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Research Article

Comparative Evaluation Of Flexural Strength Of Indirect Composite And Peek With And Without Aging

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ABSTRACT

AIM : The aim of this short study was to assess a crucial property that must be inherent in dental materials in order to be used reliably.
MATERIALS AND METHODS: According to ISO standardisation, 40 rectangular samples of PEEK (Group A) and indirect composite (Group B), each with 20 in each group, measuring 20 x 5 x 2.5 mm, were created. Of these, 10 samples (Group AI, Group AII) in each group were not aged, and the remaining 10 samples (Group BI, Group BII) were aged using thermocycling. A Three point bend test was used to test flexural strength both with and without aging. Unpaired t test statistical analysis was used to compare the two groups.
RESULTS: Flexural strength in both the composite as well as PEEK groups was lower after aging of the said specimens, but PEEK exhibited higher flextural strength when compared to indirect composite materials. (Mean Group AI: , Group AII: , Group BI:, Group BII:)
CONCLUSION
Flexural strength of PEEK was significantly higher than indirect composite, both with and without aging of specimens.

Keywords: peek, indirect composite, three point bend test, flextural strength

INTRODUCTION

In the last few years, composite resin formulas have advanced. Composite restorations can still have flaws, chipping, and fracture, nevertheless. Previously, it was necessary to replace a damaged composite restoration.[1]Every time it must be replaced, more tooth structure may be lost, therefore many times, they are not replaced, but merely repaired by clinicians. [2]
Some researchers also depended on nanotechnology to produce nanocomposites, in order for longer survival. [3]Yet, the success and survival rate of these restorations remains in question. In order to overcome the shortcomings of composites, PEEK was introduced.
PEEK($C_{19}H_{12}O_3$) [4] is a polyaromatic semi-crystalline thermoplastic polymer known as polyetheretherketone, or PEEK, has mechanical characteristics that make it suitable for use in biomedical applications. [5]It was developed in 1978 by scientists in England.
PEEK possesses high temperature stability of upwards of 300 °C, resistance to chemical and radiation damage, and favourable biocompatibility [6]Fixed dental prostheses, such as post-and-core, fixed partial dentures, and crowns, have made extensive use of polyetheretherketone (PEEK). The superior mechanical qualities of PEEK enable superior stress dispersion in comparison to other materials, hence safeguarding the abutment teeth.[7]For more effective clinical dental uses, it can be combined with materials like fibers and ceramics to increase its mechanical strength. The mechanical properties of 3D-printed PEEK can be influenced by printing temperature and speed, and it has superior flexural and tensile strength when compared to traditional pressed and CAD/CAM milling production methods.[8]

One drawback noted by many, is poor colour stability and gayish hues. As dentistry has advanced, newer composites have commendable mechanical and optical properties. [9]Thermocycling has been considered the in vitro standard for aging of specimens , as the uniform stress is imposed on all specimens. [10]
The bend strength or stress that prevents a material from failing to bend is known as flexural strength. When bending a material, the extreme fibres will experience greater stress than the other fibers since the stress is highest at the edge (concave surface) and lowest at the convex surface.

MATERIALS AND METHODS

SAMPLE PREPARATION

This in vitro study was done in Saveetha Dental College and Hospital, Chennai, India.
The Saveetha Dental College Institutional Ethics Committee (SRB/SDC/FACULTY/21/PROSTHO/079) gave its clearance before this study could be carried out.
The sample size for this investigation was determined using G*Power software 3.1.9.7 using a prior study carried out by Massereti et al. as a guide.
The sample size calculated was 40 (20 samples in each group).
A bar 25 ± 2 mm × 2 ± 0.1 mm × 2 ± 0.1 mm in accordance with ISO specification No. 4049/2000 and ANSI/ADA specification No. 27., standard for the 3 point bend test as stated by Morresi *et al.*, 2015 for flexural strength test using Blender software(1025, Amsterdam) and a Standard Tesselation File was created.

