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REVIEW ARTICLE

Effectiveness of Polyether Ether Ketone Framework in Comparison to Metal Framework for Hybrid Denture Prosthesis - A Systematic Review

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ABSTRACT
Polyetheretherketone (PEEK) represents a relatively new material and is regarded as a promising alternative in fixed and removable prosthetic dentistry. It is a linear, aromatic, semi-crystalline thermoplastic polymer with high melting point and with other notable mechanical properties. The main objective of this study is to critically review articles that have used poly ether ether ketone and metal as a framework for hybrid denture and evaluate its clinical effectiveness. An electronic search was performed in PubMed, Google scholar and Cochrane Library until 15th October 2019. The assessment of the articles was done using selection criteria. Out of the 22 articles selected 5 were excluded based on title and abstract. Out of the remaining 17 studies, 10 were excluded based on inclusion and exclusion criteria, and finally 7 were selected on the basis of core data. From this review it can be concluded that PEEK offers a promising clinical outcome as a framework for hybrid dentures, still requiring long term validation to fully attest its validity in implant supported prosthesis.
KEYWORDS *:PEEK,hybrid ,dentures, prostheses*

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INTRODUCTION

Oral rehabilitation is delicate in terms of functional and aesthetic outcomes and only an adequate material choice and processing can ensure long-term stability and patient satisfaction [12]. This requirement of replacement is further essential in completely edentulous patients in whom the function is highly compromised. The advent of implant supported restorations has opened new avenues that offers a fixed prosthesis for a completely edentulous patient that offers them a predictable, long-term prostheses with improved function, and efficient maintenance of alveolar bone [31].

In general an edentulous arch could be rehabilitated with four to eight endosseous implants with a screw retained hybrid prosthesis [29]. The hybrid denture consists of a framework and veneering material in case of a metal framework or an en bloc framework with the tooth anatomy milled on it which is further layered with ceramic and screwed onto the implants. This allows the patient to have a completely fixed prosthesis which can only be removed by dental professionals [11]. A large number of materials are available to produce the prosthesis infrastructure. The framework materials have evolved from gold alloys to milled titanium and zirconia [1].

Metallic alloys exhibit high tensile strength (>300 MPa) and elastic modulus (>80,000 MPa) sufficient to prevent deformations and the cantilevers fractures [6]. Titanium alloy (Ti) has corrosion resistance,

biocompatibility, low cost, and good mechanical properties [18]. The need for superior aesthetics and lower cost led to the demand of non-metallic materials for hybrid denture framework. The use of zirconia framework has attracted a lot of attention as it presents a survival rate similar to metal infrastructure with a much superior aesthetic outcome [24, 26].

Polyetheretherketone (PEEK) represents a relatively new material and is regarded as a promising alternative in fixed and removable prosthetic dentistry. It is a linear, aromatic, semi-crystalline thermoplastic polymer with high melting point and with other notable mechanical properties [27]. Physical properties like the elastic modulus of PEEK is 3.6 GPa, and by incorporating carbon fibres, the elastic modulus can be improved to 18 GPa which is quite comparable to that of cortical bone, i.e., 15GPa [3]. PEEK being radiolucent has reduced magnetic resonance imaging artifacts and is very rigid with a flexural strength of 140-170 MPa [31]. Another plus point of using PEEK is that it does not attrite the opposing natural teeth. Its biocompatibility and bio-stability are supported by the US FDA Drug & Device Master files [10]. Bio HPP, the modified form of PEEK is more advantageous for being anti-allergic in nature, non-metallic in taste, excellent polishing properties, low plaque affinity, and good wear resistance [9]. PEEK offers a range of processing options and an array of formulations, ranging from unfilled grades with varying molecular weights, to image contrast, coloured and carbon fibre-reinforced grades. PEEK hence offers a unique combination of mechanical properties, resistance to chemicals, wear, fatigue and creep as well as exceptionally high temperature resistance, up to 260°C (480°F). PEEK has been used over the last decade in both medicine and dentistry.

