The Ideal Hybrid Framework Material? - A Literature Review

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INTRODUCTION

With the increase in average lifespan of individuals, complete edentulism has become a commonly recurring problem. Because of its high prevalence, it is considered a morbid public health issue around the world (exceeding 10% in adults aged ≥ 50 years)(1). Edentulism is a handicap that has an impact on one's quality of life, confidence, as well as nutrition(2). It also causes orofacial system dysfunction, including problems with chewing, swallowing, speech, intermandibular relationship, and facial aesthetics(3). A complete denture is the most traditional and common treatment for complete edentulousness. However the functional and esthetic success of it is less compared to fixed treatment options. The advent of implant supported restorations has opened new paths for completely edentulous patients to have a fixed prosthesis that provides predictable long-term success with improved function and effective preservation of alveolar bone(4). Implant supported prosthesis could be completely fixed or removable.

Removable treatment options include overdentures. Although overdentures give patients greater confidence than a complete denture, despite their added cost, they still have to be removed everyday(5). Hence the increased demand for efficient function and esthetics has further popularised completely fixed restorations which are usually supported by 6-8 osseointegrated implants. FP3 or Hybrid prosthesis consists of a bar (metallic or non-metallic) covered by a veneering material which is then screwed on to the implants. It is a fixed dental prosthesis and can only be removed with the help of a dental professional(6). Hybrid prosthesis offer a lot of advantages, including reduced occlusal load impact force, lower fabrication costs, and extremely aesthetic restorations(6,7).They can also be made over implants that are tilted or axially placed(8).

Keywords: Hybrid denture, Framework, Titanium, Zirconium, PEEK, Cobalt Chromium

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Abstract

Hybrid denture prosthesis have been used popularly in prosthodontics as a tooth replacement option. with some controversy. Hybrid dentures consist of one of the most novel options in the restoration of the edentulous arches. The implants are only placed only in the anterior region and the prosthesis is provided in the posterior region with the assistance of a cantilevered bar or framework. Conventionally the framework for such a prosthesis is fabricated using titanium or cobalt-chromium metal. Traditionally the frameworks were fabricated using metal casting. However, with the advent of digital dentistry CAD CAM frameworks have become very popular which have allowed the use of an array of materials such as zirconia,peek amongst other traditionally used metals. With a focus on materials used in the fabrication process of hybrid dentures, the goal of this study was to summarise the pertinent literature in this area. In conclusion, hybrid dentures seem like a viable treatment option which can be fabricated using multiple materials such as PEEK, zirconia, titanium, cast base metals, noble metals etc.

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Over time, the framework materials have progressed from gold alloys, cobalt-chromium, milled/printed titanium, to non-metal materials like zirconia and peek(9). According to Drago et al, “framework must be fabricated from materials and protocols that allow passive and accurate fit between frameworks and implants and/or abutments”(8,10).

Metallic alloys have adequate tensile strength (>300 MPa) and elastic modulus (>80,000 MPa) to resist deformations and fracture of cantilever. Traditionally the internal metallic frameworks were fabricated using conventional casting procedures (9,11). However, it was observed that casting procedures were more successful in noble metal frameworks such as gold and Ag-Pd, compared to base metal alloys (12). However the long run use of noble metals wasn't feasible due to their high cost. Titanium, a material with superior qualities such as biocompatibility (13), corrosion resistance, low cost and good mechanical properties (14) was a popular choice for the framework. However, it was difficult to cast due to its high melting temperatures, low density, and reactivity with elements in casting investments (15). This problem could be overcome with the advent of digital manufacturing which may help us avoid the limitations posed by manual casting of titanium(16).

**Hybrid Denture**

Completely edentulous patients have various treatment options which range from removable prosthesis such as complete dentures, to semi-fixed such as implant supported overdentures and finally fixed options like - FP1, FP2 and FP3 prosthesis. A hybrid denture is an FP3 prosthesis which replaces the missing teeth along with the gingival tissue. It encompasses a flangeless denture, supported by implants and a metallic or non-metallic bar. The tissue coverage of the prosthesis is minimal, as it doesn’t extend over the palate and conventional tissue landmarks. Thus it is a good option as it gives the patient comfort of a fixed prosthesis, while having the option of easy removal and replacement by the dentist.

**Evolution of hybrid denture**

The original design of a hybrid denture was given by Swedish researchers(17). The prosthesis was fabricated on 2 endosseous implants and was made of a gold framework covered with acrylic and consisted of acrylic teeth(18). However this wasn't feasible due to the high cost of noble alloys, hence alternative materials such as cobalt-chromium, silver-palladium and titanium alloys were explored. However, due to the expansion and contraction that occurs during the casting process, cast metal frameworks are prone to porosity and distortion(19)(20). This issue could be corrected with the advent of CAD-CAM dentistry. CAD-CAM dentistry allowed us to fabricate prosthesis with greater accuracy, homogeneity at lower costs(21)(22). The use of CAD-CAM technology also allowed us to explore other non-metallic bar options such as zirconia and peek. High aesthetics, high fracture resistance, better lifespan, improved stain resistance, and greater customizability were all advantages of zirconia(23). While high impact polymers like PEEK(polyetheretherketone) were colourless, biocompatible and had stiffness similar to cortical bone(24). This material can alleviate the stress being directed on implants and provide lesser stress shielding(25).

**Concepts Of Designing Hybrid Denture Framework**

Hybrid denture frameworks have been produced using a variety of methods and materials over the years. Drago et al (10) described guidelines for hybrid prosthesis stating that “framework must be fabricated from materials and protocols that allow passive and accurate fit between frameworks and implants and/or abutments.”

