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Original Article

A Comparative Evaluation of Effect of Denture Cleansers on Color Stability, Surface Roughness, and Hardness of Polyether Ether Ketone

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Abstract

Introduction: With the rising incidence of edentulousness, the need for dentures as well as their hygiene is of utmost importance. Very scarce data are available for effect of denture cleansers on color stability, surface roughness, and surface hardness of PEEK.

Purpose: This *in vitro* study was conducted to evaluate and compare the effect of different denture cleansers on color stability, surface roughness, and hardness of PEEK.

Materials and Methods: Thirty PEEK specimens were prepared with diameter of 20 mm and thickness of 3 mm by CAD/CAM milling process and divided into three groups (n = 10). Specimens of each group were immersed in different denture cleansers of thyme oil, sodium perborate, and ozonated water for 10 min per day for 180 days. Initial and final color, surface roughness, and surface hardness of each specimen were measured after 180 days of immersion and difference was calculated. Data were tabulated and subjected to statistical analysis. Level of significance was set at $P \leq 0.05$.

Results: PEEK exhibited lowest color change and surface roughness, when immersed in thyme oil followed by sodium perborate and ozonated water. Increase in hardness was seen when PEEK specimens were immersed in ozonated water.

Conclusion: After immersion of PEEK specimens in different denture cleansers, the values of change in color and surface properties were within acceptable limits.

Key words: CAD/CAM, Color stability, Denture cleansers, Ozonated water, PEEK, Sodium perborate, Surface hardness, Surface roughness, Thyme oil

INTRODUCTION

Due to continuous developments in dentistry, modification of materials is encouraged. The polymer modification and ceramic particles were included in it. Polyether ether ketone (PEEK) is one of such polymers, which is used in medical field. Moreover, due to tissue biocompatibility, it is used for hip replacement. It was modified for dental use as alternative to metal framework and veneered by reinforced composite for optimum esthetics. PEEK was reported to have good mechanical properties and modulus of elasticity similar to denture.[1-3]

Dental prosthesis is an artificial replacement of missing oral structures restoring function, form, and esthetics. Thus, they should be manufactured using esthetically acceptable, precise, durable, and biocompatible dental materials. New researches and technologies in prosthetic dentistry are at its peak. Material researchers are continuously testing innovative materials to match the technological advancements and ever-increasing patient desires for function and esthetics as well.[4-7]

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A newer polymeric material polyether ether ketone (PEEK) has been introduced in recent times, which has unmatched strength, superior biocompatibility, low plaque affinity, esthetics, and characteristics structure.[8] PEEK is a close to the dental structure. PEEK is a polycyclic, aromatic, and thermoplastic polymer that are semi-crystalline and has a linear synthetic, tooth colored polymeric material, characterized by high mass-based stability, strong resistance against temperature loads, chemical and physical and radiological stress, and corrosion. Due to its outstanding properties in combination with outstanding biocompatibility and the high stability, it is used in variety of applications such as for the fixed dental prosthetic framework (FDP) or the removable partial denture abutment framework, and as a material for provisional implants abutments.[8,9]

In the clinical success of prosthesis, surface properties play an important central role. One of the most important clinical properties for all dental materials is that color stability and color changes are indicators of aging or damaging of the materials. Several factors may play a role for the discoloration of dental material after long-term use.[10]

For the longevity of the prosthesis, surface roughness, surface hardness, and color stability of the material are crucial. Therefore, the present study was taken up to evaluate and compare the effect of different denture cleansers on color stability, surface roughness, and hardness of PEEK.

MATERIALS AND METHODS

Thirty specimens were prepared of PEEK denture base material with diameter of 20 mm and thickness of 3 mm [Figure 1]. Specimens of each group were immersed in different denture cleansers for 10 min per day for 180 days. Color measurement was done with the help of spectrophotometer. The surface roughness (Ra μm) measurement was done with the help of contact profilometer with a diamond stylus (tip radius of 2 μm). The surface hardness measurement was done with help of Shore D Durometer using 50-gf load for 30 s [Figure 2]. Thyme oil, sodium perborate, and ozonated water were selected as denture cleaners. Immersion procedure was carried for 180 days (6 months) to find out the long-term effects of different denture cleansers on color, surface roughness, and surface hardness of specimens [Figure 3].

After initial evaluation, the specimens were immersed in different denture cleansers. Ten specimens of each group were immersed in thyme oil, sodium perborate, and ozonated water, respectively [Figure 4a-c]. Each specimens were immersed in thyme oil, sodium perborate, and ozonated water for 10 min/day. After 10 min, specimens were thoroughly washed and stored in distilled water. This procedure was repeated daily for 180 days. After immersion into a different denture cleansers, final color, surface roughness, and shore D surface hardness of all specimens were measured for the same surface as done before immersion. Difference between initial and final color, surface roughness, and shore D surface hardness was calculated.