Clinical classification of PEEK [21]:

1)PEEK for bone replacement-maxillo-facial and cranial implant

2)PEEK for spine surgery-spinal cages

3)PEEK for orthopaedic surgery

a. For bone and hip-replacement-articulation implants.

b. Orthopaedic devices from PEEK material-fixation-plates, screws

4)PEEK for tooth replacement-dental implants from CFR-PEEK; dental prosthesis, intra-radicular posts.

5)PEEK for cardiac surgery-intracardiac pump; heart valves.

With its biocompatibility and its shock absorbing characteristics, its wide area of applications and also the possibility of CAD/CAM manufacture such a material could be a viable alternative as a non-metal framework for hybrid denture prosthesis.

Hence the aim of this systematic review to evaluate the clinical effectiveness of polyetheretherketone framework in comparison to metal framework for implant supported hybrid denture prosthesis.

MATERIAL AND METHODS

STRUCTURED QUESTION

In cases requiring hybrid denture prosthesis, is there a significant difference in effectiveness of hybrid prosthesis supported by Polyetheretherketone framework in comparison to hybrid prosthesis supported by metal framework?

DATA COLLECTION AND ANALYSIS:

The data was collected from the studies that were included based on the author's name, publication year, study type, subjects, interventions, treatment time, method of measurements and outcomes assessed.

SEARCHED DATABASES:

The electronic databases that were included are:

National Library of Medicine (PubMed), Google Scholar, Cochrane database of systematic reviews.No limitation regarding publication date was kept.

SEARCH PROTOCOL:

The search methodology employed was a combination of MeSH terms and Keywords. The keywords were categorised as Population, Intervention, Comparison, Outcome measures. Keywords within each group were combined using the Boolean operator (OR). Searches between Population and Intervention were combined using (OR) and between the other groups were combined using the Boolean operator (AND)

ELIGIBILITY CRITERIA:

The title and abstract of the entries from the initial electronic database searches were read. Full text versions of the studies that could be potentially included in this review were read and a final selection was done according to the inclusion and exclusion criteria.

Inclusion Criteria:

- Articles on hybrid dentures which have used polyetheretherketone as framework material
- Articles on hybrid dentures which have used metal as framework material

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- Articles that compare polyetheretherketone and metal as framework materials for hybrid dentures
- Randomised control studies, Non-Randomised control studies, Prospective or Retrospective cohort, Invitro study, Animal studies

Exclusion Criteria:

- Review articles
- Case Reports

RESULTS

The search strategy led to obtaining 257 articles from PubMed, 36 articles from Google scholar and 2 articles were handpicked. 64 clinical trials were included from the PubMed search of which 52 were excluded based on title and abstract and a total of 8 articles were selected. Of the 36 articles obtained from Google scholar, 24 were eliminated based on the relevance of the heading and abstract, and a total of 12 articles were selected. The total number of studies which were selected from the database were 22, of which 10 were eliminated as they did not meet the inclusion criteria and/or outcome measures and 5 were excluded based on title and abstract and finally 7 articles were included on the basis of core data. These 7 articles were reviewed and consolidated as given in the table.

