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Research Article

EVALUATION OF POLISHED AND UNPOLISHED ACETAL RESIN CLASP COLOR WITH DIFFERENT BEVERAGES (IN VITRO STUDY)

Shereen M Sadek., Fatma A El-Waseef., Dalia M Hana and Nesreen El Mekawy

Faculty of Dentistry, Mansoura University, Mansoura, Egypt

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A B S T R A C T

Background: Clasp materials play a critical role in overall aesthetic outcomes of removable partial dentures. The long-term maintenance of these outcomes depends on color stability of these materials. Staining of prosthodontics materials may result in patient dissatisfaction and additional expense for replacement.

Purpose: The purpose of this in vitro study was to evaluate the effect of various commonly consumed beverages on the color stability of Acetal resin clasps when being polished or left non-polished.

Materials and methods: A normative class IV Kennedy partially edentulous maxillary heat cure acrylic resin model was chosen, duplicated to obtain the stone master casts .10 Acetal resin RPDs were constructed and finished. A mechanical polishing was performed for the ten left clasps of Acetal resin RPDs while leaving the right ones to be non-polished. Before immersion, Acetal resin RPDs we reanalyzed for color characteristics against a gray background with A3 using a spectrophotometer. They were immersed infour beverages media (tea, coffee, cola, and orange juice).The Specimens were removed at 1, 7, and 28 days respectively, desiccated, and analyzed by the spectrophotometer.

Results: The results reported statistically significant differences between polished and non-polished clasps for both tea and orange juice solutions (0.03* and 0.006* respectively).
With respect to **(L)** parameter (lightness), higher mean values were revealed for non-polished Acetal resin clasps when being immersed in tea and orange juice solutions (71.1±2 2.7 and 72.5 ±1.28 respectively).Whilst this significant difference is also for coffee solutions only (P=0.004*) concerning **(A)** parameter (red/ green value).No significant difference was revealed for **(B)** parameter (yellow/ blue value) and **(W)** (whiteness) when immersing Acetal clasps (polished and non -polished) in all solutions under investigation.

Conclusion: Color changes were exhibited by non-polished clasps specimens immersed intea, coffeeand orange juice solutions. Polishing procedures significantly improve the color stability of Acetal resins clasps when being immersed incommonly consumed beverages.

INTRODUCTION

Admittedly, the elderly population continues to increase with a surprising rate during the last decades. This includes increasing in partially dentate patients who require prosthetic rehabilitation.[1,2] Although implants and conventional fixed partial dentures (FPDs) have certain advantages ,removable partial dentures RPDs remain the primary most common treatment modality. [1] Patently, RPDs effectively ameliorate oral-health-related quality of life (OHRQoL), eventually, improve oral function in patients with partially edentulous arches. [3.4] The need for removable dental prostheses RDPs is increasing also, hence, RDPs are expected to serve more long. [5]

Corresponding author:* **Nesreen El Mekawy
Faculty of Dentistry, Mansoura University, Mansoura, Egypt

Various metal alloys and polymer materials were currently used in the fabrication of partial and complete removable dentures. Nevertheless, the requirements of an ideal removable prosthesis material were not fulfilled yet. [6] The most common conventional metal alloys used for RDPs construction are cobalt-chromium (Co-Cr) alloys. At the same time, RPD clasps were made from the same metal alloy. [7] There upon, the major disadvantage uttered by the patients "perspective" is the appearance of metal clasps in esthetic zones. Nowadays, in modern dentistry, to achieve better patient satisfaction, aesthetic is a crucial factor of the treatment options.

Therefore, this consideration is momentous in RPD treatment as well. [3.8]

Because the major problem of RPDs is the display of the metal clasp assemblies, so, esthetic (RDPs) are deemed the most and best compatible treatment modality for those patients restoring their missed teeth with superior esthetics demands. [9]

Thermoplastic resin RPDs (TR-RPDs) are also known as flexible dentures, non-clasp dentures, clasp-free dentures, and metal-free dentures. [10]They are increasingly utilized as a new alternative to traditional metal clasp-retained RPDs to restore partially dentate arches aesthetically.[11,12]Flexible RDPs provide durability, superior aesthetics,[11] improve patient comfort due to low elastic modulus and softer surface,[13 - 18]and require less expense and time for fabrication. [11]

