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Color Stability of Re-Injection Acetal Resin with Different Percentages or Several Times

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Abstract

Studies in a variety of scientific disciplines have experimented with various techniques for recycling and reusing the materials they utilize on a regular basis, in this study suggest to re cycling waste of acetal resin.

Purpose: The purpose of this study was to assess and compare the color change of re-injection acetal resin with different percentages or several times.

Material and Methods: Specimens were prepared with dimensions (20±1 mm in diameter x 0.5 mm in thickness) for color stability test and injection according to the manufacture̕s instruction for acetal resin as denture base materials and aesthetic clasp. The first group represent control group with (100% New) and other five groups as experimental groups (group II, group III, and group III) with different percentages between new acetal materials and old acetal materials, while two last groups with several times (group IV and group V) only used old acetal materials. Preparation the ratio between the new material with the old material according to pilot study and the best ratio in this study is 25% new acetal material and 75% old acetal material (group II). The old material is preparation by acetal sprue is collected and cutting by cutter and re-injection with new acetal resin.

Results: Statistically non-significant difference in color change in re-injection acetal resin, when comparing the control group with mean (1.046±0.094) and re-injection groups with means respectively (1.040 ±0.076,0.942±0.115,0.993±0.137, 0.978±0.060, and 0.970±0.098).

Conclusion: Color change was statistically non-significant differences between all studied groups.

Introduction:

Dental materials' color stability is an important criterion for their performance within patients' mouths and reflects their clinical efficacy [1, 2]. Any color variations in denture base materials show material deterioration and/or aging, so the color of the base should match the underlying tissues' color and look [3, 4].

Also, Changes in color and shine could be an indication of age or degradation of the denture base material, whereas color and gloss are significant components for the aesthetic appearance and acceptability of removable prosthesis. These alterations might be categorized as clinically acceptable or visibly noticeable [5]. Denture base resins' color is an essential factor for aesthetic evaluation. The denture base material must retain its color despite the barrage of commonplace colorants. The influence of different food colorants or drinks and beverages on the color of denture base materials has also been documented [3, 6, 7]. Reduced long-term quality of a denture is indicated by a change in color [8].

The challenge in the current world is in reducing, reusing, and recycling various resources. Reusing is a phrase used to refer to reusing the materials that can be reused and minimizing material waste, whilst reducing is used to refer to reducing the amount of the earth's resources and utilization should only be when necessary. Whereas recycling is the second source of oxygen for today’s existence, so attempt to recycle anything which can be recycled to keep the environment cleaner and greener [9]. In dentistry, several research advised to reuse or recycling dental materials such as dental amalgam [10]; orthodontic brackets [11]; phosphate-bonded investment material [12]; Zircon waste resulting from CAD-CAM (computer-aided design and computer-aided manufacturing) [13]; and recycled PMMA monomer [14]. The majority had a limited knowledge concerning recycling techniques. They may consider appropriate disposal as degradable or non-degradable dental materials [15, 16]. Yet, no studies reported the recycling of waste results from the injection denture base and acetal clasp.

Since more than 50 years ago, thermoplastic polymers have been employed in dentistry.; their use has grown along with the demands placed on the industry and the general public. These materials offer exceptional qualities that make them great candidates for treatments that are both esthetic and biocompatible[17]. The flexite company first proposed Rapid Injection Systems in 1962. The business unveiled the first Flexite thermoplastic resin, a fluoropolymer (a material similar to Teflon)[17, 18].

In 1971, acetal was used for the first time as an indestructible thermoplastic polymer. During this time, the first thermoplastic polymer-based tooth-colored clasps were developed through quick injection methods. Using acetal resin, the dental firm revived tooth-colored clasps in 1986. The patients liked the clasps since they were flexible, didn't require cyclic adjustment to keep them sealed, and had tooth-colored aesthetics[19].

By polymerizing formaldehyde, acetal resins were created. Poly(oxyethylene) (POM), a homopolymer, was a link formed by an oxygen molecule between a series of alternating methyl groups[20]. Polyurethane and polycarbonate have been used to create a variety of co-polymers. POM had been extensively utilized as an implant material for over 26 years. Its usage in total hip replacement, temporomandibular joint reconstruction, and mechanical heart valve occludes had been encouraged by the material's demonstrated high degree of biocompatibility. A stress-absorbing element for a dental implant system has also been made of POM[20].

Thermoplastic polyoxymethylene, also known as Acetal, offers excellent mechanical qualities, including high strength, greater abrasion resistance, decreased creep, and higher surface luster. It also conveys a high degree of rigidity, hardness, low coefficient of friction, impact strength, high wear resistance, and dimensional stability[21-23]. In addition, it has high chemical resistance, low water absorption and high biocompatibility [24] .

Also, because to the flexibility of these materials, the Acetal resin clasps did not deform after 36 months of simulation and required less force to insert and remove than the conventional Co-Cr clasps [25, 26].
The objective of this study was to evaluate the color change of re-injection acetal resin materials with different ratio or re-injection with several time (one time and two-time re-injection old acetal materials). The scientific benefit of this study is an economic goal, because of the acetal resin is an expensive, and to benefit from the waste of this material so we suggest to re-injected it.

