Impact strength of CAD/CAM milled Poly Ether-Ether-Ketone Denture Base Material (In-vitro Study)

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ABSTRACT

Background poly ether ether keton is a new material introduced in the dentistry field as an alternative to conventional heat-cured acrylic resin prosthetic material .objective: to evaluate the impact strength of poly ether ether-ketone as an alternative to poly methyl metha acrylate denture base material. Material and methods: An invitro study was carried out in the laboratory of the removable prosthodontics department faculty of dental medicine at Al-Azhar University Cairo boys; A total of 20 specimens were prepared and divided in two equal groups control groups (n=10 PMMA) groups C and test group (n=10PEEK) group k, results: impact strength of test group showed significant higher impact strength than control group. Conclusion**:** PEEK material had higher impact strength and could be used as denture base material to overcome sudden impact forces to which PMMA may be sustained during function or exposure to sudden impact force.

KEYWORDS: PEEK, PMMA, Impact strength, Denture base, CAD/CAM

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INTRODUCTION

Poly methyl methacrylates is the most commonly used denture base material. Properties that contributed to the success of these materials as a denture base are excellent appearance, ease of processing and ease of repair. However, an inherent disadvantage is the liability of an acrylic resin denture to break during service. [1, 2]

Studies have shown that 68% of acrylic resin denture Break within a few years of fabrication intraorally duo to repeated masticatory force lead to fatigue failure and fracture while extra orally high impact force may occur as a result of dropping of prosthesis with consequent fracture of denture base [3, 4]

Most maxillary denture fracture are caused by a combination of fatigue and impact failure ,whereas For mandibular denture 80% of fracture are caused by impact in most situation fracture occur along the midline of the denture base .[3, 5]

Many approaches have been proposed to strengthen the acrylic resin prosthesis including addition of more bulk of material in areas receiving more stresses[6] or reinforcing the resin. The most common reinforcing technique is the use of solid metal forms or fibers embedded in the prosthesis. [7, 8]

Due to last drawbacks it was necessary to introduce a new materials to overcome last problems so that it would be beneficially to use alternative material such as thermoplastic resins and poly ether ether keton .[9, 10]

Thermoplastic resins being used for a broad variety of applications from removable flexible partial dentures, preformed partial denture clasps, fiber reinforced fixed partial dentures, temporary crowns and bridges, provisional crowns and bridges, obturators and speech therapy appliances, orthodontic retainers and brackets materials, occlusal splints, sleep apnea appliances, and implant abutments. [11, 12]

Several studies were conducted to evaluate several properties of peek material [13, 14] to indicate accessibility of use such material into prosthodontics field- in-between these studies the present study.

Polyetheretherketone (PEEK) has increasingly employed in dentistry and has attracted more interest for medical devices than any other material in the last 20 years it is one of the Polyaryletherketones (PAEKs)[15] polymer group family, which is characterized by ultra-high molecular weight polyethylene (UHMWPE) [16, 17]

PEEK available for medical purposes as granules that can be pressed or blank disks to mill. Which has numerous advantages over PMMA including; exceptional solvent resistance, low modulus of elasticity, and biocompatibility with bone make this polymer a good candidate to replace the use of metals in the body.[16, 18]

Several studies were carried out to evaluate impact strength of peek material to illuminate accessibility of use such material in prosthodontics field between these studies the present study. [19, 20]

Impact strength is the measure of energy absorbed by the material when it suffers sudden fracture. Ideally, denture base resin must offer sufficient impact strength to overcome the high extra oral impact forces which may occur as a result of dropping the prosthesis.[21, 22] So it’s mandatory to evaluate impact strength of Poly

methyl methacrylates and poly ether ether ketone denture base material , Impact strength tests are commonly evaluated by Charpy or Izod configurations. But here we were used Charpy test.[23, 24]

The null hypotheses of this study was that the PEEK will not have a significant difference on impact strength.

Aim of the study

The aim of this in vitro study was to evaluate impact strength of poly ether ether-ketone as alternative to polymethyl-methacrylate denture base material.

MATERIAL AND METHODS

This study was conducted in the laboratory Removable Prosthodontic Department, Faculty of Dental Medicine (Boys, Cairo), Al-Azhar University. A Total numbers of twenty specimens of test material **(n=10 PMMA and n=10 PEEK**).were prepared using ready-made blocks, which were cut according to impact strength test using CAD/CAM (Auron Machine).[10, 25] Acording to **Quassem MA et al ,2019**[23] The Impact strength was evaluated using charpy test. Acrylic resin and poly ether ether keton specimen 65mm X 10 mmX 2.5mm were used.

The specimens were polished with sandpaper and cooled to room temperature. Then divided into two equal main groups groups according to type of polymeric materials to be e to be evaluated.[26, 27]

The specimens were supported horizontally in Charpy's impact testing machine (a pendulum type machine with a disc shaped hammer, and adjusted to zero line in the machine then the specimens struck by the hammer at the mid span on the side opposite to the groove and the value for impact strength is calculated from the following formula:

Impact strength =Energy absorbed ÷ (Width x Thickness)[28, 29]

RESULTS

Descriptive statistics showing mean values and standard deviation of impact strength test results measured in Joule (J) as function of material groups are summarized in table (1) and graphically drawn in figure (A).

