

## **EFFECT OF POLYETHERETHERKETONE (PEEK) AS DENTURE BASE MATERIAL ON PERI-IMPLANT BONE LEVEL CHANGES IN IMPLANT BAR RETAINED OVERDENTURE USING CAD/CAM TECHNOLOGY**

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### **ABSTRACT**

**Objectives:** This research was carried out to evaluate the effect of Polyetheretherketone (PEEK) as denture base material on peri-implant crestal bone level changes in edentulous patients rehabilitated with implant-supported primary-secondary bar overdenture and retained attachments attached the body of the bar constructed by CAD / CAM technology.

**Materials and Methods:** Twenty completely edentulous patients complaining from insufficient retention of their mandibular denture were selected to participate in this study. All the patients were rehabilitated with an implant-supported bar overdenture. For All patients three implants (3.7mm) in diameter (11mm) in length were inserted in the interforaminal region using computer guided surgical template. Four months later, Cast bar with two semi precession attachment at the distal ends of the bar was constructed, The cast bar was scanned using bench laser scanner to obtain virtual model with the bar, the housing on the top of the bar and the female part of the attachment was designed using computer aided designing (CAD) the mold into wax by computer aided manufacturing (CAM). The CAD/ CAM wax pattern of housing and the female part of the attachments were transferred into acetal resin using the injection molded technique. Overdentures were constructed for all patients following the conventional technique. According to the denture base material, a toss coin was made to randomly divided the patients into two equal groups; **group I** received mandibular implant-retained overdenture were processed using heat cured acrylic resin, following the long curing cycle (heated at 78C° for eight hours), while for **group II** Polyetheretherketone (PEEK) lower overdenture was constructed, using the injection-molding technique. Radiographic evaluation of peri-implant bony changes was made using standardized long cone paralleling technique with custom made acrylic template and the Rinn-xcp at insertion, six, twelve and twenty four months were measured and statistically analyzed. The significant level was set at  $P \leq 0.05$ . ANOVA for repeated measures test was used to compare between follow up periods within groups and when statistically significant it was followed by simple main effect analysis with Bonferioni correction. One way ANOVA test was used to compare between groups at different follow up periods.

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**Results.** Both groups showed a statistically insignificant increase loss in crestal bone height around the implants. Although the data obtained from table 1 revealed increase in the amount of bone changes for group I and Group II compared to group I during the follow up period statistical analysis of the data using ANOVA test for repeated measures revealed no significance difference ( $P \geq 0.05$ ).

**Conclusion:** CAD/CAM technology and use of Polyetheretherketone (PEEK) as denture base material should be considered whenever possible to preserve the implant supporting structures in implant bar retained overdenture.

## INTRODUCTION

The prosthetic management of the edentulous patient has long been a major challenge for dentistry. Nowadays, oral rehabilitation with an overdenture on splinted or unsplinted implants is considered the standard care in cases of mandibular edentulism. Implant-retained overdentures have many advantages in comparison with the conventional dentures including good retention, good stability, improved function and esthetics and reduced residual ridge resorption<sup>(1-3)</sup>

Recently, many attachments systems have been successfully used with removable implant overdentures. Implant restorations can be retained or supported by individual attachments, splinted with a bar for an overdentures or splinted by a framework that supports a fixed restorations<sup>(4-6)</sup>.

The choice of attachment is dependent upon the retention required, morphology and anatomy of the jaw, oral function, mucosal ridge and patient compliance for recall.<sup>(6)</sup> Ability of the bar to minimize the potential for micro motion at the interface between bone and implant may help successful osseointegration of immediately loaded implants dentures<sup>(7,8)</sup>.

