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Original Article

Footprint of Different Bar Materials on Complete Overdenture Retention

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Abstract:

Objective: To evaluate the effect of bar constructed from conventional Cr-Co and digitally fabricated milled PEEK one (subtractive method) on the retentive quality of tooth supported mandibular overdenture after predetermined insertion and removal cycles resembling patient daily cycles of usage.

Materials and methods: A stone model for mandibular arch with remaining two canines was used for this research The canines were prepared into a dome shaped abutment**.** The prepared cast was duplicated into ten clear heat cured acrylic resin casts (5 casts in each group). Over-dentures were fabricated in the conventional way. The acrylic casts were digitally scanned using an extraoral 3D scanner. Virtual bar was designed on the Exocad software. After which the pattern was printed with 3D printer into the castable resin. The bar pattern was then conventionally cast into Cr-Co alloy. The virtual 3D (STL) file was sent to the milling machine to start milling of PEEK bar. To measure retention the force gauge was attached to the orthodontic wire, and pulling action was initiated, 10 readings were taken for each model. Insertion and removal cycles were repeated to simulate the daily insertion and removal cycles of the patient (3, 6, 9 and 12 months) respectively. **Results:** The values of retention were higher in case of PEEK bar compared to Metal one, yet in both groups there was gradual decrease in the retention values through the follow up period in both groups.

Conclusion: Milled PEEK bar showed better retention values as compared to metal bar thus it can be widely used in CAD-CAM fabricated removable dental prostheses and dental attachments due to its favorable mechanical, chemical and physical properties.

Keywords: Bar overdenture, Retentive clip, Milled PEEK bar, Cr-Co alloys, digital force gauge

Introduction:

Tooth supported over-denture is one of the basic treatment options considered, when the patient has three or less teeth remaining. It provides the advantage of better support compared to the conventional complete denture due to combined tooth-tissue support, instead of the entirely tissue support found in the conventional complete denture.(1)

Abutments teeth are prepared into many forms thus can provide different degrees of support and sometimes they provide some retention.(2)

Attachments are mechanical devices added to the remaining teeth to provide added means of retention beside to the physiologic means of retention.[3] Different overdenture attachments designs are available including bar and clip, ball and O-ring, ERA, and magnet attachments. The selection of the most suitable system depends on the number, distribution, and position of the remaining natural teeth.[4] From these attachments is the bar attachment. Bar attachment is one of the mostly used attachments.[1,4] There are basic two forms of the bar attachment, bar unit which is the rigid form and the bar joint which allows some flexibility. Hader bar is a rigid bar which connects teeth, roots, or implants. It is a semi precision bar attachment. Hader bar is a multi-sleeve bar type, this allows the bar to conform to the ridge curvatures, so it can used in oval arch shaped ridges. [5, 6]

Different prostheses fit on the bar with sleeves, riders or retentive plungers. The bar should be properly related to the gingiva, it should not cause food entrapment, or gingival proliferation, or blanching of the tissues. Bar attachments allows splinting of the abutments, retention, stability, and support. It also allows different heights of copings depending on the inter-arch space available. [7,8]

It is unadvisable to use Hader bar in cases where there is insufficient space for placement of the attachment and denture teeth, or the patient is unable to perform the oral hygiene requirements of a bar restoration.[9]

Bars are usually fabricated by making a wax pattern of a bar attached to waxed up copings formed on the abutments. Casting of the wax pattern with cobalt-chromium ingots, this is considered the conventional way of fabrication. The conventional bar provided adequate retention when used as the retainer in over-denture prosthesis.[7]

PEEK is a highly biocompatible material, with good mechanical properties, high temperature resistance, chemical stability, polishability, good wear resistance, low plaque affinity and high bond strength. Also PEEK has a low modulus of elasticity of 4 GPa, and is as elastic as bone, providing a shock absorbing property and reduction of stresses transferred to the abutment teeth. All these properties allowed it to be a good alternative to metal alloys. [10,11]

In recent years, dentistry has gone digital, and many of the appliances that were fabricated in the conventional way have been digitalized in its fabrications. Digital technologies helped dentists and technicians in fabrication ranging from single units to multi units and full arch dentures. They provide a durable and an accurate prosthesis. The main two techniques of digital fabrication are additive technique and the subtractive technique. [12]

The digital techniques have provided a simpler alternative in the fabrication of different appliances. The rapid development of computer-aided design and computer-aided manufacturing (CAD-CAM) technology led to the introduction of new materials that could be precisely milled for the fabrication of dental prostheses. [13]

So, This study aimed to compare the retentive values of metal bar retained tooth supported overdenture with digitally fabricated pattern and conventional casting, with digitally milled PEEK (subtractive technique).