RESULTS

Table shows summary of mean and standard deviation of change in color, surface roughness, and hardness of PEEK specimens after immersing in different denture cleansers.

The result of the present study exhibited change in color of all specimens of PEEK denture base material immersed in all the denture cleansers evaluated. Least color change was seen in group II that was immersed in sodium perborate followed by group III(ozonated water) and I(thyme oil). There was statistically non significant change between all groups. ($p>0.05$)

There was change in surface roughness of all specimens of PEEK denture base material immersed in all the denture cleansers evaluated. Least surface roughness change was seen in group II (sodium perborate) followed by group I (Thyme oil) and group III (Ozonated water). There was statistically non significant change between all groups. ($p>0.05$)

Further, there was change seen in shore D surface hardness of all specimens of PEEK denture base material immersed

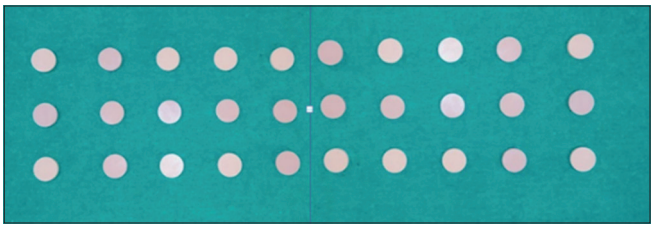

Figure 1: Test materials: PEEK samples

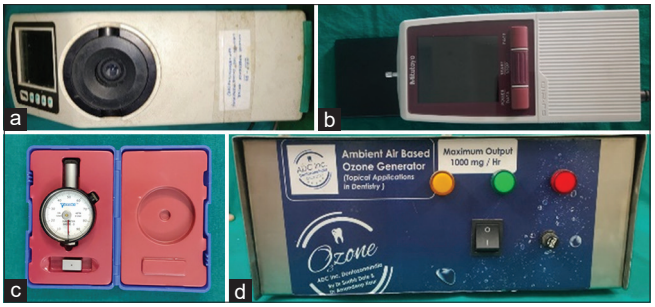

Figure 2: (a) Spectrophotometer, (b) Surface profilometer, (c) Shore D durometer, (d) Ozone generator

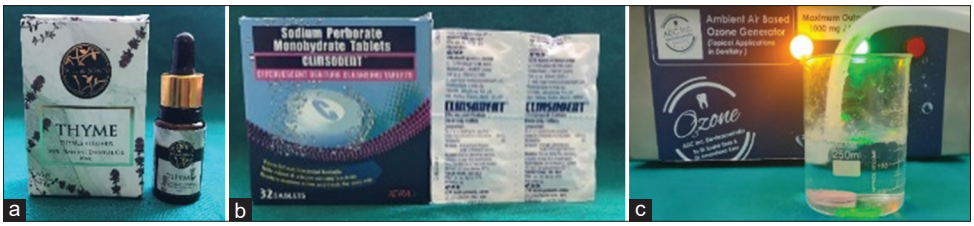

Figure 3: (a) Thyme oil, (b) Sodium perborate, (c) Ozonated water

in different denture cleansers evaluated. All the denture base resin specimens of group I and II in the present study exhibited decrease in hardness with immersion in denture cleansers. There was statistically significant change between groups. ($p<0.05$) [Table 1].

DISCUSSION

In the last two decades, treatment options and materials used in dentistry progressed remarkably. The application of CAD/CAM (Computer-aided design/computer-aided manufacturing) technology contributes positively to comfortable and high quality dental services. CAD/CAM technologies have been introduced as an alternative to conventional processing techniques. The prosthesis fabricated through CAD/CAM is rated as promising for the successful long-term use. CAD/CAM polymers which have various cross-linking densities are used for fabricating prosthesis.[3,11]

The present study was conducted to evaluate and compare the effect of different denture cleansers on color stability, surface roughness and hardness of PEEK. Disc shaped test specimens were fabricated using PEEK with 20mm diameter and 3 mm thickness. These dimensions were used as it is compatible size for performing tests for color stability, surface roughness, and surface hardness, and this was similar to the dimensions used by Durkan *et al.*[12] and Sharabasy *et al.*[13] in their study.

Specimens of each group were immersed in different denture cleansers for 10 min per day for 180 days. Liebermann *et al.*[14] found that daily 10 min of immersion in any denture cleansers is needed for specimens to exhibit change in color and surface properties. Thyme oil, sodium perborate, and ozonated water were selected as denture cleaners. Immersion procedure was carried for 180 days (6 months) to find out the long-term effects of different denture cleansers on color, surface roughness, and surface hardness of specimens. This duration of immersion was similar to that of Liebermann *et al.*,[14] Wieckiewicz *et al.*,[15] and Stawarczyk *et al.*[16] After immersion for 10 min in, different denture cleansers specimens were stored in distilled water to prevent them from effect of drying.