Bar constitute an excellent anchorage system that provides greater retention, decrease the risk of overload to each implant as a result of a greater surface area, improved load and biomechanical distribution by its splinting effect and it can also correct severe un-parallelisms<sup>(9,11)</sup>. The main disadvantages of bar attachments are the need for

a large space, mucosal hyperplasia, oral hygiene problems and necessity of the retention clip's activation.<sup>(12,13)</sup>

Bars should be straight, be parallel to the rotation axis, and be positioned 1-2 mm above the alveolar crest. There are some different bar designs as Dolder Bar (ovoid or "U" shape), Hader Bar (keyhole shape) and Ackermann Bar (spherical shape)<sup>14</sup>. Implant-supported milled bars, are bars with precision attachments and rigid anchorage made by casting, electro-erosion or CAD-CAM<sup>15-17</sup>. They have double retention by convergence wall of two degrees and using other attachments systems anchored to the bar<sup>(18)</sup>. Retention can be obtained directly from the bar by means of a clip, resilient liners or retention can be obtained from stud attachments attached the body of the bar. The use of bar with stud attachment is favorable when there is insufficient inter-implant distance to accommodate for a clip or when movement is required with a bar having two or more non-linear segments<sup>(18)</sup>

Milled bars have been used as substructures for implant-supported prostheses for completely edentulous patient, and can be fabricated by precision milling conventionally cast frameworks<sup>(15)</sup> and the matrices can be fitted using electric discharge machining or a computer-aid design/computer-assisted manufacturing (CAD/CAM) procedure<sup>(17)</sup> CAD/CAM technology has significantly improved the restorative aspects of implant dentistry CAD/CAM fabrication of bars and frameworks has resulted in elimination of distortion, fewer fabrication steps, better fit, and faster turn-around

CAD/CAM technology has revolutionized the field of implant dentistry. CAD/CAM bars and framework have proven more accurate, less time-consuming to produce and less expensive. All of this results in improved decreased treatment time, experience for the patient, and greater accessibility<sup>(19)</sup>.

Introduction of new material in dentistry serves the great demand of osseointegration among population. Thermoplastic resins have been used in dentistry for over 50 years. <sup>(20-22)</sup>.

The "TSM ACETAL DENTAL" is a thermoplastic techno-polymer with a monomer free crystalline structure and is a product of formaldehyde polymerization. Its characteristics are; high resistance to abrasion, high elastic memory, low thermal conductance, excellent tensile and shock strength, and rigidity and resist to occlusal wear <sup>(23)</sup>.

All of these features, coupled with remarkable aesthetic performance, make "TSM Acetal Dental" a good substitute for metals and acrylic resins in many prosthetic applications. These characteristics make it an ideal material for preformed clasps for partial dentures, single pressed unilateral partial dentures, partial denture frameworks, , occlusal splints, provisional bridges, and implant abutments.. It was further modified by reinforcement with glass spheres and glass fiber to increase its potential use as a denture base material <sup>(24,25)</sup>. Acetal resin have a sufficiently modulus of elasticity and high resilience that controls the excessive torquing forces that may act on the implants in bar retained overdenture<sup>(26)</sup>.

Polyetheretherketone (PEEK) is a polymer that has many different uses in dentistry. BioHPP (High Performance Polymer) is based on polyether-etherketone (PEEK) polymer and is used as a framework material for removable dental prosthesis, tooth-implant-supported and implant-supported bridges <sup>(27)</sup>.

Their strength is due to the special ceramic filler with the grain size of 0.3- 0.5  $\mu\text{m}$ , which optimized the mechanical properties. Constant homogeneity

can be produced due to this very small grain size, this homogeneity is an important for these outstanding material properties and forms the basis for consistent quality. PEEK dental implants have exhibited lesser stress shielding than titanium dental implants due to closer match of mechanical properties of PEEK and bone. Due to a 4 GPa modulus of elasticity, which is like elasticity of bone, it can reduce stresses transferred to the implants <sup>(27,28)</sup>.

The aim of the present study was to evaluate the effect of Polyetheretherketone (PEEK) as denture base material on peri-implant crestal bone level changes in edentulous patients rehabilitated with implant-supported primary-secondary bar overdenture and retained attachments attached the body of the bar constructed by CAD CAM technology.