Zarb and Jansson described two methods of fabrication of the framework(26) (10,26,27). They were as follows:

where metallic frameworks made up the bulk of the prostheses, while artificial teeth and minimal denture bases consisted of the only non-metallic components.

Implant fixed prostheses consisting mostly of acrylic resin denture bases (wraparound design) and artificial teeth, with minimally sized metal frameworks(28).

Factors taken into consideration during the fabrication of the framework include:

- Bulk for strength
- Adequate access for oral hygiene procedures
- Reduced display of metal on both facial and occlusal surfaces
• Strategic thinning of implant frameworks to allow for retention of acrylic resin denture teeth and denture bases (29)(30)

It's worth noting that the appropriate length of the framework wasn't mentioned in early implant literature. Since the implants for a hybrid prosthesis are placed anteriorly, the posterior portion of the framework will be cantilevered from the anterior. As a result, the cantilever's length, height, and width were critical in limiting the prosthesis deformation (31). According to Glantz (28), the amount of deformation of the cantilever is directly proportional to the cube of the length and inversely proportional to the width and the cube of the height of the cantilever (32). As a result, the framework's length should be kept to a minimum while its width and height should be maximised (28).

Materials Used For Hybrid Denture Framework

Cast Noble Alloys (33)

Gold (Type III), silver, palladium, and platinum are the four principal noble metals utilised in dental alloys. They give the alloy its inert quality, which allows it to withstand oxidation and corrosion by acids. Silver-palladium alloys have become more popular in implant frameworks because they have mechanical qualities equal to type III gold alloys at a lower cost. Palladium silver alloys comprise 50-60% palladium and the rest is silver, giving the alloy a white/silver colour. This alloy's elastic modulus is roughly 105GPa, making it the most advantageous of the noble metal alloys (34). However, silver increases ductility while decreasing hardness. Silver also reduces tarnish resistance. The greatest drawback of the noble alloys group is the tendency for greenish discoloration on application of porcelain.

Cast Base Metal Alloys

The majority of base metal alloys are nickel-chromium alloys, however cobalt-chromium and iron-based alloys can also be used. This group covers all non-noble metal alloys with the exception of beryllium. They possess significant hardness, a considerable yield strength and elastic modulus. They are also significantly cheaper than noble metal alloys. Cast base metal alloys possess the property of passivation.

Titanium

The usage of commercially pure titanium (CP Ti) and its alloys for dental applications was first discovered in the year 1977, since which its application in dentistry has increased dramatically. Titanium also possesses the property of tarnish and corrosion resistance, due to which it is an ideal option for implant prostheses. Ti-6Al-4V is the most common titanium alloy used in dentistry (35). It's biocompatible, affordable, has a low specific gravity, and has qualities that are comparable to cast gold (36). Due to its high melting point of 1668°C and high rate of oxidation at 900°C, titanium alloys necessitate a special casting equipment with arc melting capability and an argon atmosphere. It also has a tendency to interact with the investment material (37), necessitating the use of oxides such as MgO, ZrO2, or Y2O3 as a casting investment. Other framework construction processes, such as using pre-machined components and welding procedures, are possible with titanium. However, fracture of frameworks has been reported in early-welded titanium frameworks (38). When compared to laser welded titanium frameworks, milled titanium frameworks have a superior fit and a reduced incidence of fractures (38, 39).

Zirconia

In fixed prostodontics, zirconia has been accessible to use as an alternative to metal frames. The use of zirconia in the manufacturing of implant frameworks and other digitally designed prosthesis has been made possible due to the development of CAD CAM in dentistry.

The three types of zirconia commonly used in clinical dentistry are as follows:

1. fully sintered or Hot Isostatic Pressing (HIP)
2. partially sintered zirconia
3. non-sintered or “green state” zirconia.

Low corrosion potential, low thermal conductivity, high flexural strength (900-1200 MPa), and hardness are among the
chemical and physical features of zirconia stabilised by yttrium oxide (1200 Vickers)(40). It also removed the grey shadow caused by underlying metal at the cervical region of the restoration(40,41).

**PEEK Implant frameworks**

The historical perspective of framework materials includes the evolution from cast gold to modern milled titanium and zirconia providing biocompatibility, corrosion resistance and CAD CAM manufacture. Nevertheless one of the major disadvantages of these frameworks remains the high stiffness measured as flexural strength that affects the shock absorption of prosthesis (Menini et al., 2011). PEEK imparts its stiffness from aromatic benzene rings and its ability to rotate in an axial direction thanks to ether oxygen bonds(Najeeb et al., 2015). As the stiffness of PEEK is double that of lithium disilicate and similar to cortical bone, it can alleviate excessive stress being directed on implants and provide lesser stress shielding(Najeeb et al., 2016). In the clinical studies done by Mustafa Helmy et al(Diederich, 2018) and Paulo Malo et al(Maló et al., 2018), PEEK-acrylic resin implant supported hybrid denture proves to be a valid treatment option. CSR of the prosthesis was reported to be 98% in the study done by Paulo Malo, with a single failure in a double full-arch rehabilitated bruxer patient, presenting as a fracture line in mandibular arch prosthesis. Implant survival rate was 100% after a period of 1 year. Similar results for CSR was reported in the study by Mustafa Helmy.

**Conclusion**

In conclusion With the advent of digital dentistry the variety of materials used in the fabrication of implant frameworks has significantly eg. titanium, zirconia, PEEK etc. Further research is required to understand the best material available in the fabrication of the implant framework.

**REFERENCES**


