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Different Materials Used as Denture Retainers and Their Colour Stability

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Abstract

BACKGROUND: Retainers are of great importance for the longevity of the prosthetic removable partial denture during various functions especially the esthetic one. The key of successful clasp selection is to select a direct retainer that will control tipping and torquing forces on the abutment teeth, provide retention against reasonable dislodging forces and are compatible with both tooth and tissue contour together with the aesthetic desire of the patient.

AIM: This study aims to compare different clasp material to enhance the choice of the clasp based on the aesthetic point of view.

METHODS: The colour evaluation of the tested materials had been evaluated by computer aided technique with digital camera with 3 Mega Pixels of resolution.

RESULTS: In the current research, the technique of colour evaluation was carried out to compare different clasp materials to enhance the choice of the clasp based on the aesthetic point of view. Most commonly, Removable Partial Denture (RPD) retainers are fabricated identically from the metal framework's alloy as Cobalt Chromium (CoCr) alloy although it is unaesthetic. This esthetic problem has been overcome by other methods and by utilising different materials, these included covering the retainers with tooth-coloured acrylic resin, as well as the introduction of esthetic materials as; Thermoplastic Acetal, Versacryl, and Thermopress.

CONCLUSION: It has been concluded that the non-metallic Acetal resin clasp shows superior physical properties regarding colour stability.

Introduction

The most important calibre of esthetics is colour. Usually, denture base gets contaminated with various materials intraorally. The acrylic resin denture base material is highly potential to soak up distinct contaminants. Moreover, it is subjected to sorption, the practicability of both absorption and adsorption of liquids relying on the ecological circumstances then leading to possible discolouration, so colour stability is one of the most important factors in denture base materials selection [4].

The esthetic dental restorations play a great role in recent communities not only for females but also for males, due to the emphasis of physical look. Dental implant succeeded in expanding such scope, yet it is not highly recommended for the tremendous scale of patients, especially those who are suffering from some medical, psychological and financial problems [5].

Esthetic removable partial dentures (RPDs) are considered as the best and most compatible preference remedy for these subjects in replacing their lost teeth with superior esthetics. One of the major problems of RPDs was the display of the clasp assemblies. Etching the retainer's arm and overlaying it with a tooth-coloured resin coat is one of many recent ways employed to solve this issue. Moreover, as the physical appearance of these esthetic retainers is of vital essentiality, yet their mechanical properties play a great role in their success and intraoral utilisation [6].

The difficulty in using of acrylic resins or resin composite to veneers on metals of RPD appears in the diversities between both their potentiality to inflect and coefficients of thermal expansion. Non-noble metals possess durability and resist remarkable flection. However, extreme disfigurement takes place to resins concerning both their physical and thermal status, as the matrix becomes fragile beyond its elastic borders. The resin composite matrix also tends to be brittle beyond its elastic limit. As a sequel, the capacities of both metals and resins for plastic disfigurement are in a broad conflict. Latest concerns extend to the impact of the intraoral masticatory strength together with both the adjustability and extra magnitude of the veneered retainers formed by the assembling of the covering matter. Exaggerated declining in the retainer's length and thickness should be averted to secure the stiffness and shorten the fracture of the retainer as well as provide maximum esthetics [7].

The rotational path RPD is a simple method that abolishes the utilisation of the intraoral esthetically unpleasant retainers anteriorly. It employs an anterior immobile part of the framework and an ordinary pliable posterior retentive retainer as the retentive components. Retainers' least utilisation, the superiority of esthetics and minimal accumulation of plaque are the main merits of such design. However, both clinical and laboratory procedures in demand for the rotational path RPD are skillfully precise [8] [9] 10].

Lingual retention provides an equivalent magnitude of invisible retention as that situated on the buccal surface. Such retention is achieved by substituting the bracing arm with parallel guide standard surfaces and accurately designed rests both with the retentive element placed lingually [11]. Denture clasps constructed from both a substance matching the tooth shade and thermoplastic resin have been utilised on a wide scale to both enhance the resemblance in metallic retainers' structures and support esthetics [12] [13] [14].