List of Products Used In this Study

Material	Product	MANUFACTURER
PEEK Blank	PEEK	Intamsys PEEK, Shanghai, China
Indirect Composite Resin	Composite Resin	SHOFU CERAMAGE, India

The samples were fabricated in house at Saveetha Tessellation Centre, using a 5 axis milling machine- IMES iCore, CORiTEC 350i milling machine ® and all specimens were tested at the White Lab, SDC.
The specimens were mounted on a jig, and the load was applied with an Instron Universal Testing Machine (Instron 5565, Instron Corp, Norwood, MA) at a crosshead speed of 0.75 ± 0.25 mm/min until the sample fractured. The maximum load exerted on the samples was recorded, and the flexural strength at failure was calculated by the following formula:
One of the produced PEEK samples was used to create a silicon mold (Zhermack Elite Glass Silicon Transparent, Zhermack SpA, Italy), which was subsequently utilized to create the indirect composite samples.
The base and mold were lubricated with a thin layer of Al-Cote. Under low-light conditions, sufficient composite was applied to fill the mold, and the excess composite was removed using a wax spatula.
In order to create a smooth and level surface, the indirect composite resin was first placed within the mold and coated with glass.
A thin coat of Al-Cote was applied to a clean glass slide, and the slide was placed on top of the sample. Finger pressure was applied to achieve a smooth surface and good adaptation of the composite. [11,12]
Each sample was light cured for 40 seconds through the glass slide using the Smartlite iQ2. Since the length of the rectangular bars for the three-point flexure test exceeded the diameter of the curing-light tip, three overlapping curing times were employed until the entire length of the samples was covered.

During all sample preparation, light intensity (620 mW/cm^2) was checked periodically with the Cure Rite radiometer (Efos Inc, Mississauga, Ontario, Canada). .
Using Tegramin-20 equipment (Struers), the samples were polished using a series of silicon carbide sheets (SiC) up to P4000 grit while being cooled with water. Then, for five minutes, they were cleaned in an ultrasonic bath (Ultrasonic T-14; L&R Manufacturing Co.) that was filled with distilled water.
Following this, a total of 40 samples, 20 in each group, were fabricated and categorised based on aging and thermocycling. Group IA(N=10, Composite without thermocycling), Group IB (N=10, Composite post thermocycling) underwent ageing with 1000 cycles of thermocycling, while Group IIA (N=10, PEEK without thermocycling) was CAD/CAM milled PEEK without thermocycling, and Group IIB (N=10, PEEK post thermocycling) underwent 1000 cycles of thermocycling.[11]