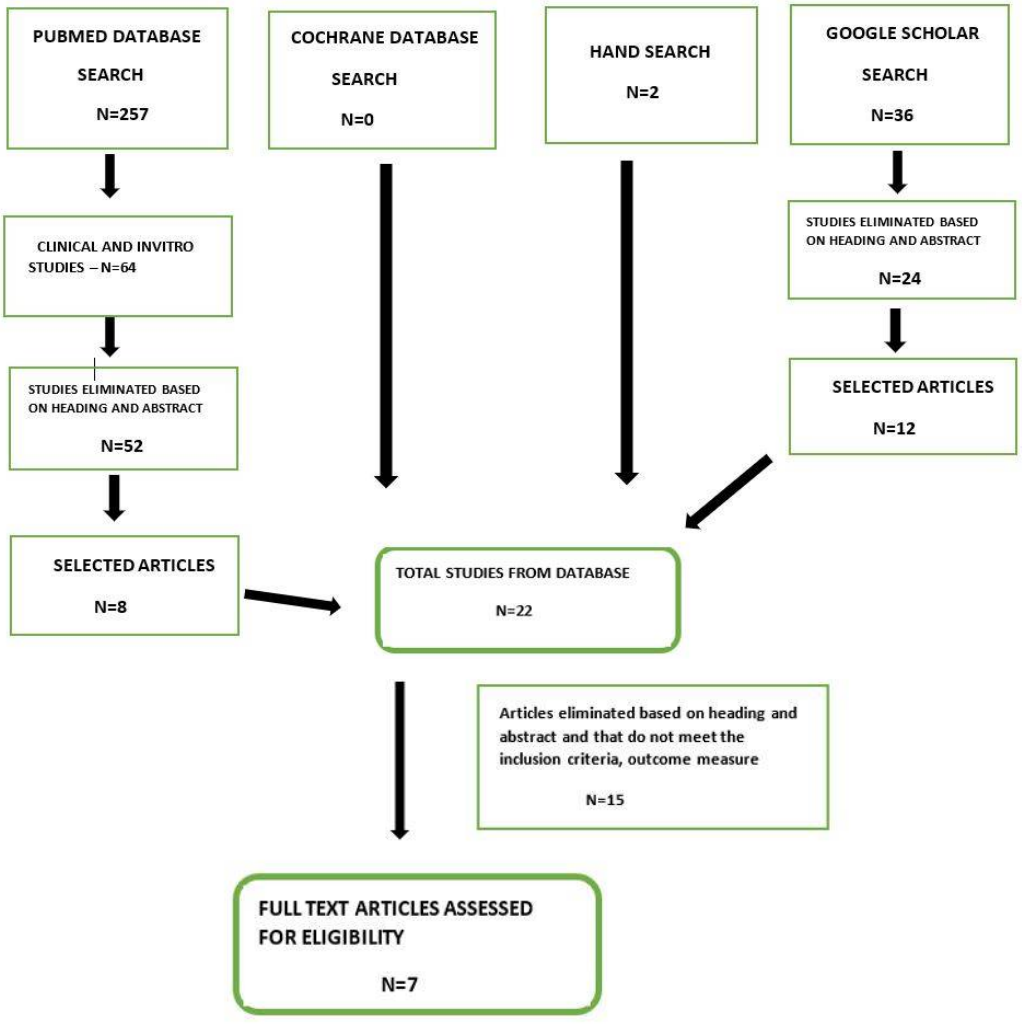

Fig 1: Flow Chart Depicting the search methodology describing the total number of articles obtained, the ones excluded, inclusion of handpicked articles and finally the total number of articles that were retrieved for analysis.

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DISCUSSION

Hybrid prosthesis often refers to implant supported fixed rehabilitation of an edentulous arch composed conventionally of a metal based substructure covered with acrylic resin [25]. In this systematic review, we have explored the literature to support the use of non-metal alternatives for hybrid denture framework specifically the use of Polyether Ether Ketone.

This systematic review reveals 7 articles which report the use and properties of Polyether ether ketone and different metals as materials for hybrid denture framework. Due to the lack of literature that compared the use of PEEK and Metal framework for hybrid denture in a single study we have selected articles that discuss the properties of these individual materials and why they would be suitable as framework material for hybrid denture framework.

Despite the use of PEEK in the field of medicine and dentistry for over 3 decades [16]. The availability of long term clinical trials is surprisingly limited. Of the 4 studies that discuss the use of PEEK as hybrid denture framework, 2 are clinical studies and 2 are in-vitro studies. The studies on metal framework for hybrid denture have a much longer clinical follow up and this review includes 3 such studies. Bone Loss around implants and CSR (Cumulative Survival Rates) were the most commonly measured outcome. There was an obvious lack of attempt to measure patient centric outcomes, and the kinds of prosthetic failures encountered.

