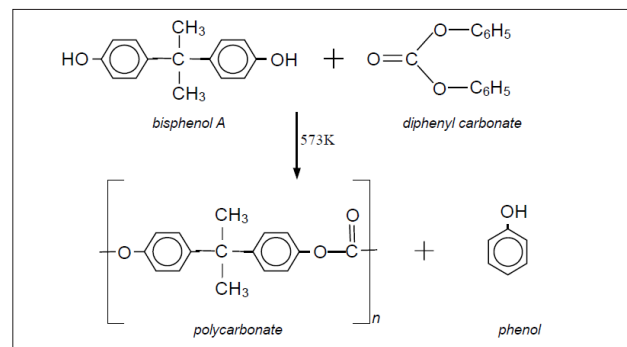
Valplast was developed by dental technicians, Arpad and Tibor Nagy, in their Master Touch Dental Laboratory in New York, America in 1953, from a hybrid of four types' diamine and dibasic acid monomer. Clasp made of Valplast blend with natural surrounding teeth and gingiva, as well as smooth and comfortable against the surface of the tongue (19). Due to its high physical strength, wraps around distal clasp arch with only unilateral teeth present is achievable and the denture exhibits better retention and stability as compared to conventional RPD (20). Valplast exhibited superior performance in impact strength and flexural strength among flexible denture materials like Bre-flex, De-flex and Lucitone FRS (21).

Flexite employs the use of vinyl composite and it eliminates the use of metal as a clasp. Thus, providing patients with precise fit, tissue coloured aesthetics and comfort while using a denture. Flexite thermoplastic material is monomer free resin and does not need two components such as conventional acrylic resins. It offers several types of monomer free plastics such as Flexite Plus, Flexite Supreme, Flexite MP and others. Each one has its own characteristic, where they may differ in their flexibility, rigidity, and transparency. Each fulfils a different need in dentistry. Flexite is used in fabricating RPD, dentures, sports mouth guards, tooth coloured clasp and TMJ, bruxism and anti-snoring devices.

Vertex Thermosens is a monomer-free denture base material. It exhibits comparable teeth movement after processing and similar dimensional change in mouth as in PMMA (22). The flexibility of this thermoplastic material allows the transfer of stresses from denture to surrounding tissues to reduce trauma from denture. The colour of thermoplastic denture bases matches oral tissues to perfection and eliminates the use of metal clasps as in the conventional removable partial denture design (23).

### Polycarbonate

Polycarbonate (PC-type) was commercialized in the early 1960s. It is a polymer chain of bisphenol-A carbonate and is usually derived from bisphenol A and phosgene (Figure 1). Some examples of commercially available PC-type resins are Reigning and Jet Carbo Resin. They melt at 230 °C-290 °C. These materials are fracture resistant flexible, with a lower wear resistance than acetal resins (24). Although PC exhibits fracture resistance and translucent for excellent aesthetics, but its low wear resistance limited its use to provisional crowns rather than for partial denture frameworks (25).



**Figure 1:** Diagram shows the synthesis process of polycarbonate resins

### Polyethylene Terephthalate

Polyethylene terephthalate (PET-type) resin is another type of thermoplastic resin. It is made from ethylene glycol monomers and terephthalic acid. An example of commercially available PET is Estheshot. Study showed that PET has adequate fitting accuracy for incorporating metal framework into dentures as it has the smallest gap and is significantly smaller than the conventional PMMA (26). It has been reported that denture made of PET has high elastic moduli that tended to cause stress to the abutment teeth during insertion and removal of the denture (27). To achieve good retentive forces, the Estheshot requires a clasp arm with thickness of 1 mm, engaging 0.25 mm undercut depth or more (28).