Materials and methods:

A stone model for mandibular arch with remaining two canines was used for this research The canines were prepared into a dome shaped abutment with height of 2-3mm from the gingival margin with chamfer finish line.

The prepared cast was duplicated ten times using addition silicon (BREDENT

Germany) into ten clear heat cured acrylic resin casts (5 casts in each group). A thickness of 3mm were removed from the acrylic ridge and replaced with tissue mimic (GENESIS, Korea) to form the pseudo–mucosa above the ridge. Ten over-dentures were fabricated in the conventional way one on each model. For each acrylic cast the following procedure was done.

The acrylic casts were then sprayed with special spray to be readable to the scanner, then fixed on the scanner table and scanned using an extraoral 3D scanner (3D scanner, Ceramill map400, Amann Girrbach, Koblach, Austria) to design the retainers on the canines spanned with bar to obtain the STL file. **FIG 1(A,B,C)**

Group I: Fabrication of the printed castable resin for the metal bar:

The virtual 3D STL File was inserted into the EXOCAD software; (Rosa-Parks-Str.2 64295; Darmstadt, Germany). The STL file of the virtual bar was used to design bar pattern. After which the pattern was printed with 3D printer into the castable resin (Castable Blend 3D Resin, Fun To Do Co, Alkmaar, Netherlands). The bar pattern with copings were conventionally sprued and cast with cobalt chromium alloy (BEGO WIROBOND) then finished and polished. **FIG. 2 A**

Group II: Fabrication of the CAD-CAM milled PEEK bar:

The virtual 3D (STL) file was sent to the milling machine (Ceramill Motion 2, Amann Girrbach) to start milling of PEEK discs (BioHPP, bredent GmbH & Co.KG, Senden, Germany) to produce the PEEK bar. **(FIG. 2B**) The retentive riders (plastic clips) were placed on the bar for pickup of the bar attachment.

Measuring retention:

Two Suction discs were cemented to the prosthesis at the lingual side of the overdenture; orthodontic wires were ligated at the geometric center of the prosthesis, for the attachment of the digital force gauge (Force meter gauge-TAIWAN-Batch number: RH-406932). The model was fixed to the table of Jelenko surveyor for measuring retention. The force gauge was attached to the orthodontic wire, and pulling action was initiated, 10 readings were taken for each model. The same procedure was repeated for the PEEK bar. Insertion and removal cycles were repeated to simulate the daily insertion and removal cycles of the patient. The periods of function selected were 3, 6, 9 and 12 months respectively. **(Fig. 3 A ,B)**

Statistical analysis:

Data were statistically analyzed using SPSS (Statistical package for social science) version 20. Two-way ANOVA test was applied and Bon-ferroni post hoc test for pairwise comparison. $P < 0.05$

Results:

Data were collected, tabulated, statistically analyzed and shown in table (1) and figure (4)

I. Effect of bar material on retention:

- **At baseline (zero cycles)**

Retentive values were 12.54 ± **0.847 N** for PEEK bar and 10.68 ± **0.622** N in Metal bar .
No statistically significant difference was found between both groups (p=0.563).

- **After three months (270 cycles)**

The (PEEK bar) mean retention was 11.66 ± **0.767N** which was significantly higher compared to the Metal bar 9.35± 0.326N (p=0.004)

- **After six months (540 cycles)**

PEEK bar showed significantly higher values, 10.53 ± **0.726N** compared to Metal bar, 8.48± **0.401N** ($p \leq 0.001$).