## MATERIALS AND METHODS

Twenty upper and lower completely edentulous patients complaining from insufficient retention of their mandibular denture were selected to participate in this study. Inclusion Criteria of patient selection include-Middle aged patients whose ages range between 50-60years, adequate bone height 12mm and width 7 mm between first premolars with u shaped arch form ,normal ridge relationship (Skeletal class I maxilla mandibular relationship) and adequate inter arch restorative space at least 15mm and good oral hygiene .Exclusion criteria were: V- shaped edentulous ridge, Patients with any flabby tissues, bony undercuts, sharp bony edge, thin ridge or any abnormalities at the alveolar ridge , patients suffering from neuromuscular disorders,. temporomandibular joint disorders . Un-controlled diabetes, osteoporosis, history of chemotherapy and radiotherapy, para functional habits, smokers and administrative or physical considerations that would seriously affect the results of this study.

All the patients were informed about the treatment , the surgical and prosthetic steps, the risks and the

benefits and the implant treatment alternatives were explained thoroughly and were informed that they will be a part in a study that needs their best co-operation. All the patients agreed to share and follow the recommendations and given the instructions in the form of signed consent to them.

To fulfill the predetermined criteria, thorough clinical and radiographic examinations were carried out for all patients. A preoperative radiographic examination was made using Cone beam computed tomography (CBCT) to locate the position of mental foramina, level of inferior alveolar canal and detection of anterior looping of mental nerve and the available bone height, width and density.

All the patients were rehabilitated with an implant-supported bar overdenture. The virtual planning for implant placement was made using cone beam CT software to determine implant site, length, diameter and angulation (Fig 1). For All patients three implants (3.7mm) in diameter (11mm) in length were inserted in the interforaminal region using computer guided surgical template (Fig 2). Four months later, the implants were uncovered healing abutments were screwed for two weeks, then transfer copings with long head screws were used following open tray impression technique using medium body rubber base in a special tray,

Implants analogue were the screwed to the transfer copings, then impression was poured using hard dental stone . (Fig 3). Plastic abutment were secured to the implant analogues then plastic bars (10mm in height and square in cross section ) was attached to the plastic abutment using durally with two semi precession attachment at the distal ends of the bar.

The bar pattern was secured to the stone index on the milling machine table and, using a tapered milling bur (4-degrees), a guide plane is created on both facial and lingual sides of the bar pattern. The plastic female portion of the attachment was mounted to the milling machine hand piece and attached to the distal end of the bar, parallel placement of the attachment to the path of insertion is essential to ensure ease of insertion for the patient and longer life span of the attachment. The whole assembly was tried in the patient mouth and checked for passivity, then cast, and secured over the implant analogues on the master cast. Cast bar was tried in the patient mouth to assure passive fit and RVJ x-ray was taken to assure intimate contact between the assembly the implants .

The cast bar was scanned using bench laser scanner to obtain virtual model with the bar, the housing on the top of the bar and the female part of the attachment was designed using computer aided

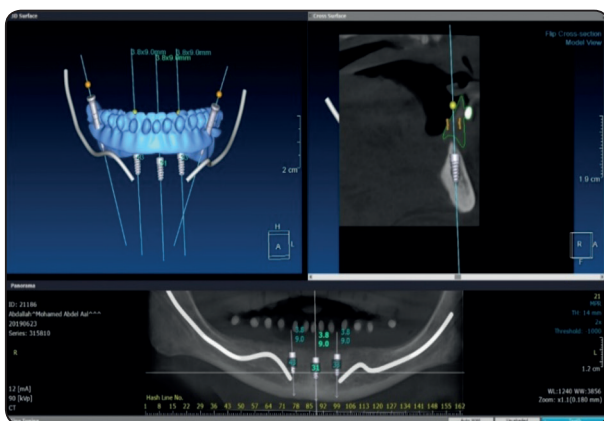


Fig (1): Cone beam C.T. software to determined implant site, length, diameter and angulation