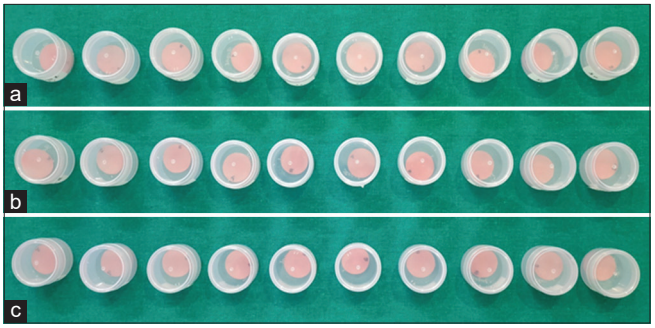

Figure 4: Specimens immersed in different denture cleansers. (a) Group I – Specimens immersed in thyme oil, (b) Group II – Specimens immersed in thyme oil, (c) GROUP III – Specimens immersed in thyme oil

Table 1: Summary table of mean change in colour, surface roughness and Shore D surface hardness of all groups after immersing in different denture cleansers

Group	Change in color (▲E) (Mean ±S.D)	Change in surface roughness(μm) (Mean ±S.D)	Change in surface hardness (Mean ±S.D)
I	2.0310±.43041	0.057±0.037	0.574±0.622[a]
II	1.8380±.70267	0.049±0.038	0.529±1.021[b]
III	1.9250±.49887	0.079±0.0538	-0.926±0.755[b]

Values with different lowercase superscript are statistically significant

After removing the specimen from different denture cleansers after a total of 180 cycles of immersion, the samples were cleaned with distilled water and wiped with dry clean cloth and air dried at room temperature. The surface to be examined was ensured by careful cleaning of each test specimen before the experiment. This technique of cleaning the test specimens was similar to study of Frederico Silva de Freitas Fernandes *et al.*[17] who used distilled water for 10 min to clean specimens. Color, surface roughness, and surface hardness were measured for each specimen before and after immersing procedure.[18]

CIELAB color system [Figure 3], most widely recognized order system, was developed in 1978. It is a uniform three-dimensional system that arranges the three dimensions of color at almost equal intervals and determines color changes.[19] The surface roughness (Ra μm) measurement was done with the help of contact profilometer with a

diamond stylus (tip radius of 2μm). Contact profilometer was used in this study to measure change in surface roughness, because the stylus is in continuous contact with the surface and this method is not sensitive to surface reflectance or color unlike used in optical profilometer. The surface hardness measurement was done with help of Shore D Durometer using 50-gf load for 30 s.

The result of the present study exhibited change in color, surface roughness and shore D surface hardness of all specimens of PEEK denture base material immersed in all the denture cleansers evaluated. In this study, specimen of PEEK color change NBS range is range of 0 to 2 so it is considered as a perceivable by human eye but clinically acceptable. The measured values for surface roughness all test specimens after immersion in different denture cleansers were within acceptable limits of change. (0.15 to 2.0 μm).

The change in color, surface roughness, shore D surface hardness can be attributed to their composition and the solution in which they were immersed. PEEK generates active radicals on its surface under heat and ultraviolet irradiation. The radical species subsequently induce functional monomer(such as vinyl monomer) polymerization, resulting in a functional group decorated PEEK surface. The changes of surface properties of the PEEK specimens can be attributed to the combination of monomers with free radicals species via oxygen bonding. However, because it exhibits a crystalline as well as an amorphous structure (which means strength and increased durability), the decrease was not statistically significant. Furthermore, the material has a slow rate of crystallization, so it is resistant to the effects of corrosive materials.[20]

The two main components of thyme oil showing antimicrobial properties are thymol(2-isopropyl-5-methylphenol) and carvacrol (5-isopropyl-2 methyl phenol). Thyme essential oil was c as the plant extract denture cleanser acts as antifungal and antimicrobial with least minimum inhibitory concentration (MIC) values. Sodium perborate denture cleansers act by releasing oxygen which has a high dissolving effect on plasticizers and loosen debris through mechanical means. Mode of action of ozone is attributed to lethal oxidation of bacterial protoplasm, membrane oxidation followed by lysis, cell electron transfer, or capture thus irreversibly altering the buffering mechanism and membrane alteration.

CONCLUSION

PEEK is a supreme material and has become extremely widespread in dental field. This suggests its wide application in fabrication of FDP and CPD framework, in implantology for fabrication of implant abutments, implant supported prosthesis framework, etc. PEEK specimens exhibited changes in color, surface roughness, and surface hardness when immersed in different denture cleansers (sodium perborate, thyme oil, and ozonated water). The change in color, surface roughness, and surface hardness of PEEK after immersion in denture cleansers was well within clinically acceptable limits. Sodium perborate, thyme oil, and ozonated water can be used as denture cleansers with PEEK denture base material. It is necessary on the part of the dental professional, to ensure that the denture wearing population knows how to select and use the appropriate denture cleanser so as to improve denture home care protocol.

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