### Indications and contraindications of flexible dentures

#### Indications

- i. Severe undercuts where pre-prosthetic surgery is not feasible. In these cases, the retentive part or denture flanges can flex around undercuts without causing much irritation to the tissues.
- ii. Patients allergic to acrylic or metal
- iii. As a long term interim denture (29) after placement of implant
- iv. For existing patients complaining of anterior clasps and want to hide the grey metal colour on the front teeth (15). Most dentists choose it for aesthetic reasons as well (29)
- v. For existing patient who is not comfortable with conventional acrylic partial dentures.
- vi. Flexible denture is also suitable for pre-formed clasps for partial dentures, single pressed unilateral partial dentures, partial dentures frameworks, provisional bridges, occlusal splints, obturators, speech therapy appliances, orthodontic retainers and implant abutments (30).
- vii. Prosthetic rehabilitation of patient with hereditary ectodermal dysplasia.
- viii. Periodontally compromised teeth and hypersensitive teeth.

- ix. In maxillectomy patients, flexible material can be incorporated in making an obturator for acquired defect after surgical recession of palatal cancer lesion (31).

### **Contraindication**

Flexible denture is contraindicated in patients with deep overbite or less than 4 mm inter-arch space in the posterior area. Patient that has bilateral free-end distal extensions with knife-edge ridges or lingual tori on the mandible is also contraindicated to use flexible denture and patient with displaceable flappy tissue due to reduced tissue support (15).

### **Advantages of flexible denture**

The elastic property of material makes them unbreakable (32), making it a suitable replacement for cobalt chromium denture base which is also unlikely to break due to its rigid nature. However, Valplast has an advantage as it is a more aesthetic denture base. This is due to its colour, enabling aesthetic matching with the underlying gingiva. Besides that, clasps can be made translucent for aesthetic purposes and absence of metal show through permits versatility in clasps design and positioning (27). Thus, less complicated design is needed as compared to a cast removable partial denture.

Flexible denture also has an advantage for patient who is allergic towards Polymethylmethacrylate (PMMA). The material involved, nylon, is more biocompatible with tissue and unlikely to cause any allergy. Besides that, the flexible denture is also light in weight compared to cast removable partial denture. This provides more comfort and patient will not feel heavy when wearing denture. Other than that, as the name suggest, flexible denture is flexible in nature. It may act as stress breaker due to the flexibility of major connector and thus the force can be distributed more evenly. The saddle also floats independently above the tissue, giving less stress to abutment teeth. In long term, partial flexible denture may act as a tissue conditioner. This is due to slight movement above the tissue which will stimulate blood circulation of the alveolar ridge beneath it and will reduce the progressive atrophy of alveolar ridge. Finally, a flexible denture construction takes less time for both dentist and patient, as there is no requirement for mouth preparation for most of the cases as compared to when using conventional cast partial denture.

### **Disadvantages of flexible denture**

Nylon denture base has a significantly lower flexural modulus compared to PMMA polymers (33), with Valplast denture material exhibiting good mechanical strength among other nylon products. Unfortunately, the denture surface is easily scratched or damaged (34) and yet to meet the standard of PMMA materials in terms of physical

and mechanical properties(1). The acrylic denture teeth are mechanically retained to nylon denture base material thus having a high probability of being dislodged from the denture base. Fitting of a flexible denture requires added skills and special armamentarium to adjust the nylon denture base. Studies assessing colour stability of flexible denture material are scarce in literature compared to PMMA. However it has been reported that Ppflex is as stable as conventional denture material, while Valplast showed greatest colour change on accelerated aging (35). However, the tested denture material gets harder with time.

### **The flexible RPD treatment planning and designing**

The Flexible RPD treatment planning and designing starts with studying accurately surveyed and mounted diagnostic casts, the amount of inter-arch space and the occlusion which determines the placement of components. Furthermore, an accurate diagnostic cast can be used as a master cast to construct the flexible partial dentures to reduce cost for certain patients (36).

The survey concept is different with flexible RPD, as it is more of a "survey zone", rather than a survey line as for the conventional RPD. Therefore, the survey line for the flexible RPD shows the area which need to be planned and may be subjected to enameloplasty that would provide a circumferential guide plane of a 2.0 mm height that goes around the tooth. The occlusal rest can be incorporated in the design and that would require tooth preparation for occlusal rest seat.