Polyoxymethylene (POM) which is well known as Acetal resin, an injection-moulded resin also acts as a standby to the classical PolyMethylMethAcrylate (PMMA). Fabrication of POM takes place by the polymerisation of formaldehyde. The homopolymer polyoxymethylene is a series of alternating methyl sets united by an oxygen whit. Besides that, it behaves elastically on a wide scale which allows it to be utilised as the suitable material for retainer construction. This is due to its superior proportional limit with the minimal viscous flow [12].

POM has been consumed globally in dentistry as an offset for both PMMA and metals in tremendous of prosthetic employments since two decades ago. The most commonly effective appliances were the esthetic clasps of RPD [14] [15] [16], cast posts and cores as well as brackets [17].

An attempt to perform aesthetic removable partial denture is the usage of Valplast as a retentive clasp for esthetic reasons since it belongs to Nylon family. They are thin and light in weight, resistant to fracture and esthetically good due to their pink and translucent shade which matches that of natural dentition and gingiva. Its indications extend to the cosmetic improvement of teeth that appear elongated due to gum recession and for acrylic resin's allergic patients [18]. Moreover, thermoplastic resin injection materials (Thermopress) are characterised by being easily manipulated and providing esthetically acceptable results [19].

Colour values can be measured by visual methods of specifying colour (subjective method) or by the aid of instruments (objective method). Besides that, Color is a sensation captured by our eyes in three dimensions; three terms were needed to explain colour measurements [20]. Hue recognises each colour from another, while Lightness (Value) distinguishes light colours from dark ones and Chroma describes how different colour is from grey [21].

This study aims to compare different clasp material to enhance the choice of the clasp based on the esthetic point of view.

Material and Methods

An ideal model of the maxillary partially edentulous case (Kennedy class III) usually utilised for educational purposes was selected as a master model replicating the anatomical features of the teeth.

Duplication of the model was carried out to fabricate a stone cast with both the maxillary premolar and molar into wax and ready to be to be surveyed before casting the wax into metal. Surveying was essential to provide mesially (8 mm) and lingual guide planes (6 mm) to create a (0.25 mm) undercut area on the distobuccal surface and prepare an occlusal rest seat (2 mm) deep on the mesiocclusal surface for the molar tooth. Moreover, on the distobuccal surface, both distal (8 mm) and lingual guide planes (6 mm) were fabricated as well as, (0.25 mm) undercut area on the mesiobuccal surface and an occlusal rest seat (2 mm) deep (Figure 1).

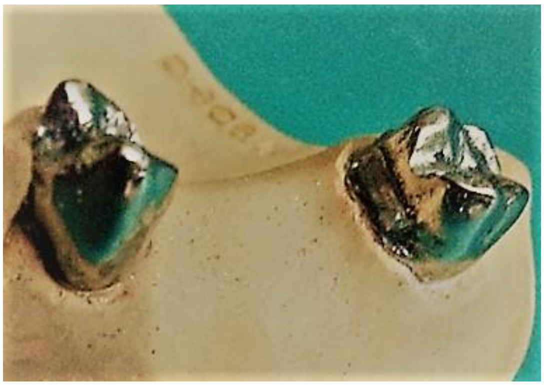

Figure 1: Surveyed metal teeth models

The specimens included five premolar clasps with (0.25 mm) undercut, and five molar clasps with (0.50 mm) undercut.

The five different clasps used for each abutment tooth were fabricated from Cobalt Chromium (CoCr) metal (Vitllium; Cobalt Chrome alloy): Cobalt 64%, Chromium 28%, Molybdenum 5.5%. Type 1-ADA, Spec. No. 14 From (Dentorium Co., U.S.A.), Versacryl (Keystone Industries GmbH, Sigen, Germany), Valplast (Valplast Denture Acrylic Resin for Flexible Dentures, IRIS, Tianjin IRIS Int. Trade Co. Ltd., Industrial district, Tianjin, China), Acetal resin (Acetal Copolymer, Flexible Acrylic Dental Clasps, Korea Engineering Plastics Co. Ltd., KEPITAL Europe GmbH, Wiesbaden, Germany) and Thermopress (Thermopress, Thermopress 400, Bredent): From (Gmbh & Co.KG, Germany). Each type of these clasps was fabricated as recommended by the manufacturer attaching to them a wax plate (4 × 7 × 3 mm) which was attached to the minor connector parallel to the path of insertion. The plate was utilised later for maintaining the clasp in the testing machine (Figure 2).