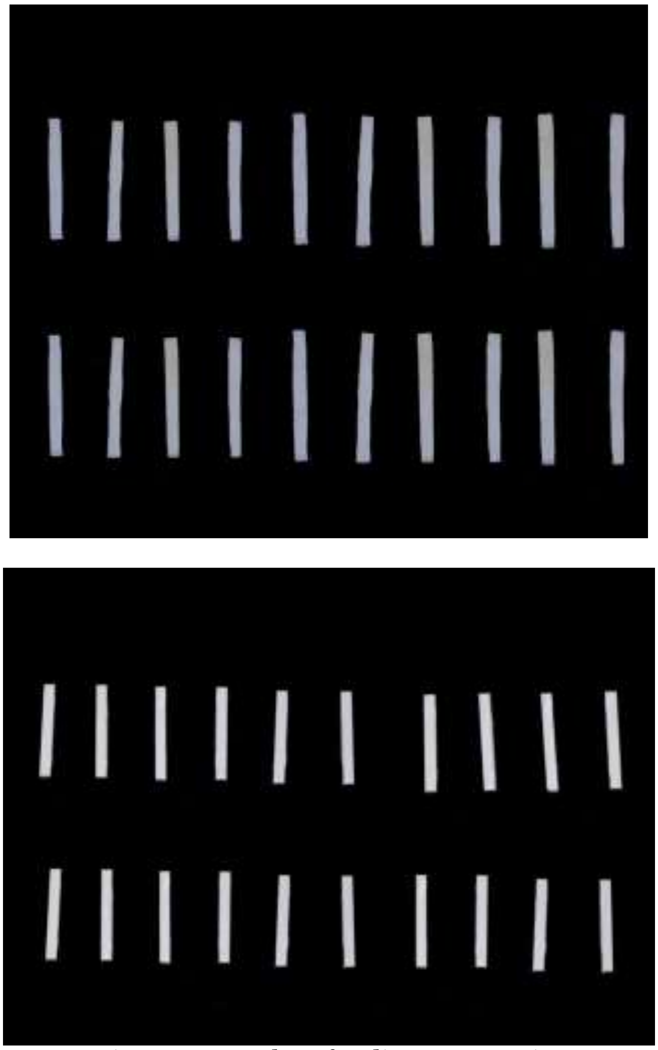
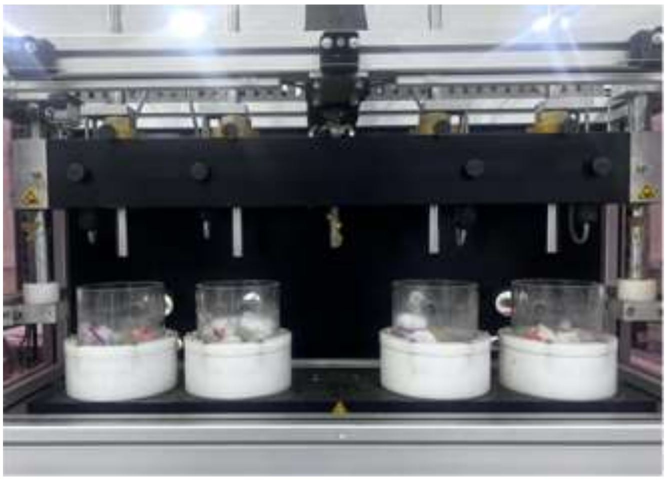


Figure 1: Samples of Indirect composite



THERMOCYCLING OF SPECIMENS

Using a thermocycling apparatus (Dual-Axis Chewing Simulator TW-C4.4, Tae-won Tech, Incheon, Korea), the samples (group IB, N = 12 and group IIB, N = 12) were kept in a distilled water bath between 5^{0} C and 55^{0} C with a dwell time of 6 seconds and a dry time of 5 seconds. The samples were subjected to 1000 cycles of thermocycling. After thermocycling, the samples were kept at room temperature in their individual containers with distilled water until they were tested for microhardness. In this study, the application of 1000 cycles translates to putting the material under consideration under stress levels comparable to clinical use for a roughly 1.2-month period (36 days).[13,14]

FLEXURAL STRENGTH TEST

To determine the maximum force and maximum flexural displacement, the thermocycled and non thermos cycled samples underwent a three-point bend test using an INSTRON E3000 UTM (ElectroPuls) with a span length of 16 mm and a cross head speed of 1 mm/min.
The flexural strength values (σf), in MPa, were calculated as follows:
$\sigma f = 3PL / 2wb^2$
where:
P is the fracture load (N);
L is the distance between the supporting rollers (20 mm);
w is the specimen height (in mm);
b is specimen width (in mm).
Data analysis
The flexural strength was calculated using the data obtained and summarized in the Excel sheets. parametric tests, the independent samples t-test, and independent sample test analysis in SPSS version 23.0 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) were used to determine the differences between the groups.

RESULTS

40 rectangular samples of PEEK (Group A) and indirect composite (Group B), each with 20 in each group, measuring 20 x 5 x 2.5 mm, were created. Of these, 12 samples (Group AI, Group AII) in each group were not aged, and the remaining 10 samples (Group BI, Group BII) were aged using thermocycling. A consistent methodology was used to test flexural strength both with and without aging.