Polyoxymethylene (POM) is known as Acetal resin, that has good short-term mechanical properties, and it is quite flexible. This material was primarily confirmed to be utilized on the basis of their better esthetics, which allowed the clasps to simulate the abutment tooth color. [19] Furthermore, It has a sufficiently high resilience, and shows a low coefficient of friction and modulus of elasticity, thus it allows its use in the fabrication of retentive clasps, supporting elements and connectors for RPDs.[20]Additionally, it has no or little porosity which eliminates accumulation of the biological materials like plaque, consequently, leads to resist discoloration and stains. These characteristics make it an ideal material for RPDs clasps fabrication. [21]Patients diet and lifestyle are considered as extrinsic pigments causing color changes of Acetal resin.[22]Arikan *et al*. [23] reported that the water sorption and solubility of pink and white Acetal resins were relatively small and within ISO specification limits.

Polishing of prosthetic appliances may be performed chemically or mechanically. Products used in mechanical polishing have different abrasiveness levels that result in surface controlled wear and remove general gross irregularities. [24] Mechanical polishing is more efficient in surface roughness improvement, water sorption reduction and solubility elimination of the acrylic resin. [25-28]

Color measurement devices were used to detect small color changes in the dental field.

Spectrophotometers usually measure color using the CIE L* a* b* system recommended by the International Commission of Illumination. [29] Several reports investigated the color changes of the esthetics clasps constructed from Acetal resin due to the consumption of common daily beverage. To our knowledge, no study has yet evaluated the impact of different beverages on polished and unpolished Acetal resin clasp color.

MATERIAL AND METHODS

Fig 1 stone cast

This is in vitro study accomplished on a normative partially edentulous maxillary heat cure acrylic resin (Vertex-Acrylic resin-Holland) model, representing class IV Kennedy classification with all incisor teeth missing.

To obtain the stone master casts on which the Acetal resin RPDs were constructed, acrylic resin model was duplicated in a special flask and then poured with type II dental stone (Fig 1).

The master casts were surveyed (Tjdent- Williams Surveyor-China), all sensitive areas were relieved by adding 0.1 mm layer of blue inlay wax in accordance to Fenn *et al*. [30]

The design of class IV RPDs was drawn on the stone master cast using black pencil. RPD design was extended anteriorly at labial soft tissue undercut area where labial flange was placed and extended laterally to mesial surfaces of the canines on each side. Clasps would encircle the abutment buccally utilizing the proximal undercut areas. The denture extended posteriorly at the slope of the hard palate till the posterior end of the rugae area.

Partial Denture Construction

Ten waxed frameworks were designed over the duplicated casts. Prefabricated sprues were made by modeling wax. The waxed frameworks were invested in a special flask designed for injection-molding technique (fig 2).

Fig 2 waxed frameworks were invested in a special flask

Dewaxing was carried out. A thin coat of a separating agent; (acrylic sep-plaster separating liquid bred entry. Germany) was applied to the model and allowed to dry completely. A cartridge of suitable size was selected, placed in electric cartridge furnace for softening of Acetal resin material (Biocetal-thermoplastic acetal-Roko-poland)at 250C, for 15 to 20 minutes. This was performed by utilizing Digital Molding Machine (Multipress-digital molding machine-Roko-Poland) (Fig 3.).[31]

Fig 3 Digital Molding Machine

with a special knife or disk. Finishing was done with vulcanite

burs and mounted stones. [32] The finished frameworks were adapted to the master casts, waxing up was made and the anterior teeth were arranged. No need for the retention holes because the artificial teeth would bond to the denture base chemically. Priming the apical surface of artificial teeth with monomer was performed to increase the chemical retention.