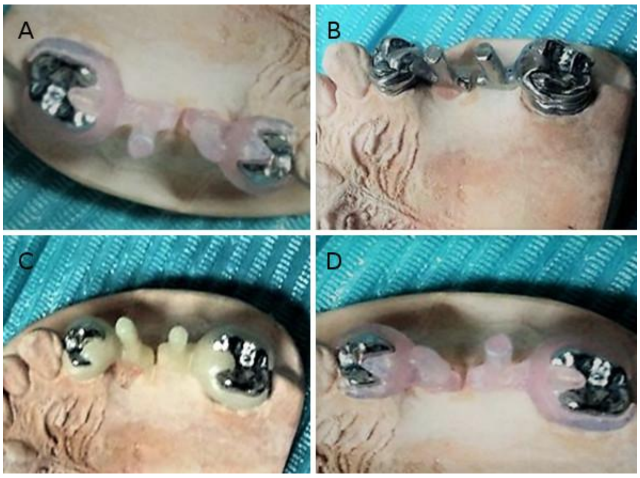

Figure 2: The Specimens; A) Acetal Clasps; B) Metal Clasps; C) Thermopress Clasps; D) Versacryl Clasps

Images Used in The Current Study Were Taken with The Following Image Acquisition System:

1) Computer-aided technique which was a combination of a digital camera (*Scope Capture Digital Microscope, Guangdong Co. Ltd., China.*) and image processing software (*Image J 1.43U, National Institute of Health, USA*) was the method used to register the color of any pixel of the specimen's image using three color sensors per pixel.

2) Digital camera with 3 Mega Pixels of the resolution was utilised to evaluate the colour. This camera was placed vertically at a distance of (2.5 cm) from the samples. The angle between the axis of the lens and the sources of illumination is approximately 45º.

3) Illumination was achieved with 8 LED lamps (*Adjustable by Control Wheel*) with a colour index (Ra) close to 95%.

4) The images were taken at maximum resolution (2272 × 1704 pixels) and connected with an IBM compatible personal computer consuming a fixed magnification of 90X. The images were recorded with a resolution of 1280 × 1024 pixels/image. Digital microscope images were cropped to 350 × 400 pixels utilising Microsoft office picture manager to specify/ standardise area of colour measurement.

5) To calibrate the digital colour system, the colour values of the 32 colour charts were measured.

6) Once the system was calibrated, it was possible to infer the Lab Color Space (Lab) values by the Red (R), Green (G) or Blue (B) (RGB) measurements from the camera without utilising the colourimeter along with image processing software (Figure 3).

Specification:

Image sensor	1.3 Mega Pixels
Still capture resolution	1600x1200 (2M), 1280x1024(1.3M), 1024x960, 1024x768, 800x600, 640x480, 352x288, 320x240, 160x120
Video capture resolution	1600x1200 (2M), 1280x1024(1.3M), 1024x960, 1024x768, 800x600, 640x480, 352x288, 320x240, 160x120
Focus Range	Manual focus from 10mm to 500mm
Frame Rate	Max 30f/s under 600 Lus Brightness
Magnification Ratio	20x to 200x
Video format	AVI
Photo format	JPEG or BMP
Light source	8 LED (adjustable by control wheel)
PC interface	USB2.0
Power source	5V DC from USB port
Operation system	Windows2000 SP4/XP/Vista/Win7, Mac OS X 10.5 or above
OSD language	English, German, Spanish, Korean, French, Russian
Bundle software	MicroCapture
Size	110mm (L) x 33mm (R)

Figure 3: Scope Capture Digital Microscope

A total number of 10 specimens were used in this research and divided into two different groups; 5 specimens in each group.