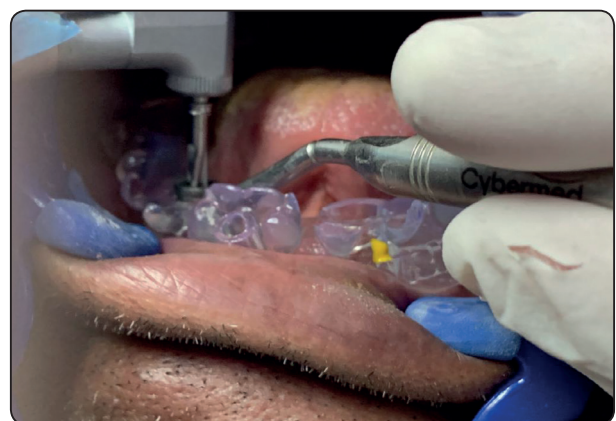


Fig. (2) The computer guided surgical stent for proposed implant site was constructed by using 3d printer

designing (CAD) the mold into wax by computer aided manufacturing (CAM). The CAD /CAM wax pattern of housing and the female part of the attachments were transferred into acetal resin using the injection molded technique (Fig 4).

To all the patients, overdentures were constructed following the same conventional principles. Centric occluding relation was recorded at the accurate vertical dimension of occlusion. Modified cusped acrylic teeth were used and balanced on semi-adjustable articulator for centric and eccentric positions following the lingualized concept of occlusion. The waxed up denture was tried in the patient's mouth to ensure proper facial contour, aesthetic, even contact between all the posterior teeth and harmony between centric occlusion and centric relation at the predetermined vertical dimension of occlusion. At the time of denture base construction, a toss coin was made to randomly divide the patients into two equal groups.

**For group one;** Mandibular implant-retained overdenture were processed using heat cured acrylic resin. Heat cured acrylic resin was packed into the flask and heated at 78C° for eight hours following the long curing cycle, while Polyetheretherketone (PEEK) lower over denture was constructed for **the second group** using the injection-molding technique.



Fig. (3): Implants analogue were the screwed to the transfer copings

Prior to insertion, dentures were clinically remounted to refine the occlusion; to ensure free anterior contact in centric and free non-interfering contact during all excursive mandibular movements. Patients were recalled frequently for post-insertion inspection and adjustment. Recall visits were scheduled at time of implant loading, six, twelve ,twenty four months for inspection of the prosthesis and collection of the data (radiographic evaluation). Clinical evaluation for the cases was also carried out to inspect oral hygiene, denture bearing structures and implants.

#### Radiographic evaluation:

Changes of Peri-implant crestal bone level were assessed using intra-oral radiographs taken with the standardized long cone paralleling technique using custom made acrylic template and the Rinn-xcp system<sup>(30)</sup>. After performing the needed post insertion adjustment, periapical radiographs were taken after six months, twelve months and twenty four months to complete a period of two years follow up period. A piece of wire was embedded in the acrylic template was used as a reference point to assess marginal bone height changes at the mesial and distal aspect of each implant using Digora software system. Each time patients were recalled, dentures were evaluated and occlusal adjustment was performed.



Fig. (4): The CAD /CAM wax pattern of housing and the female part of the attachments were transferred into acetal resin using the injection molded technique

**RESULTS**

All the data was collected and tabulated. Statistical analysis was performed by Microsoft Office 2010 (Excel) and Statistical Package for Social Science (SPSS) version 20.

The significant level was set at  $P \leq 0.05$ . Kolmogorov-Smirnova and Shapiro-Wilk tests was used to assess data normality, and data was assumed normally distributed. ANOVA for repeated measures test was used to compare between follow up periods within groups and when statistically significant it was followed by simple main effect analysis with Bonferioni correction. One way ANOVA test was used to compare between groups at different follow up periods.