	1	2	3	4	5	6	7	8	9	10
Group AI	82	84	86	82	84	85	85	84	86	89
Group AII	69	66	65	67	66	68	69	66	64	65

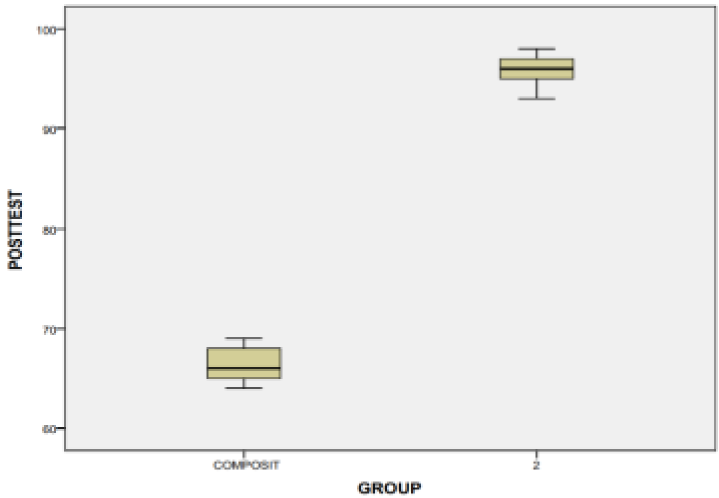
***Table 1**: Flextural strength values of all the tested samples.(MPa)*

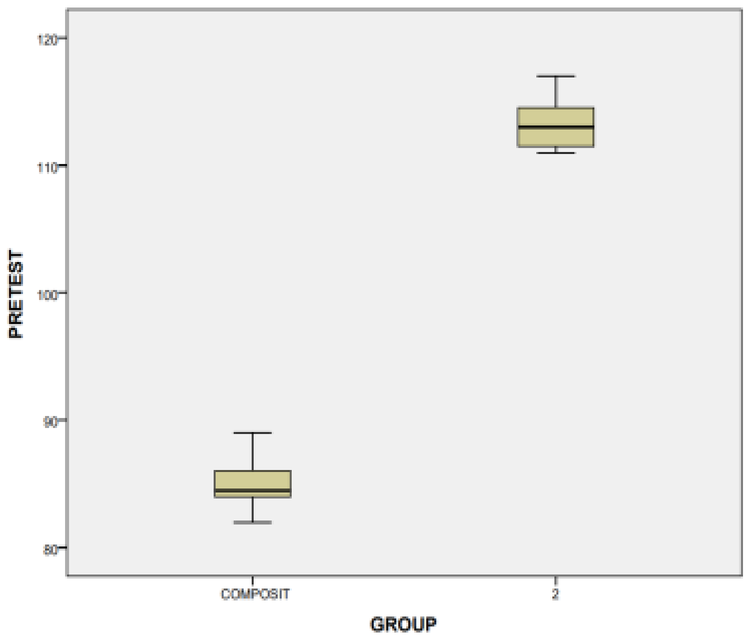
SAMPLE	1	2	3	4	5	6	7	8	9	10
Group BI	113	115	117	111	115	113	114	112	112	111
Group BII	98	96	97	93	96	97	98	95	96	95