The First Group (Coffee)

Specimens of this group were 5 in number, and all were stored in Coffee solution. This solution was prepared by pouring (20 g) of coffee (*Nescafe*

Classic, Nestle, Egypt) into (1000 ml) of boiled water. Then the solution was stirred every (30 min.) for (10 sec.) until it cooled down till room temperature. Proper filtration of the Coffee mix was carried out later on through a filter paper. The specimens were immersed into (20 ml) of each immersion media and kept in the incubator (*PSA, Advanced technology, Cairo, Egypt.*). The solution was freshened once every 3 days to reduce the precipitation of particles in the staining solutions, and the solutions were stirred once a day [22].

The Second Group (Distilled Water)

This group included 5 specimens that were stored in Distilled Water.

Colour Evaluation

1. Colour measurement of each specimen (T0) was performed employing computational technique with a combination of a digital camera and image processing software.

2. The specimens were placed in containers as mentioned above. Subsequent colour measurements were Taken After 4 Weeks of Immersion (Tfim). All the specimens were kept in the incubator during measurements at 37 °C.

3. The mean of colour change for each material was calculated with the aid of C.I.E. *L a b* uniform colour scale. The magnitude of the total colour difference is formulated by Δ*E*.

4.

$$\Delta E_{CIELAB} = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2}$$

Δ*E* the magnitude of total colour difference.

Δ *L* is the luminance or lightness component that ranges from (0 to 100).

Δ *a* is a chromatic component acting as parameter and ranges from (green to red).

Δ *b* is a chromatic component acting as parameter and ranges from (blue to yellow).

Δ *a and* Δ *b* both range from (-120 to 120).

Data were presented as the mean and standard deviation (SD) and explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Colour Parameters revealed a parametric distribution, so One-Way ANOVA was utilised to study the difference between tested materials on mean Color Parameters followed by Tokay's posthoc test for pairwise comparison when ANOAV is significant. Dependent t-test was utilized to compare between different tested solutions for each material.

The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA.) Statistics Version 23 for Windows.

Results

Difference between the mean of the luminance or lightness component (ΔL) of different tested materials in both Coffee and Distilled Water groups

Mean, and standard deviation (SD) for the luminance or lightness component (ΔL) for different tested materials were presented in Table 1.

Versacryl (-2.63 ± 1.33) displayed the highest mean of the luminance or lightness component (ΔL) followed by Acetal resin (-4.52 ± 0.25) and Valaplast (-5.2 ± 0.75) then followed by Thermopress (-7.09 ± 0.23) at p ≤ 0.001 for Coffee.

Versacryl (4.03 ± 0.31), Thermopress (3.66 ± 0.44) and Valaplast (4.07 ± 0.24) revealed the highest mean of the luminance or lightness component (ΔL) compared to Acetal resin (1.68 ± 0.31) at p ≤ 0.001 for Distilled Water.

Table 1: Mean and standard deviation (SD) of the luminance or lightness component (ΔL) for different tested materials in first and second groups

		Material								
	Groups	Acetal resin		Thermopress		Versacryl		Valaplast		p-value
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
ΔL	Coffee	-4.52[b]	.25	-7.09[c]	.23	-2.63[a]	1.33	-5.20[b]	.75	≤0.001*
	Distilled Water	1.68[b]	.31	3.66[a]	.44	4.03[a]	.31	4.07[a]	.24	≤0.001*
	p-value	≤0.001*		≤0.001*		≤0.001*		≤0.001*		

Means with the same letter within each row are not significantly different at p = 0.05. * = Significant, NS=Non-significant.

Difference between the mean of the chromatic component (Δa) that ranges from (green to red) of different tested materials in both Coffee and Distilled Water groups

Mean, and standard deviation (SD) for the chromatic component (Δa) for different tested materials were presented in Table 2.

