IN-VITRO PERFORMANCE EVALUATION OF POLYETHERETHERKETONE (PEEK) IMPLANT PROSTHETICS WITH A CANTILEVER DESIGN

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Background:

Over the last decade full arch metal implant supported prosthetics have been used as replacement for missing teeth in edentulous patients. Due to the potential shock absorbing properties and patients' demands for metal free restorations, there is rising enthusiasm surrounding the use of High Performance Polymers (HPPs) such as the polyaryletherketone (PAEKs) as metal alternatives for such cases. Of the PAEK family, Polyetheretherketone (PEEK) is the most established member and is a thermoplastic polymer which has seen extensive use in highly demanding industrial applications (aerospace, semiconductor, automotive) over the previous 30 years. A medical grade PEEK version (PEEK-OPTIMA®, Invibio Ltd.) has been used for over 4 million load bearing spinal fusion cage devices due to the excellent mechanical behaviour, strength to weight ratio and chemical stability. These properties have had some use in dentistry over the last decade mainly as PEEK healing caps and temporary abutments, but the material has remained somewhat under-exploited. Such a material is extremely interesting for use in full arch frameworks (Figure 1) due to its proven biocompatible nature and its shock absorbing characteristics.

Figure 1: Example of a PEEK full arch implant prostheses.

Aim:

The aim of this in-vitro study was to investigate the behaviour of PEEK implant supported prosthetics with a cantilever design in a five year chewing simulation. The restorations´ performance during thermal cycling and mechanical loading (TCML) as well as fracture strength after TCML was determined.

Material and methods:

To investigate the performance of PEEK implant supported prosthetics with a cantilever design, two series of half size all-on-4 implant supported prosthetics (n=8) were milled according to clinical requirements, from a JUVORA™ dental disc (JUVORA Ltd.) in different denture designs:

1. fully anatomic PEEK denture without veneering,
2. PEEK framework with composite veneering (Figure 2).

Restorations were fixed on an artificial jaw with two placed metal pins (diameter equivalent to restorations on 4.1 mm implants and secondary parts) which simulated dental implants (Figure 3). The restorations were loaded in a cantilever situation and a chewing simulation (TCML) was performed with $1.2x10^6$ occlusal loadings (50 N) combined with 3000x5/55°C thermal cycles. Fracture force was determined after TCML in the universal-testing-machine UTM (crosshead speed: 1mm/min; failure determination: 10% loss of current force). All restorations were controlled for failures during the chewing simulation.

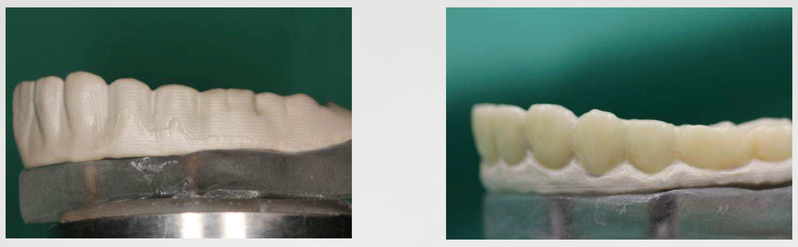

Figure 2: Fully anatomic PEEK prostheses and PEEK framework with composite veneering.

Figure 3: Restorations were fixed on an artificial jaw with simulated dental implants.

Results:

None of the PEEK restorations failed during the 5 year chewing simulation (TCML). Mean fracture values after the 5 year chewing simulation (TCML) of the investigated cantilever restorations varied between 4393 N for the fully anatomic PEEK prostheses without veneering and 2553 N for the veneered PEEK prostheses (Table 1). The failure observed of the veneered cantilever restorations when under these high loads was due to the cracking of the veneering. Veneering of the PEEK material seems sufficient, but care should be taken when veneering the frameworks. The failure forces observed for both PEEK restorations were very high, and therefore these seem suitable for clinical application.

5 year simulation ($1.2x10^6$ cycles)	Average Failure Force (N)
Fully anatomic PEEK prostheses	4393
PEEK framework with composite veneering	2553

Table 1: Force required to fail the implant supported prostheses following the TCML chewing simulation equivalent to 5 years intra-oral use.

Conclusion and Clinical Implications:

Regarding 500 N in posterior areas as a threshold level for required fracture forces, both the veneered and fully anatomic PEEK full arch prosthetics showed sufficient fracture forces. The good fatigue behaviour of PEEK when associated with its stiffness confers some promise as a substructure that could also add an element of shock absorption.

This may have benefits for general patient comfort and bring an element of damage reduction for bruxism cases.

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