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To evaluate and compare the abrasion resistance and flexural strength of parylene coated polymethylmethacrylate

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Abstract

Background: Poly(methyl methacrylate) is one of the most significant unaltered acrylic polymers for dental applications (PMMA). A family of polymers known as parylene, or poly para-xylylene, are employed as coating materials because of their exceptional capacity to form a protective layer on a variety of surfaces. By using vapour deposition polymerization to create parylene, a uniformly thick coating that is nearly impermeable to moisture, biocompatible, chemically inert, and thermally stable can be created. Additionally, it has excellent mechanical qualities and a high degree of crystallinity. Despite experimental studies demonstrating a number of benefits, such as a reduction in microbial adhesion on coated acrylic resin and silicone specimens, the use of parylene in dentistry is still limited.

Aim: To evaluate and compare the abrasion resistance and flexural strength of parylene coated PMMA with non-coated PMMA.

Materials And Methods: Forty-two samples of dimension 65*10*3 mm were divided into 2 groups.

Group 1(n=21): Parylene C coated PMMA.

Group 2(n=21): Non-coated PMMA.

Following a toothbrush simulator, the abrasion resistance of coated and non-coated PMMA specimens was tested with the help of an optical profilometer. A 3-point bend test (UTM) was used to check the flexural strength of the samples. The values obtained were statistically analysed using Shapiro Wilk test.

Result : Group 1 reported better flexural strength with a p value of 0.242 and better abrasion resistance with a p value of 0.695 when compared with group 2.

Conclusion : Flexural strength and abrasion resistance of PMMA increased with Parylene coating.

Clinical Implication : The abrasion resistance and flexural strength of PMMA can be improved by coating PMMA with parylene .

Keywords : UTM, Optical Profilometer, PMMA, Parylene, Abrasion Resistance, Flexural Strength.

Introduction

Poly(methyl methacrylate) is one of the most significant unaltered acrylic polymers for dental applications (PMMA). PMMA, which was developed and commercialised many years ago, is one of the most commonly used industrial polymeric materials and is still being actively used in cutting-edge scientific research. Polymethyl methacrylate (PMMA), despite being widely used in dentistry, has a number of material flaws that could become apparent with extended intraoral use like microbial colonization and mechanical properties which are subject to distortion.[1]

The class of organic polymers known as poly(para-xylylenes) produced via vapour deposition and initially identified by Szwarc in 1947 is known commercially as parylene. The pyrolytic breakdown of p-cyclophane, a dimer made up of two p-xylylene molecules, into each of its constituent components at 600ºC is the first step in the formation of parylene films. This process produces a monomer vapour that, when injected into a deposition chamber at room temperature, instead of returning to its original dimeric powder form, creates a transparent, robust, and highly crystalline polymer film.[2]

Parylene polymers are employed as coating materials because of their exceptional capacity to form a protective layer on a variety of surfaces. By using vapour deposition polymerization to create parylene, a uniformly thick coating that is nearly impermeable to moisture, biocompatible, chemically inert, and thermally stable can be created. Additionally, it has excellent mechanical qualities and a high degree of crystallinity. Despite experimental studies demonstrating a number of benefits, such as a reduction in microbial adhesion on coated acrylic resin and silicone specimens, the use of parylene in dentistry is still limited. In addition the effect of parylene coating on properties of PMMA like abrasion resistance and flexural strength is not known.[1]

Therefore the purpose of this study was to determine the effect of parylene coating on the abrasion resistance and flexural strength of polymethylmethacrylate (PMMA).

Materials And Methods

The study includes a total of 42 samples:

Group 1(n=21)- Parylene coated PMMA discs

Group 2(n=21)- Non coated PMMA discs

Fabrication of samples:

42 wax patterns of dimensions 65*10*3 mm were fabricated using baseplate wax (DPI) (Figure 1). The wax patterns were then flasked using dental stone (Kalabhai kalstone). The samples were dewaxed, packed with heat cure PMMA (DPI)and acrylized in a hot water bath for 2 hrs at 74ºC, followed by heating at 100°C for 1 hour (Figure 2,3).

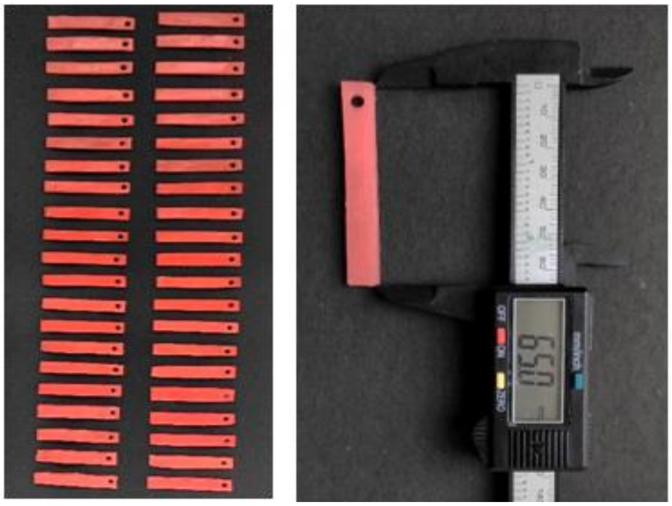


Figure 1: Wax Patterns of Dimensions 65*10*3mm were fabricated

Figure 2: Wax Patterns were flasked, dewaxed, packed and acrylized with heat cure PMMA.