Flasking, wax elimination, mixing of heat cure acrylic resin (Vertex-Acrylic resin-Holland), packing, curing, deflasking, all were carried out. Finishing was done by removal of excess acrylic resin from the processed denture using stone wheel burs, stone burs, and steel burs. Care must be taken not to heat the denture during grinding as recommend by Nougueira *et al*[33]

Polishing Procedure (Fig 4)

A mechanical polishing was performed for the ten left clasps of Acetal resin RPDs. This was done using aluminum oxide past (0.2 g for each clasp) (Universal polishing; Ivoclar vivadent sao paulo, Brazil) in conjunction with a felt polishing wheel (Shfu innc, Kyoto-Japan) attached to an electric motor at a speed of 3000rp for 5 seconds for each clasp.[34]

Fig 4 Polishing Procedure

Immersion Media

Four immersion beverages media (tea solution, coffee solution, cola, and orange juice) were used in this study as following: tea solution (Lipton Yellow label Tea, Unilever Mashreq-Tea company, Egypt) was prepared by immersion teabags ($^{4\ g}$) into 100ml of boiled water; while, coffee solution was prepared by adding 4g of coffee (Nescafe classic, Nestle Egypt) into 20ml boiled water. Both solutions were stirred every 30 min for 10sec until they cooled down to room temperature and then filtered through a filter paper. 20ml of cola (coca-cola., Egypt) and orange juice (Juhayna orange, Egypt) taken from newly cans stored at room temperature and put each solution in its container.

Specimens Preparation and Evaluation

Each retentive tip of the ten clasps of Acetal resin RPDs was cut using Steel bur and Diamond disc. The dimension of the cut part of the clasp was 2mm x 2mm, (nearly circular in shape), to facilitate the measurements by Ultrascan pro spectrophotometer (Spectrophotometer, Hunter lab ultra-scan pro-USA) before immersion procedure. Specimens were immersed in the corresponding immersion medium in an incubator at37C. Specimens were removed at 1, 7, and 28 days, desiccated, and analyzed for color characteristics against agray background with A3 using a spectrophotometer. Alloperations were completed by a single investigator using the CIE1976 (L*a*b*) color space system. The L*, a*, b*values of each specimen were recorded. [35]

Statistical analysis and data interpretation

Data were fed to the computer and analyzed using IBM SPSS software package version 22. Qualitative data were described using number and percent. Quantitative data were described using median (minimum and maximum) for non-parametric data and mean, standard deviation for parametric data after testing normality using Shapiro-Wilk test. Significance of the obtained results was judged at the (0.05) level, Student t-test was used to compare between the data.

RESULTS

Table 1 Comparisons between polished clasps (left side) and non-polished clasps (right side) of Acetal resin RPDs

Acetal		Tea solution	Cola solution	Coffee solution	Orange Juice
Polished	L	61.94±4.43	64.91±2.32	72.37±0.56	66.17±1.66
Unpolished	L	71.12±2.7	66.45±10.23	68.45±5.39	72.52±1.28
Test of Significance		**t=3.07 p=0.03***	**t=0.25 p=0.81**	**t=1.33 p=0.25**	**t=5.3 p=0.006***
Polished	A	0.95 (0.80, 0.95)	1.01 (0.69 , 1.02)	1.05 (0.85-1.14)	0.90 (0.89 , 1.14)
Unpolished	A	0.83 (0.79 , 1.95)	1.24 (1.02 , 1.26)	1.47 (1.47, 1.52)	1.6 (1.14 , 1.71)
Test of Significance		**z=0.22 p=0.83**	**z=1.8 p=0.08**	**z=1.99 p=0.04***	**z=1.77 p=0.07**
Polished	B	15.16 (13.9-16.35)	14.95 (14.75 , 15.45)	16.24 (14.95 , 16.52)	15.82 (14.12 , 15.95)
Unpolished	B	16.51 (15.88 , 17.88)	19.8 (16.63 , 23.61)	16.98 (15.05, 20.21)	18.82 (15.62, 20.17)
test of significance		**z=1.53 p=0.13**	**z=1.96 p=0.05**	**z=1.1 p=0.28**	**z=1.1 p=0.28**
Polished	W	-47.61 (-53.0 , -40.21)	-42.01 (-46.67 , -41.8)	45.1 (-55.9 , 45.9)	-37.66 (-42.3 , -34.87)
Unpolished	W	-49.3 (-68.01 ,-44.49)	-53.88 (-67.13, -47.0)	-54.1 (-61.22 , -50.25)	-45.3 (-50.86 , -41.82)
test of significance		**z=0.66 p=0.51**	**z=1.96 p=0.05**	**z=1.09 p=0.28**	**z=1.53 p=0.13**

Table (1) revealed comparisons between polished clasps (left side) and non-polished clasps (right side) of Acetal resin RPDs with regard to color change upon immersion in different solutions. With respect to (**L)** parameter (lightness), the results elaborated statistically significant differences between polished and non-polished clasps for both tea and orange juice solutions (0.03* and 0.006* respectively).