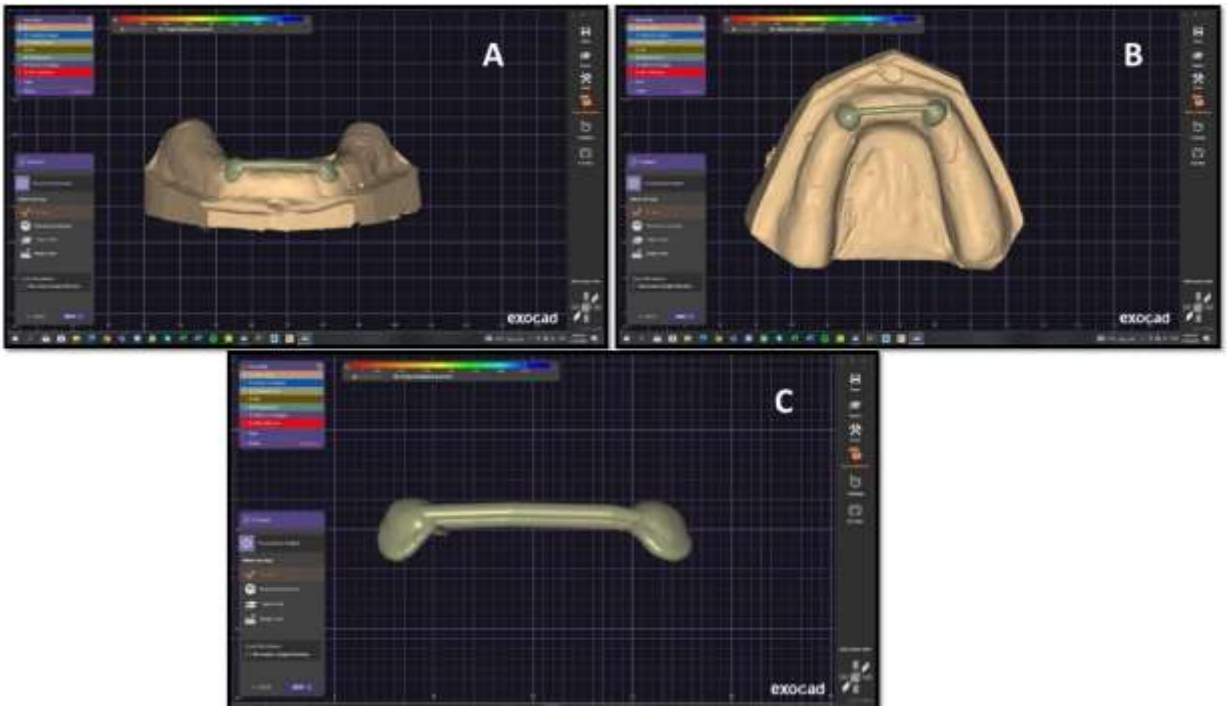

FIG 1: Showing Bar designing on the Exocad

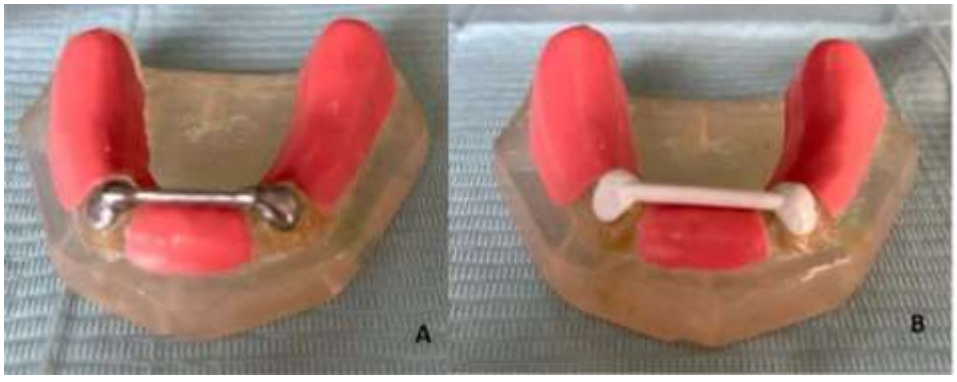

FIG. 2(A,B): Showing metal and milled PEEK bar

Fig. 3: A: Overdenture with suction discs and wire , **B:** Measuring retention with the digital force gauge

- **After nine months (810 cycles)**

The mean value of retention was 8.36±**0.647N** for PEEK bar and 7.03 ±**0.520N** for Metal bar. No statistically significant difference was found between both groups (p=0.375).

- **After twelve months 1080 cycles**

PEEK bar mean value of retention was 8.02± **0.412N** while the mean value of retention for Metal bar was 6.78± **0.30N.** No statistically significant difference was found between PEEK bar and Metal bar where (p=0.642).

II. Effect of time on the retention values within each group:

i. Metal bar group:

There was significant decrease in the retention values after 3 months. No significant change was noticed between 6, 9, and 12 months of follow up.

ii. PEEK bar group:

The same findings were found for PEEK bar group, there was significant decrease in the retention values after 3 months. No significant change was noticed between 6, 9, and 12 months of follow up.

Discussion:

In the following study the metal bar pattern was digitally fabricated then casting was done conventionally, while for the PEEK bar the whole work was done digitally through CAD/CAM milling (subtraction method). This was done to decrease human errors that may affect the final accuracy of the attachment.

Retentive yellow plastic clips are commonly used for retention with the bat attachment. [6] This may be assigned to their modulus of elasticity with excellent resiliency which is reflected on their retentive quality as they snaply fit over the corresponding bar.