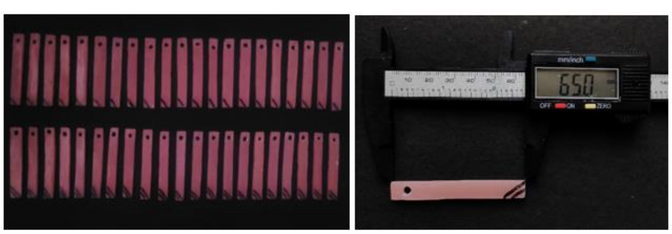


Figure 3: Heat cure PMMA samples of dimensions 65*10*3mm were obtained after acrylization.

Coating PMMA specimens with Parylene:

21 specimens were coated with Parylene C (SCH-India) using a vapour deposition method (Figure 4).

Figure 4: 21 specimens were vapour coated with Parylene C.

Tooth brush abrasion of the samples:

A tooth brush simulator, was used to create surface roughness on the coated and non coated PMMA samples (Figure 5) .

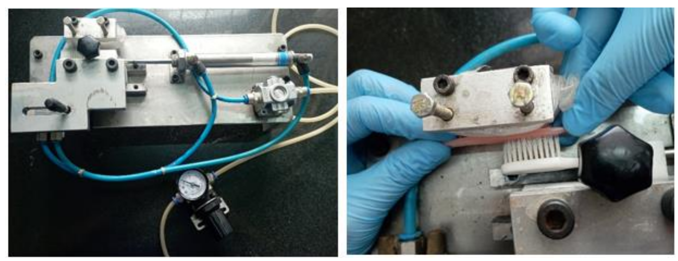


Figure 5: A tooth brush simulator was used to create surface roughness.

The abrasion resistance of coated and non coated PMMA specimens was tested with the help of an optical profilometer (Talysurf CCI) (Figure 6).

The flexural strength of the coated and non coated specimens was tested with the universal testing machine (Multitest 10i) at a crosshead speed of 5 mm/sec (Figure 7).

Figure 6: An opatical profilometer was used to measure the abrasion resistance.

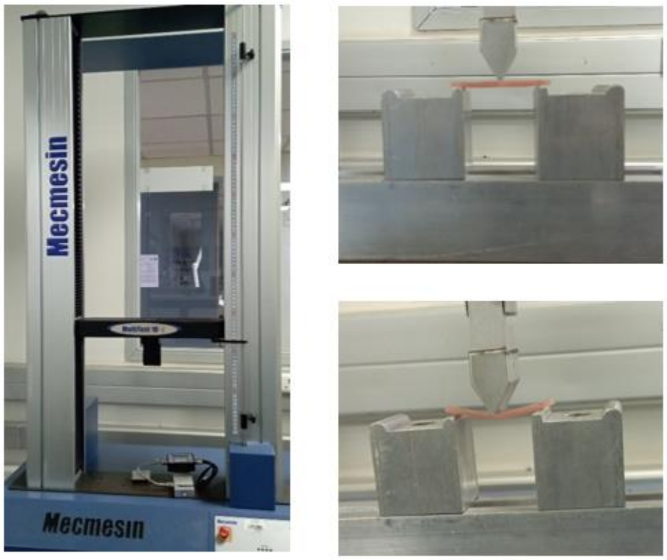


Figure 7: A universal testing machine was used to measure the flexural strength.

To perform the statistical analysis Statistical Package For Social Sciences (SPSS) version 20. [IBM SPASS statistics (IBM corp. Armonk, NY, USA released 2011)] was used. Data was entered in the excel spread sheet. Descriptive statistics of the explanatory and outcome variables were calculated by mean, standard deviation for surface roughness, median and IQR for flexural strength. Independent sample t test was applied to compare the surface roughness between the groups. Mann-whitney test was applied to compare the flexural strength between the groups. The level of significance is set at 5%.

Results

The mean R_a of group 1 was higher- 1.1100 as compared to the mean R_a of group 2- 0.9400. Mann- Whitney test was applied to compare the mean surface roughness between the two groups. Hence parylene coating improved the abrasion resistance of PMMA samples. Mann- Whitney test showed a p value of 0.242 (Table no. 1).

Table 1: Comparison of the surface roughness between the groups using mann-whitney test

Groups	Minimum	Maximum	Median	IQR	p value
Group 1	.64	3.27	1.1100	1.38	0.242
Group 2	.39	5.85	.9400	1.38	

The flexural strength of group 1 was higher- 97.490±18.091 as compared to group 2- 95.520±13.969. Mann- Whitney test was applied to compare the flexural strength between the two groups. Mann- Whitney test showed a mean difference of 1.97 with a p value of 0.695 (Table no. 2).