All patients reported improved retention and stability of their mandibular implant-supported overdenture. In addition all patients reported that their functional, phonetic, and chewing abilities were improved. In both groups, a number of patients had their opposing prostheses relined during the 2-year period.

Table (1) represents the mean value of peri-implant bone loss and their level of significance during the follow up period for group I patients (implants bearing primary-secondary supporting bar and heat cured acrylic denture base overdentures) and group II patients (implants bearing primary-secondary supporting bar and Polyetheretherketone (PEEK) denture base overdentures) between consecutive intervals and from loading to each recall appointment.

The data revealed that the mean value of peri-implant bone loss for group I patients ( bar retained lower acrylic overdentures) between consecutive interval loading - 6 months (0.31), interval 6 – 12 months (0.17) and interval 12 –24 months (0.11). A total change of (0.48) and (0.59) was calculated at the end of the twelve months and twenty four months follow up period respectively. Although the data obtained from table 1 revealed increase in the

amount of **peri-implant bone loss** during the follow up period, statistical analysis of the data following ANOVA test for repeated measures revealed in significance difference ( $P \geq 0.05$ ) between follow up periods.

The data revealed that the mean value of peri-implant bone loss for group II patients ( bar retained lower Polyetheretherketone (PEEK) overdentures) between consecutive interval loading - 6 months (0.29), interval 6 – 12 months (0.16) and interval 12 –24 months (0.8). A total change of (0.45) and (0.53) was calculated at the end of the twelve months and twenty four months follow up period respectively. Although the data obtained from table 1 revealed increase in the amount of peri-implant bone loss during the follow up period, statistical analysis of the data following ANOVA test for repeated measures revealed in significance difference in between follow up periods.

Although the data obtained from table1 revealed increase in the amount of bone changes for group I and Group II compared to group I during the follow up period statistical analysis of the data using ANOVA test for repeated measures revealed no significance difference( $P \geq 0.05$ ) .

TABLE & GRAPH 1: Mean and standard deviation values of peri-implant bone loss of the studied groups at different follow up periods.

Groups Interval	Group one Mean-SD d1 d2	Group two Mean- SD d1 d2
Loading-----6 m	0.31±0.04 <sup>a--a</sup>	0.29±0.02 <sup>a--a</sup>
6m-----12 m	0.17±0.021 <sup>a--a</sup>	0.16±0.011 <sup>a--a</sup>
Loading-----12 m	0.48±0.19 <sup>a---ab</sup>	0.45±0.015 <sup>a---ab</sup>
12m-----24 m	0.11±0.05 <sup>a---a</sup>	0.8±0.035 <sup>a--a</sup>
Loading-----24 m	0.59±0.21 <sup>a---ab</sup>	0.53±0.01 <sup>a---ab</sup>

*AONVA for repeated measures, similar superscript letters indicate non significant difference.*

*d1 within group d2 between groups*

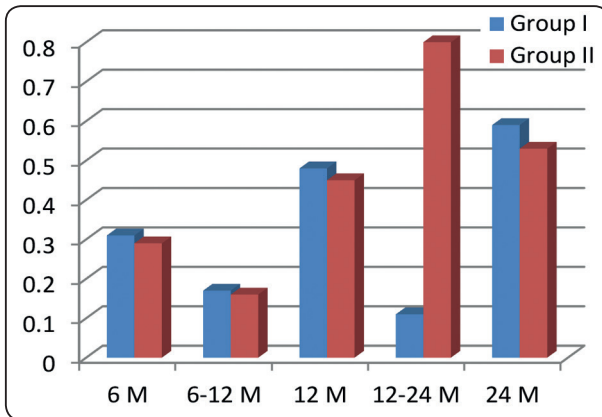


Fig. (5): Bar chart representing comparison between peri-implant bone loss of the studied groups at different follow up periods.