Table 2: *Flextural strength values of all the tested samples.(MPa)*

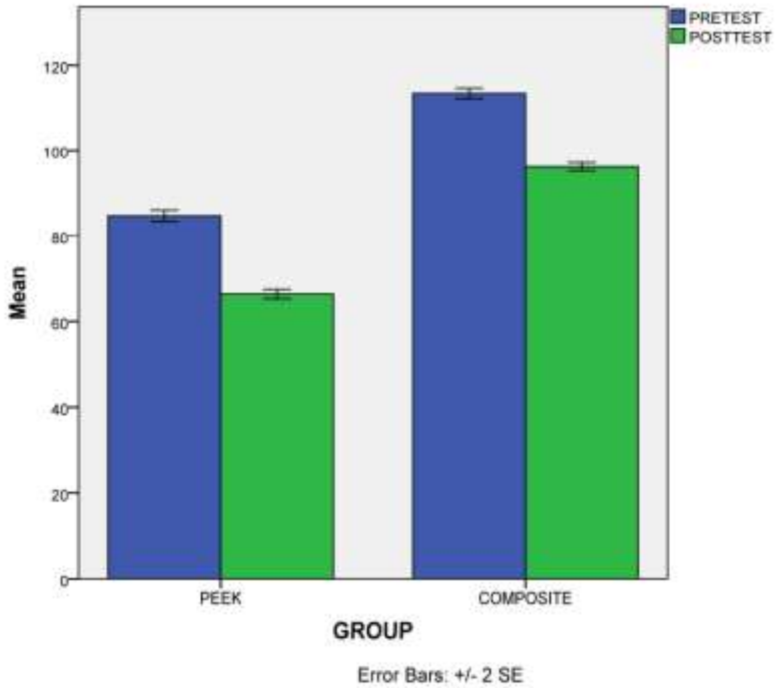
STATISTICAL ANALYSIS:

Descriptive statistics were computed on Microsoft Excel (Microsoft Corporation,1985) and then transferred for statistical analysis. The normality of the data distribution was assessed using the Kolmogorov-Smirnov normality test. Statistical analysis involved paired student t-tests for within-group comparisons before and after aging and unpaired t-tests for comparisons between the two materials. All data analyses were performed using SPSS software (Version 26.0; SPSS, Inc., Chicago, IL, USA). Significance was established at $p<0.05$.





	PEEK			COMPOSITE		
	MEAN	S.D	P VALUE	MEAN	S.D	P VALUE
PRE- TEST	84.70	2.058	.000	111.3	1.947	.000
POST-TEST	66.50	1.716		96.10	1.524	



DISCUSSION

This in-vitro study aimed to compare and evaluate the microhardness of commonly used materials: Indirect composite resin (Group I) and CAD/CAM milled PEEK (Group II) after exposure to thermocycling.
Wear is generally considered to occur due to occlusal interactions leading to complications like impaired chewing function, antagonist wear, and loss of durability of the prosthesis[11]
Restoration failure is a major concern with regard to long-term success and longevity of restorations.[15]
In a previous study conduced by Dhivya Priya et al, the flexural strength of PEEK after 500 cycles of thermocycling was the highest among all groups followed by PEEK subjected to 1000 cycles of thermocycling [16]In an invitro study, it was concluded that manual veneering of PEEK frameworks with conventional composite and using a thicker framework could be more successful than digitally veneered PEEK frameworks with either CAD milled composite or lithium disilicate.[17]
The results of these studies showed statistical significance, and showed higher flextural strength of PEEK, both with and without aging. PEEK fixed partial dentures are reported to show better esthetics and despite the fact, PEEK frameworks showed equivalent mechanical properties as metal alloys[18]
Within the limitations of this study, it was noted that there is a significant difference between the values of flextural strength with and without aging within the Indirect Composite (IC) group and the PEEK group.

CONCLUSION

The comparative evaluation in this study shows a significant decrease in flextural strength for both groups, PEEK and indirect composite after aging.Restoration failure is a major concern with regard to long-term success and longevity of restorations. Although reduced after aging, PEEK showed higher flextural strength values as compared to indirect composite, Therefore, the use of PEEK in posterior restorations may be endorsed for use in dentistry

LIMITATIONS

The study was conducted invitro, and therefore human testing is required in order to establish the properties of PEEK in the oral cavity when exposed to oral fluids and masticatory loads.

Conflict of Interest

The authors did not have any conflict of interest, financial or personal, in any of the materials described in this study.

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