Table 2: Comparison of the Flexural Strength Between The Groups Using Mann-Whitney Test

Groups	N	Minimum	Maximum	Mean	S.D	Mean diff	p value
Group 1	21	63.91	132.47	97.490	18.091	1.97	0.695
Group 2	21	67.23	129.65	95.520	13.969		

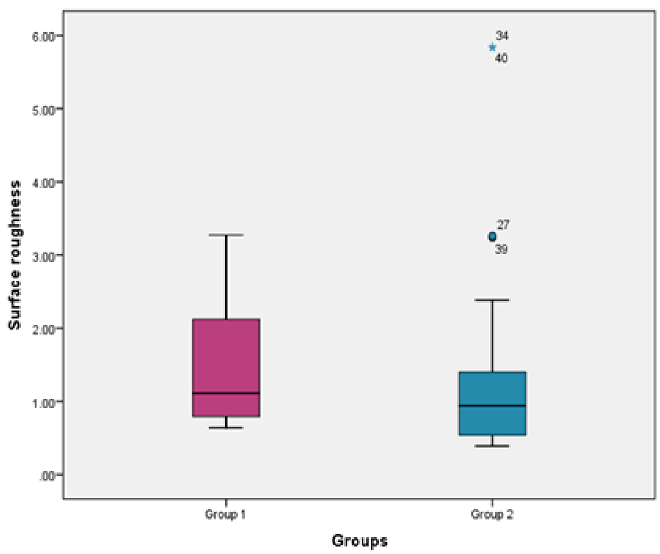
Discussion

Parylene is a conformal protective polymer that may be formed onto crystalline polymers ranging in size from 1 mm to 50 mm and used to cover the surfaces of substrates like metal, glass, paper, resin, plastic, and ceramic via chemical vapor deposition and polymerization. Since it can shield any component structure by coating its surfaces, it has found extensive use in the aerospace, automotive, electronics, and biomedical device industries. Excellent qualities and traits of parylene coating include its high degree of transparency, insulation, biocompatibility, hydrophobicity, and resistance to organic and inorganic solvents, acids, and friction.[3]

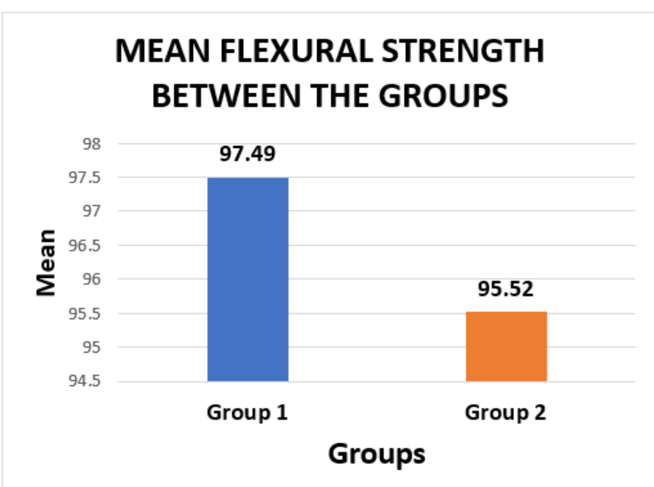
The three most common kinds of parylene are parylene C, parylene D, and parylene N. The fundamental structure of the parylene family is represented by the chemical formula polyp-xylene for parylene N. By substituting a single chlorine molecule or two chlorine molecules, respectively, parylene C and parylene D are created.[3]

Despite experimental studies demonstrating a number of benefits, including a reduction in microbial adhesion on coated acrylic resin and silicone specimens, the use of parylene in dentistry is still limited. Further research is necessary to determine whether Parylene may be used as a covering material for PMMA intraoral prosthetics and to determine its effect on other properties of PMMA.[1]

The results of this study showed that coating the surface of PMMA with Parylene C increased its abrasion resistance and flexural strength (Graph 1 & 2).



Graph 1: Comparison of abrasion resistance among the groups



Graph 2: Comparison of flexural strength among the groups

Bourlidi S et al conducted a study that investigated how surface roughness and SFE would change depending on the initial finishing and Parylene C coating thickness of PMMA specimens. For practically all of the groups, the results showed that R_a decreased following the coating. This finding was consistent with those of a prior study that used a comparable experimental design and obtained lower Ra values as a result of the coating.[1]

Zhou L. et al. conducted a study in order to determine whether silicone elastomers and parylene coatings applied to denture bases can successfully minimize Candida albicans adherence and, consequently, lower the incidence of denture stomatitis. According to the findings, silicone elastomers and denture base resins with a parylene coating had less C. albicans adherence and aggregation on their surface.[3]

More research is required to determine how the surface characteristics of parylene C can influence microbial adherence. It is also necessary to examine how parylene C affects the retentive, mechanical, chemical, and color stability of removable prostheses.

Clinical Implication

The surface of PMMA can be vapour coated with Parylene to increase its abrasion resistance and flexural strength.

Conclusion

Within the limitations of the study it can be concluded that:

1. Parylene C Coating improved the abrasion resistance of PMMA.
2. Parylene C Coating improved the flexural strength of PMMA.
3. The abrasion resistance and flexural strength of Parylene coated PMMA was higher when compared to non coated PMMA.

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