It's noteworthy that higher mean values were reported for non-polished Acetal resin clasps when being immersed in tea and orange juice solutions (71.1±2 2.7 and 72.5 ±1.28 respectively).Whilst this significant difference is also for coffee solutions only (P=0.004*) concerning (**A)** parameter (red/ green value).Where, no significant difference was revealed for (**B)** parameter (yellow/ blue value) and (**W)** (whiteness) when immersing Acetal clasps (polished and non - polished) in all solutions under investigation.

DISCUSSION

Thermoplastic resins have been used in dentistry for over 50 years. During that time, the applications have continued to grow, and the interest in these materials of both the profession

and the public has increased. The materials have superior properties, characteristics and provide excellent aesthetic and bio-compatible treatment options.[11, 12]Therefore, flexible dentures fabricated from thermoplastic resin have been utilized as an alternative method of treatment to overcome the undesirable metal exposure.[36]

Color changes include; dehydration, stain accumulation, material components leakage, abrasion or roughness of the material surface and/or chemical modification. However, acrylic resins denture bases show color stability in air or water. Not with standing, loss of color stability is caused by immersion in beverages like coffee. [22] Coffee and Tea have yellow colorants (tannic acid) that differ in its polarities. Nonetheless, the tea constituents have high polarity so it released first, followed by; coffee constituents with lower polarity. The discoloration caused by tea is due to the adsorption of these highly polar colorants onto the material surface.[23]

Yet the higher color change occurred in unpolished thermoplastic acetal resin clasps than the polished acetal when immersed in tea, coffee and orange juice. The stain ability of polymers by coffee has been attributed to the presence of yellow colorants with different polarities. Tannic acid has been proved especially responsible for the staining of this beverage. Other influential factors of coffee staining are the addition of sugar and the processing method, such as filtering. This suggested explanation is in agreement with Sona *et al*. [37]

It has been proclaimed that coffee staining was caused by colorants adsorption and absorption, the compatibility of polymer phase and the coffee yellow colorants may be the reasons. In addition, water molecules of beverage may be absorbed by the as an aqueous solution, This is concurred with the reports of Sepúlveda-Navarro *et al*. [38]

Up to present, a little information is available in the literature regarding the orange juice and its ability of staining. The acidity of orange juice (PH) ranges between 2.8 and 4.19. Orange juice has high sugar content that contributes to dental erosion when consumed on regular basis. Based on these studies, we might correlate our results concerning color stability of Acetal when immersed in orange juice with its vitamin C content. Generally, staining of resins by fluid pigments or beverages is caused by adsorption or absorption of colorants. However; the chemical composition of orange juice could be a contributing factor. Acidic nature of ascorbic acid may cause an erosive effect on the surface of Acetal resin that leading to adsorption of the orange juicepigment. Furthermore, the sugar content of the orange juice could facilitate the adhesive forces between the Acetal resins and the orange juice. This result is in-agreement with Abdel-Hamid and, El-sharkawy. [39]

One possible explanation of color change with respect to Acetal is related to surface roughness. It is worth mentioning that polishing process improved the surface roughness of denture base materials including Acetal. Hence, the study declared obvious better results relevant to color change in polished-clasps group compared to non-polished group. These observations appear to be in agreement withEl-Din *et al*.[40]**.** Aprevious study conducted by El mekkawy *et al*.[41]has confirmed the same results.

In this issue, the increased color differences possible reasons may be due to the ability of polymer to fluid sorption. This could be explained by the susceptibility of the Acetal resin to water sorption, with its subsequent hydrolytic effect that might alter the original color of the tested materials. [23]

CONCLUSION

Within the limitation of this study, it can be concluded that:

Acetal resin exhibited high color changes. The color changes of Acetal resin constantly increased with the immersion time. Polishing procedures essentially improve the color stability of Acetal resins clasps when being immersed in commonly consumed beverages.

Recommendation

More clinical short term and long term studies are thus required to validate the results of this in vitro study.

Competing interests

The authors report no conflicts of interest related to this study.

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