

METAL-FREE PROSTHODONTICS: A REVIEW.

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Abstract:

Dentistry today, focuses not only on the prevention and treatment of disease but also on meeting the demands for better esthetics. Therefore, it has evolved from a creative to creative science in a short span. Due to the increase in importance and attention towards esthetics, the demand for metal free prosthesis is on a verge of increase. This article will review all the materials on the progress in dental materials owing to increase in demand for aesthetic.

Key words: Metal- free, esthetics, advances.

Introduction:

The field of dentistry is known for meeting the requirements of patients by offering dental restorations and prosthesis such as inlays, onlays, crowns, fixed partial dentures (FPDs), and removable dentures, to meet patients' needs and maintain their health. During the 20th century, both dental materials and dental devices progressed remarkably.¹ Owing to the increased demand for safe and esthetically pleasing dental materials, new high strength Metal free materials have been recently introduced.

Biomaterials for dental use are classified into metal, ceramics, synthetic polymer and composite materials. For dental prosthesis, previous ceramics and resin were brittle, and the use of these alone for restoration and dental prosthesis preparation was limited due to the problem of the materials strength. Thus, metal has been frequently used; prioritizing mechanical strength over esthetics, but demands for metal-free restoration has recently increased due to esthetic problems of metal colour penetration through the marginal gingiva and gingival staining by metal, a problem of metal allergy, and environmental protection concerning rare metals.²

This review outlines the developments and progress in dental materials over the past decade which has led to the evolution of metal free prosthesis in complete dentures, fixed partial dentures, removable partial dentures, implantology and maxillofacial prosthesis.

Complete denture:

In ancient time metal denture bases were used but these dentures have heavy weight and esthetically poor appearance that's why a newer material called PMMA (Polymethyl methacrylate)

used for fabrication of denture. The mechanical properties of PMMA are significantly enhanced by the incorporation of Glass fiber. Silane coupling agents play a central role in improving bonding between fillers and the resin matrix, and they subsequently improved the resin's properties.³

The fabrication of complete dentures using a conventional method associated with certain problems. To avoid this, computer-aided design/computer-aided manufacturing (CAD/CAM) system have been successfully introduced into restorative dentistry and maxillofacial technology to simplify the fabrication procedure and resolve the associated problems.⁴⁻⁸

Panasonic Corporation of Japan presented, a composite material comprised of zirconia and alumina using ceria as a stabilizing material i.e. NANOZR, and acquired pharmaceutical approval in October 2006.²

Since it has a marked mechanical strength, and long-term stability in the mouth, clinical application for fixed prosthesis and dental implants has been

progressing.^{9,10,11} The load-bearing ability of Yttria partially stabilized tetragonal zirconia (Y-TZP) has been shown to be equivalent to that of Co-Cr alloy,¹² and NANOZR may also be applicable for denture base material substituting for metal because its mechanical strength is greater than that of Y-TZP.

Fixed Partial Denture:

Ceramics have domain the field of dentistry for the past 200 years.

Porcelain presents with poor mechanical properties & has relatively low tensile strength, it is therefore generally fused to a metal substrate to increase its resistance to fracture.¹³ However, this metal base creates metal ion discolorations that may affect the aesthetics of the porcelain reducing light transmission through the porcelain. Allergic reactions and sensitivity to various metals is seen in some patients. These disadvantages, led to the development of new all-ceramic (metal free ceramic) systems that do not require metal.¹⁴

Introduction of IPS EMPRESS 2, the metal free



Complete denture by PMMA



Complete denture by CAD/CAM



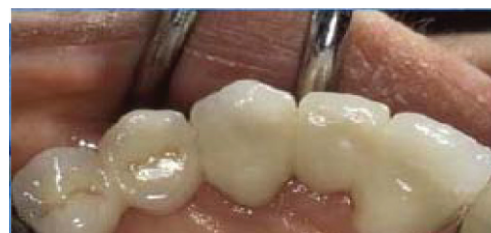
Complete denture using NANOZR as a denture base material substituting for metal



All ceramic prosthesis



Zirconia crown before cementation



Zirconia crown after cementation

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ceramic systems, resulted in a long lasting metal free ceramic restoration.

CAD-CAM with its advancements occasioned in the restoration with better esthetics, strength, and ease of fabrication in single visit. In CAD/CAM system the occlusion with the opposing tooth requires manual refinement. With the advent of newer software and advancement in systems, this shortcoming is expected to be solved in the near future.¹⁴

The most frequently used zirconia-containing ceramic systems presently accessible in dentistry are- yttrium cation-doped tetragonal zirconia polycrystals (3Y-TZP), magnesium cation-doped partially stabilized zirconia (Mg-PSZ) and zirconia-toughened alumina (ZTA) ^{15,16,17}.

Crowns with zirconia core materials have higher mechanical properties than other metal-free restorations, Yttrium-oxide is added to pure zirconia to control the volume expansion and to stabilize it in the tetragonal phase, at room

temperature.¹⁸ Yttrium-oxide partially stabilized Zirconia (Y-TZP) has mechanical properties with a flexural strength of 900 – 1200 MPa¹⁹ and high fracture toughness, making it suitable for anterior and posterior crowns as well as for long-span fixed partial dentures.²⁰

Removable Partial Denture:

Dental prosthesis produces denture esthetics that affects the beauty and attractiveness of the person.²¹ Removable partial dentures (RPDs) are the widely accepted treatment of choice for most cases as it is both effective, affordable and best treatment option for partial edentulism²² but patients are concerned about the metal exposure in cast partial dentures and hence worried about the esthetic appearance.^{23,24} The traditional use of the conventional metal clasps such as cobalt-chromium (Co-Cr), gold, stainless steel, and titanium gives poor esthetic appearance due to display in the oral cavity which hampers the patient’s comfort.