It was found that Group K (PEEK) group recorded statistically significant higher work of fracture mean value (1.321 ± 0.051 J) than PMMA group (0.8333 ± 0.043 J) as tested by student t-test

($p = <0.0001 < 0.05$). Data were compared using ANOVA test. The level of significance were seated at $P<0.05$

Table (1) Comparison of impact (work of fracture) test (J) results (Mean±SD) between both material groups

Variables		*Descriptive statistics*		
		Mean±SD	*95% confidence intervals*	
			Lower	*Upper*
Material group	*PEEK*	***1.321 ± 0.051***	1.292	1.349
	PMMA	***0.8333 ± 0.043***	0.809	0.857
t- test	*P value*	<0.0001*		

*; significant ($p < 0.05$) ns; non-significant (p>0.05) ***Table (1)***

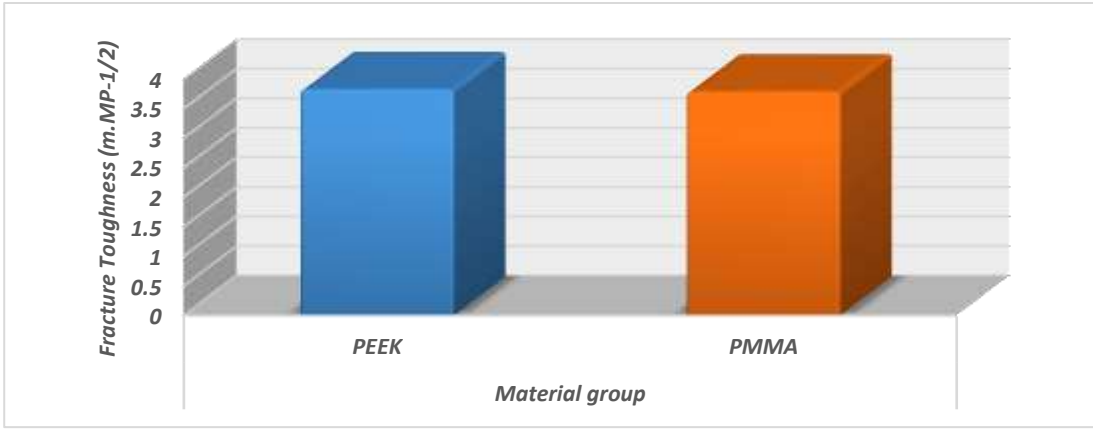

Figure (A)

DISCUSSION

As the most common failure of denture base material is liability of dental prosthesis to break when exposed to sudden impact forces or during function due to repeated forces under or over its proportional limit,[30] it was necessary to evaluate impact strength which can be defined as the ability of the material to absorb and dissipate energies, and used to measure the strength of material under shock or impact loading.[1]

To overcome the last drawbacks it was mandatory to induct anew material that has capacity to overcome problems of poly methyl

meth acrylate material of low impact strength such as poly ether ether keton material.

Polyether-ether-ketone (PEEK) is a high-performance thermoplastic polymer thus related to its high strength and durability that exhibited highly acceptance for a range of industrial applications[31] In addition, resistance to radiation , insoluble in various chemicals solvent of the mouth and at room temperature , stable over 300˚C , More durable than many metal restorations, Can be sterilized repeatedly without degradation.[17]

(PEEK) material were recently used for denture base material fabrications. To overcome some of disadvantages of acrylic resin, and offer a new safe treatment alternative for poly methylemethacrylate .[18]

Impact strength tests are commonly evaluated by Charpy or Izod configurations. But here we were used Charpy test, as it measure breaking energy per unit of cross-sectional area. ,[24] While the Izod test measures the breaking energy per unit of specimen thickness at the breaking point. [25] The Izod test is inherently less accurate than the Charpy test because the specimen geometry in the former is not symmetric (half of the specimen inside, half out). [10]

The Charpy impact test was performed on un-notched specimens as described in the International Organization for Standardization28 (ISO) standard and the American Society for Testing Materials (ASTM) D4812 standard[26]

It was observed in the present study, the impact strength of PEEK was higher than that of PMMA with differences considered as statistically significant.

These results come in agreement with the study, that conducted as an in vitro study to estimate the impact, tensile strength and flexural properties of pressed and milled PEEK material , and these properties were compared with those of PMMA. And concluded that the superior mechanical properties were associated with the peek material. [10]

Also these results was agree with a study that was conducted to evaluate denture bases fabricated by milled or thermo-pressed PEEK and PMMA as in vitro study, which showed that PEEK denture bases had a higher impact and tensile strength than PMMA, and advised with the peek material as suitable for denture bases fabrication as it provides resistance to notch concentration and fracture. [32]

These results was agree with a study that was conducted to compare between PMMA, and PEEK materials in their impact strength and concluded that superior impact strength properties related to peek material, and for that cause it become the material of choice for future use.[13]

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This result could be explained duo to hardness of the material that caused crack to prosthesis or flexibility of the material that allow absorption of force.[18]

CONCLUSION AND RECOMMENDATION

The poly ether ether keton material have higher impact strength than conventional heat cured acrylic resin denture base material. So that it would be better to use poly ether ether keton material in the future as alternative to conventional heat cured acrylic resin due to it is superior properties over the conventional heat cured acrylic resin.

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