## DISCUSSION

Several materials introduced to improve the mechanical properties of dental polymers, including the “TSM ACETAL DENTAL and the synthetic thermoplastic polymer polyetheretherketone (PEEK)<sup>(23,27,28)</sup>. This was conducted to evaluate the effect of Polyetheretherketone (PEEK) as denture base material on peri-implant crestal bone level changes in edentulous patients rehabilitated with implant-supported bar overdenture retained by acetal and attachments attached the body of the bar constructed by CAD/ CAM technology. All criteria for patient’s selection were directed to control the adverse effect of systemic and local factors that contraindicate proper osseointegration of implants and avoid excessive load or undue forces on the residual ridge and implants. . Standard clinical and laboratory techniques were followed for denture construction for all patients to decrease variables that could affect the results of this study. Cross=linked acrylic resin teeth were balanced, following the lingualized concept of occlusion to ensure axial loading of the implants.

Marginal bone loss monitoring around implants is regarded by numerous authors as the most important criterion in determining the success of implants. Generally; this criterion is accepted as a

reliable indicator of bone response to the surgical procedure, and subsequent occlusal loading.<sup>(31-33)</sup> .

In accordance with other comparative studies the findings of the present study demonstrates that the two studied denture base materials individually showed insignificance bone loss around implants ( $p > 0.05$ ) during follow up period<sup>(34,35)</sup>. Although the results obtained from this study showed that Polyetheretherketone (PEEK) overdenture base caused favorable load distribution to implant supporting structures insignificant difference ( $p > 0.05$ ) was observed when comparing the peri-implant bone loss between the two groups.

Long term success of implant based restorations is careful consideration of the passive fit, following osseointegration and placement of a final restoration, both functional and para-functional loads can be transferred to the implants that may affect remodeling of the bone-implant interface. In the case of splinted implant restorations, it is possible that the restoration itself may transmit strain to the bone-implant interface. Ideally the restoration would fit passively on the supporting implants, thus minimizing strain and the concomitant biological response.<sup>(36)</sup> The concept of clinically acceptable fit using CAD/CAM frameworks incorporates the goal of minimizing both biologic complications and mechanical complications. <sup>(26)</sup> Clinically acceptable fit in combination with control over the occlusal forces is important for ensuring success of the implants and the restoration can account for the results of this study. Also, acetal resin have a sufficiently high modulus of elasticity and resilience that controls the excessive torquing forces that may act on the implants, and can explain the favorable outcome of periimplant loss changes detected in this study.

Although resiliency of the acrylic resin absorbs energy during loading and reduces the transmission of the functional stresses to the implant the results of this study showed that the use of

Polyetheretherketone (PEEK) as denture base material caused favorable load distribution to implant supporting structures. Studies have consistently shown that HA typically exhibits excellent biocompatibility, bioactivity, and osteoconduction *in vivo* (37,38)

Pacurar et al, in their study concluded that one of the biomechanical characteristics of BioHPP was that it is flexible as bone so it transmits less stress to implants when used as a definitive prosthesis material on the underlying structure and may account for the results of this study. With a modulus of elasticity of around (4 GPa) , Bio HPP is about as elastic as bone, which helps mitigate any stress that might develop and reduces stress shielding ,also bone related torsion can also be balanced out to some extent. (Cigu et al., 2015).

In the present study, most of the patients were more comfortable after treatment than before treatment, and all of them reported that their functional, phonetic, and chewing abilities improved. In both groups, a number of patients had their opposing prostheses relined during the 2-year period. These patients had all stated at an earlier interview that their maxillary denture had lost retention after the insertion of the mandibular implant-supported overdenture. This may be explained by the better retention of the mandibular prostheses . No differences in biologic complications whether Mucositis and hyperplasia were observed in the two groups .

## CONCLUSION

Within the limitation of the follow up period of the study the use of CAD/ CAM technology as well as the use of Polyetheretherketone (PEEK) as denture base material was of great benefit to preserve the implant supporting structures in implant bar retained overdenture.

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