Versacryl (1.69 ± 0.51) showed the highest mean of the chromatic component (Δa) followed by Acetal (0.64 ± 0.34) followed by Thermopress (0.08 ± 0.34) and then Valaplast (-3.2 ± 0.34) at p ≤ 0.001 for Coffee.

Versacryl (0.12 ± 0.21) and Acetal resin (0.06 ± 0.26) displayed the highest mean of the chromatic component (Δa) compared to Valaplast (-2.79 ± 0.32) and Thermopress (-3.79 ± 0.39) at p ≤ 0.001 for Distilled Water.

Table 2: Mean and standard deviation (SD) of the chromatic component (∆a) for different tested materials in first and second groups

	Groups	Material								p-value
		Acetal resin		Thermopress		Versacryl		Valaplast		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
∆a	Coffee	.64^{b}	.34	.08^{c}	.34	1.69^{a}	.51	-3.20^{d}	.34	≤0.001*
	Distilled Water	.06^{a}	.26	-3.79^{c}	.39	.12^{a}	.21	-2.79^{d}	.32	≤0.001*
	p-value	0.01*		≤0.001*		≤0.001*		0.086 NS		

Means with the same letter within each row are not significantly different at p = 0.05. * = Significant, NS = Non-significant

Difference between the mean of the chromatic component (∆b) that ranges from (blue to yellow) of different tested materials in both Coffee and Distilled Water groups

Mean, and standard deviation (SD) for the chromatic component (∆b) for different tested materials were presented in Table 3.

Versacryl (3.82 ± 0.54) and Valapalst (4.25 ± 0.53) displayed the highest mean for the chromatic component (∆b) followed by Acetal resin (0.252 ± 0.23) and then Thermopress (-1.812 ± 0.315) at p ≤ 0.001 for coffee.

Valaplast (1.93 ± 0.50) and Acetal resin (1.86 ± 0.19) showed the highest mean for the chromatic component (∆b) compared to Versacryl (-3.42 ± 0.60) and Thermopress (-3.23 ± 0.189) at p ≤ 0.001 for Distilled Water.

Table 3: Mean and standard deviation (SD) of the chromatic component (∆b) for different tested materials in first and second groups

	Groups	Material								p-value
		Acetal resin		Thermopress		Versacryl		Valaplast		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
∆b	Coffee	.2520^{b}	.2336	-1.8120^{c}	.3148	3.8200^{a}	.5445	4.2520^{a}	.5315	≤0.001*
	Distilled Water	1.8633^{a}	.1935	-3.2320^{b}	.1891	-3.4260^{b}	.6070	1.9320^{a}	.5073	≤0.001*
p-value		≤0.001*		≤0.001*		≤0.001*		≤0.001*		

Means with the same letter within each row are not significantly different at p = 0.05. * = Significant, NS = Non-significant.

Difference between the mean of the magnitude of the total colour difference (∆E) of different tested materials in both Coffee and Distilled Water groups

Mean, and standard deviation (SD) for the magnitude of the total colour difference (∆E) for different tested materials were presented in Table 4.

Thermopress (7.33 ± 0.209) and Valaplast (7.45 ± 0.89) revealed the highest mean for the magnitude of the total colour difference (∆E) accompanied by Acetal resin (4.588 ± 0.227) and Versacryl (5.10±0.368) at p≤0.001 for Coffee.

Thermopress (6.19 ± 0.42) displayed the highest mean for the magnitude of the total colour difference (∆E) followed by Versacryl (5.32 ± 0.34) and Valaplast (5.324 ± 0.28) followed by Acetal resin (2.52 ± 0.29) at p ≤ 0.001 for Distilled Water.

Table 4: Mean and standard deviation (SD) of the total colour difference (∆E) for different tested materials in first and second groups

	Groups	Material								p-value
		Acetal resin		Thermopress		Versacryl		Valaplast		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
∆E	Coffee	4.5880^{b}	.2270	7.3360^{a}	.2096	5.1080^{b}	.3685	7.4540^{a}	.8917	≤0.001*
	Distilled Water	2.5233^{c}	.2943	6.1960^{a}	.4211	5.3200^{b}	.3496	5.3240^{b}	.2813	≤0.001*
p-value		≤0.001*		0.001*		0.386 NS		0.001*		

Means with the same letter within each row are not significantly different at p = 0.05. * = Significant, NS=Non-significant.