Table 1: Showing the mean retentive values and standard deviation of both groups along the whole follow up period.

Time interval	Conventional metal bar	Milled Peek bar	P value
Base line	10.68 ± 0.622^{aA}	12.54 ± 0.847^{aA}	p=0.563
3 months	9.35 ± 0.326^{aA}	11.66 ± 0.767^{aB}	p=0.004
6 months	8.48 ± 0.401^{bA}	10.53 ± 0.726^{bB}	p≤0.001
9 months	7.03 ± 0.520^{bA}	9.36 ± 0.647^{bA}	p=0.375
12 months	6.78 ± 0.300^{bA}	8.02 ± 0.421^{bA}	p=0.642
P-value	P < 0.0001	P < 0.0001	

Mean with different small letters indicate statistically significance difference in the same column and different capital letters indicate statistically significance difference in the same row. P<0.05

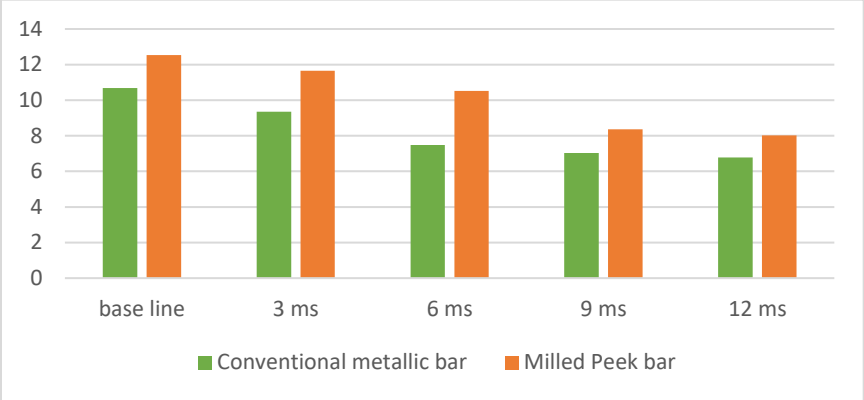

FIG. 4: Bar chart representing retention of Metal and PEEK bar in different cycles number

Therefore these clips turned out to be more widely and commonly used .[14]

Regarding the results of this study. The PEEK bar recorded higher retention values compared to the metal bar.

In comparison to the values of retention a study with similar setups reported that the retentive values regarding metal clips compared with plastic clips reported very near results regarding the values of retention.[15]

Regarding our study there was gradual decrease along the follow up period however the PEEK bar group showed higher retentive values compared to the metal bar. These results agreed with the study of Hammas M, and Abdelrehim. [14-16]

This could be related to the material of friction against which the retentive clip is placed. The difference in the retentive values may be attributed to the inherent properties of both metal surface and PEEK surface. Although the metal bar was constructed from a printed resin pattern yet the surface of the metal in contact with the investment material may show slight surface

roughness even after the finishing procedure that may have led to faster abrasion of the fitting surface of the clip compared to the milled surface of the PEEK. [17,18]. This was assigned to the high-quality finish accomplished by the CAD-CAM milling technique due to the fact of standardizing the conventional lab procedures.[19]

Also the CAD-CAM technology showed significant decrease in the surface porosity of the fabricated prostheses manifested by low surface roughness and thus decreasing the related loss of surface material as a result of continuous hinging or movement against another surface which explains the higher retention values for the PEEK bar compared to the metal one. Also regarding the material properties; flexural strength and modulus of elasticity of PEEK were not significantly influenced by thermal cycling, indicating the material's ability to retain its properties. [20,21]

Also the reinforcement of PEEK with carbon fibers has a major influence on load absorption, resiliency and wear resistance.[20]

A study reported that the plastic retentive clips, were responsible for the loss of retention. For this reason, there is a need to evaluate the retention force of different bars with various materials.[18]

The wear of retentive clips on top of bar attachments has been reported to have a direct impact on the retention of overdentures, and wear of the attachment due to friction between retentive attachment surfaces during insertion and removal or during chewing cycles. [17]

Conclusion:

Within the limitations of this study: PEEK could be suitable for CAD-CAM designed and fabricated removable dental appliances and dental attachments due to its favorable mechanical, chemical and physical properties. However, further in vitro and clinical studies are required to evaluate the long-term functioning capacity of these prostheses before PEEK can be safely recommended as satisfactory alternative to already instituted prosthodontic materials used.

Conflict of interest: The authors declare no conflict of interest.

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