### **Denture issue and adjustments**

Flexible denture should not be treated like the conventional metal or acrylic removable partial denture during issue and adjustment to avoid failure (37). The steps are as below:-

- i. Immerse it in very hot tap water (temperature around 50-60 °C) for about one minute.
- ii. Remove and allow cooling to patient's tolerance temperature.
- iii. Gently insert in mouth. The hot water permits a smooth initial insertion and good adaptation with the natural tissues in the mouth.
- iv. Tight clasps causing discomfort or loose clasp can be adjusted slightly by immersing in hot water and bending it accordingly.
- v. Areas of persistent irritation can be adjusted using green stones with a straight hand piece in recommended speed and repetitive motion, and each manufacturer provide their own kits (Figure 2).
- vi. Smoothen and polish with rubber wheel with intermittent contact to prevent material from melting.





**Figure 2:** Polishing kits for the flexible denture prostheses

**The flexible RPD clasp designs**

To achieve good retentive forces with flexible retentive clasps (e.g. Valplast), the depth of undercut and thickness of the clasp should be in the range of 0.5 mm and 1.0 mm respectively (28). There are many designs for the flexible RPD that depends on the case’s needs (38). These clasps designs can be:

1. The standard/ main clasp  
This is the most commonly used design, where in certain cases, it requires tooth preparation. The clasp is usually designed too large and bulky (Figure 3) (38).



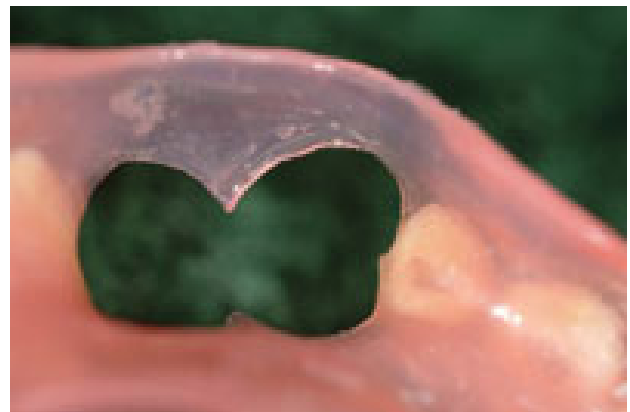
**Figure 3:** The standard/ main clasp

- ii. The circumferential clasp  
This design is indicated for the free-standing isolated tooth. It surrounds the tooth totally forming a closed ring like clasp (Figure 4) (38).



**Figure 4:** The circumferential clasp

- iii. The continuous circumferential clasp  
It is a circumferential clasp which surrounds and engages multiple teeth and may provide splinting like action (Figure 5) (38).



**Figure 5:** The continuous circumferential clasp

- iv. The combination clasp  
This clasp is engages multiple teeth in combined form of both the main clasp and the continuous clasp. The connection between both clasps will cross the occlusal table and provide rest like action (Figure 6) (38).



**Figure 6:** The combination clasp

- v. Reach around clasp  
Mostly designed for Kennedy class IV and it engages the last molar by engaging the mesiobuccal undercut area. This design is contraindicated and should be avoided, as it is too thick and very bulky (Figure 7) (38).



**Figure 7:** Reach around clasp

- vi. The “separated” clasps  
This design is more suitable for the cast RPD. It resembles multiple circling clasps. This design is not suitable for flexible RPD and it has reduced strength and retention (Figure 8) (38).



**Figure 8:** The “separated” clasps

### Conclusion

With the understanding of the properties of each flexible material, the authors have listed out its pros and cons. Therefore, careful selection of material and understanding of the flexible dentures' indications and contraindications are utmost important to make sure the best treatment outcome. Hence, patients' best interest and quality of life can be upheld.

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### Competing interests

The authors would like to declare that there is no conflict of interest in conducting and publishing the present paper.

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