Discussion

Colour evaluation techniques provide valuable information regarding the physical properties of the materials tested. However, none of the in-vitro techniques can expose the tested materials to conditions similar to that of the oral environment (in-vivo) such as pH value and temperature variations [2].

Recently, thermoplastic polymers are widely employed as denture base materials due to their translucency, flexibility, higher strength, lack of free monomers and biocompatibility [17]. Based on the literature review, studies have mainly focused on the mechanical properties of these materials, but limited published information is available on the colour stability of thermoplastic polymers after ageing [7] [23]. Colour stability is an important factor for dental materials, colour alterations due to the ageing process or any damage to the denture base material affect the esthetic results [24].

Thermoplastic Acetal is one of the thermoplastic resins that was first introduced in 1971 as an unbreakable one. During this era, quick injection methods developed the initial tooth coloured retainers which are flexible, don't need periodic adjusting to keep them tight and they were very much appreciated by the patients [25].

Achieving optimal superior esthetics usually takes place by utilising Acetal clasps since their colour matches with that of teeth, and it was documented for their high ability to eliminate expending of metal clasps which improve esthetics. Due to their low modulus of elasticity, they can be employed in larger undercuts than recommended for chromium-cobalt alloy and also exert minimal stresses on abutment teeth. This might be clinically useful due to the importance of both esthetics and periodontal health. As well as, maintaining retentive integrity, stability and protecting the health of teeth which have been a hard task to achieve are from its remarkable merits [26] [27].

Moreover, they offer the additional essential advantage of declining the potentiality for allergic reactions to metals that take place with most subjects especially the highly sensitive ones [26] [28].

The merits mentioned above allow Acetal

resin to be an ideal substance for pre-formed partial dentures' retainers, their frameworks and single pressed unilateral ones. Moreover, it fabricates the transitional bridges, occlusal splints and implant pillars. Besides that, it combats the occlusal overstrain which allows it to be suitable enough to preserve the vertical dimension through the interim restorative remedy [12] [29] [30].

Regarding the cobalt chromium alloy denture base material, it has been well known since very long time ago for its poor esthetics, especially when utilised as RPD clasps, this was due to both their undesirable metallic colour that is highly remarkable and thickness to provide the required amount of retention. Moreover, many considerations clarified that such alloy when being dipped intraorally, the metal tends to ionise. An oxide layer is fabricated on the alloy's superficies by absorption of Oxygen, which worsen much more it's very poor esthetics and declines by the time its metallic colour [31].

If one or more metals as CoCr denture base material (Vitallium) are dipped intraorally, the mineral tends to ionise. The diversity in the alloy's power tends to transfer its ions to electrolytes which then stimulate the metal to melt. The oxide layer is created on the alloy's superficies by absorption of Oxygen, which prohibits excess melting for its remaining constituents. A superficial film coating all the intraoral surfaces and fabricated by sedimentation of both salivary proteins and glycoproteins are named Biofilm [31] [32] [33] [34].

Further studies have to be carried out regarding various thicknesses and designs of both clasps and frameworks for Acetal successful dental application [32]. As the technology of injecting Acetal clasp into a mould is quite new for dentistry yet the literature is poor. Only a few data on the subject were published to date [27] [35].

Regarding the Versacryl, it has been recommended that utilising esthetic retainers in RPDs provide the patient with a metal-free smile, yet its colour stability is not that much superior as the Acetal's one [36].

In conclusion, (1) the most colour stable retainer and with excellent esthetics was the Acetal clasps; (2) Versacryl is of good esthetics yet its colour stability is not that much outstanding as the Acetal's one; (3) both Thermopress and Valaplast were the worst among the materials utilized in colour stability although they are considered as esthetic clasps; (4) Cobalt Chromium (CoCr) metal clasps are the poorest regarding esthetics.

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