POM material showing clasp of RPD



BioHPP RPD framework



PEEK implant



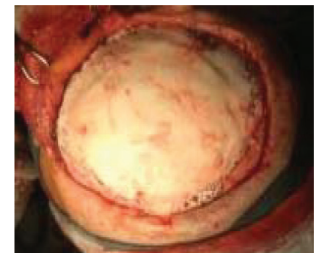
Zirconia implant



Obturator by CAD/CAM



Cranioplasty by Ti



Cranioplasty by resin

Therefore a thermoplastic resin, Acetal resin (polyoxymethylene [POM]), may be used as an substitute clasp material. An unbreakable thermoplastic resin, Acetal, was first proposed for RPD material, in 1971. These injection moulded resins were promoted mainly on its ability for superior esthetics, which allowed the clasps to better match the colour of abutment tooth.²⁵

Thermoplastic materials were introduced in clinical practice due to an aesthetically unacceptable display of metal clasps, increased prosthesis weight, the potential for metallic taste, and allergic reactions to metals.^{26,27,28}

PEEK permits RPD fabrication with metal-free esthetic clasps and occlusal rests with better occlusal stability owing to its white colour and high strength.²⁹

As an alternative RDP framework material, a modified PEEK high performance polymer (BioHPP) combined with acrylic denture teeth and conventional heat-cured denture base acrylic resin was used. BioHPP permits the fabrication of metal-free clasps and occlusal rests, providing occlusal stability and metal-free aesthetics due to its white colour and high strength.²⁹

Implant:

In order to replace missing teeth dental implants are used. For this, Brånemark introduced Titanium (Ti) and its alloys as dental implants at the end of the 1960s.³⁰ Ti materials possess good physicochemical characteristics, mechanical properties and biocompatibility.^{31,32} Ti materials have an elastic modulus higher than that of bone (titanium: 110 GPa; cortical bone: 14 GPa), and the difference may result in inadequate stress-shielding, bone resorption, and implant fracture.^{33,34} Occasional metal hypersensitivity and allergies, surface degradation and contamination related to peri-implantitis, and scattered radiation are the clinical problems accompanying Ti materials.³⁵

The Ti materials due to its metallic appearance compromises highly aesthetic restorations. There have been a lot of researches to develop substitutes for Ti dental implants, such as zirconia^{36,37}, which has a high elastic modulus and low temperature degradation.^{38,39} Polymeric compounds, such as polyetheretherketone (PEEK), which is a semi crystalline linear polycyclic thermoplastic that was developed in 1978⁴⁰.

Wolff's Law says that the bone remodels according to the load that has been applied to it. Due to shielding of normal loads by the implant there is reduction in volume of the bone around implant known as stress shielding. Finite-element analysis (FEA) of carbon-fiber reinforced PEEK (CFR-PEEK) implants suggested that they could induce lesser stress shielding than titanium⁴¹.

The mechanical and physical properties of PEEK are similar to bone and dentin, so it can be used for a number of applications in dentistry including dental implants. Here the challenge is faced while increasing the bioactivity of PEEK dental implants without affecting their mechanical properties. It is an attractive material for producing CAD-CAM fixed and removable prosthesis compared to materials such as acrylic. Further research and clinical trials are required to explore this material and possible modifications for further dental application.⁴²

Recently, high strength zirconia ceramics have acquired a place of attraction as new materials for dental implants. They are inert in the body and exhibit minimal ion release. Owing to its higher fracture resilience and flexural strength, Yttrium-stabilized tetragonal zirconia polycrystals appear to offer advantages over aluminium oxide for dental implants.^{43,44}

The inflammatory response and bone resorption induced by ceramic particles are less than those induced by titanium particles which suggest its biocompatibility.^{45,46}

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Maxillofacial:

Its the artificial device used to replace missing facial or oral structures. Now a days CAD CAM device is used for this.

Advantages of using CAD / CAM are:

- Reduced time in the office;
- Easy to use in case of reduced mouth opening;
- A simplified procedure;
- Reduced consumption of materials;
- Increased productivity;⁴⁷

The viable options option for less tissue irritation and more patient comfort are the intra oral scanning of a hemi maxillectomy patient and the implementation of CAD/CAM techniques for obturator fabrication.⁴⁸

Cranioplasties have been performed since the early 1950s⁴⁹. Acrylic resin materials form an alternative to bone substitutes in dentistry. Due to the properties like dimensionally stability, nonconductivity and economical, acrylic resins are used in implant dentistry.⁵⁰ Acrylic resin has some advantages over metal substances; it is easy to shape, lighter in weight, radiates less heat, and radiolucent.^{51,52}

Conclusion:

Keeping in mind the various hazards of using metals as prosthetic materials and the awareness and demand for aesthetics has lead to the evolution of metal-free prosthesis which will soon be the future of dental prosthesis. An adequate knowledge about the same is essential amongst the practitioners in order to bring them in practice unlike other conventional materials.

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