Comparison of Findings:

PEEK Framework for Hybrid dentures:

In the clinical studies done by Diederich,[8] and Paulo Malo *et al* [13], 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 [13], with a single failure in 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. In systematic reviews by Patzelt *et al* [22], Penaloza *et al* [28] % at the end of 1 year for former and 99.8% at the end of 2 years for the latter. Marginal Bone loss after 1 year of function was reported to be 0.37±0.58 in maxilla;0.40±0.63 in mandible which is within the accepted standards [7].

Similar results for marginal bone loss was reported in the study by [8]. He reported increased bone loss in the first 6 months compared to the measurements from 12-16 months, owing to bone remodeling in the initial phase of functional implant loading. The mean marginal bone loss from baseline to 12 months was within acceptable permissible limits.

In the vitro studies by Geraldo Alberto [5] and Aquino et al the mechanical properties of PEEK protocol bars were compared. Both the studies checked the compression loading of PEEK bars with different designs. Aquino et al concluded that T-type bar showed higher resistance to compression at left cantilever and square bars at right cantilever and that all three designs showed similar behaviour to compression load applied at the centre.

The study by Geraldo Alberto showed largest deformation in solid bars with no statistical difference between T-type and inverted T-type. This was due to the high resiliency and in clinical scenario it results in effective dissipation of masticatory load, which in turn results in smaller incidence of prosthetic failure [17].

Metal framework for hybrid denture:

This review includes 3 studies which compares titanium and different titanium alloys used in hybrid denture framework with gold alloy framework for hybrid denture. All the studies report the CSR of the prosthesis and marginal bone loss around the implants in addition to framework fractures and implant survival.

In the studies done by Andres Ortop [19, 20], predictable clinical results with an overall CSR of 98.7% for implants and 100% maintained fixed prosthesis function. Laser welded titanium framework reported with fractures related to welding joints [4]. Mean bone loss between titanium and gold alloy frameworks were not statistically significant, and well within permissible limits. CNC milled titanium framework presented with lesser risk of fracture owing to the one-piece milling technique and presented similar clinical and radiographic performance as cast-gold alloy frameworks in edentulous jaws, enabling it to be used as an alternative to cast framework for full arch implant supported prosthesis.

Strength and limitations of the study:

This systematic review appraises both the features of PEEK and different alternatives of metal in the fabrication of framework for a hybrid denture prosthesis. This provides a better understanding of the clinical and mechanical properties of the metal and non-metal option in this case PEEK framework for hybrid denture prosthesis hence enabling the clinician to make better treatment choices.

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However, it must be noted that the literature search was conducted primarily using electronic databases and limited to reviewing references of included studies, hence the current review may not have identified all the literature. There was also a sheer lack of clinical studies that compared the clinical and prosthetic outcomes of use of different framework for hybrid prosthesis. Furthermore, meta- analysis was not attempted due to the heterogeneity among studies, hence there is a need for future studies with long term follow-up.

CLINICAL SIGINIFICANCE

Polyether ether ketone is a synthetic tooth coloured material that has been used as a biomaterial in orthopaedic surgery for many years. This high strength polymer shows superior chemical stability, mechanical behaviour, shock absorption and stiffness closely resembling the human bone. Full arch fixed hybrid prosthesis requires the implants to be splinted by a framework and this conventionally has been done by different kinds of metal frameworks. The frameworks have evolved from gold alloys to the modern milled titanium and zirconia. The high stiffness of these frameworks can be considered as a disadvantage in shock absorption. Hence the rationale for doing this study is to evaluate the effectiveness of polyether ether ketone in comparison to metal framework for hybrid denture prosthesis.

CONCLUSION:

From this review it can be concluded that PEEK offers a promising clinical outcome as a framework for hybrid dentures, still requiring long term validation to fully attest its validity in implant supported prosthesis.

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