Materials and Procedures:

Fifty-four-disc specimens were prepared for color stability test, and divided into six groups as Group I: Control group (Group I) with 100% New acetal material, Group II :25 % New acetal material + 75% Old acetal material, Group III: 50% New acetal material + 50% Old acetal material, Group IV: 75% New acetal material + 25 % Old acetal material, Group V: 100% Old acetal material and Group VI: re-injection for two-time acetal material.

Specimen preparation
A total of six discs for each flask were made by using design in STL file (is an acronym that stands for stereolithography) and produce resin pattern (Phrozen Dental resin (Water washable)) by 3D printer (Phrozen Dental XL) into the desired form and dimension (27)according to the test requirements ,resin pattern was constructed with a dimension of (20±1 mm in diameter x 0.5 mm in thickness) according to ISO standard number 20795-1:2013[28].
Specimens were prepared according to the manufacturer's instructions for acetal resin (Evidsun).
The lower portion of the flask was poured with mixed dental die stone (w/p ratio is 25gm/100gm) (Zermach, Germany) according to the manufacture's instruction. then the separating media (Zermach, Germany) applied on resin pattern and the plastic mold is placed approximately 2.5 cm from the injection hole of the special flask (Muffle-Type 100), after the stone was set, wax sprues (Vertex) were constructed before placing the upper half of the flask, major sprues and minor sprues were employed and attached to certain regions, and tiny sprues were made to escape the air during injection. The stone mould was coated with separating medium, after it dried, the upper half of the flask was positioned, the four flask screws were tightened, and the second part was poured through the flask's hole while vibrating. after reach to final set wax elimination done as shown in Fig. (1). A cylinder of acetal resin of the specified color (shade A2) was placed in the injection tube and the tube was placed with a special tool on the injection machine (Sabilex). The injection machine was programmed as follows: The device allowed heating up to 220$^{o.}$ The Acetal resin cartridge and the metal disc are inserted into the heated cylinder and left inside the furnace for 20 minutes to allow the granules inside the cartridge to melt. The flask placed inside the injection unit in vertical position in a position that the injection opening was to the top surface of the flask. the material injected inside the flask by the automatic injection unit at pressure 4 bar . After three minutes, the flask removed from the injection unit and allowed to cooling at room temperature 23^{O}C. The deflasking then done and the specimens were removed from the flask . Finally fishing and polishing the specimen [29]as shown in Fig. (2).

Preparation of percentages of each group
According to the pilot study, the weight of the empty capsule is 3 g, and each flask contain six samples to guarantee the precise percentages for each group and flask. According to this investigation, 9 g of acetal is enough to injected six samples of acetal in to flask for color stability samples. In order to divide the percentages between the old and new materials, this weight has been used. On the other hand, the old acetal resin (sprue of injected acetal resin) cutting by using cutter as shown in Fig. (3). The acetal particle size, instructions, temperature and pressure are the same as for the old acetal material.

Color stability testing

UV-Vis spectrophotometer (UV-Vis-1900 Shimadzu, Japan) which is an objective method was used to evaluate color change by measuring the amount of absorbed light percentage[30] as shown in Fig. (4).

The samples not need exposure to liquids and water. samples were placed over the light outlet of the device and subjected to light. The percentage of absorbed light was then obtained from the screen of the device. The instrument was auto zeroed with nothing in the sample compartment across its working range in order to establish a baseline.The spectrophotometer which was used is ultraviolet-visible spectroscopy (UV-Vis-1900 Shimadzu, Japan). Shimadzu spectrophotometer which was used in this study measures the wavelength range from 190 – 1100 nm; it measures the intensity of light passing through a sample (I), and compares it to the intensity of light before it passes through the sample (Io). Absorbance (A) is expressed as a percentage (%) [31].

Results and Discussion:

Mean values, standard deviation (SD) and standard error (SE) are presented in Table (1) and Fig. (6) for color change test, non-significant differences when comparing control and experimental groups.

When compare the control group (1.046±0.094) with all studied group the results show that statistically non-significant differences in color change.

ANOVA test of color change test revealed that there were non- significant differences among groups as shown in Table (2).

The absorbance sensitivity analysis with all groups samples of acetal materials as shown in Fig. (5), the high UV-Vis absorbance peak for the stability color samples is shown in group I (1.160) and group IV (1.160).

Color stability is one of the most crucial clinical characteristics for dental materials, and any change in color could be a sign of material aging or damage. In addition, the appearance of the prosthesis is unquestionably a crucial requirement from patients and must meet their expectations[32]. Another potential cause of the modifications could be linked to the colorants applied for characterization, as the coloring resistance of polymers depends on both their form of polymerization and their chemistry [33]. McCutcheon K et al. suggested that repeated heating and cooling of thermoplastics like Acetal do not result in any significant chemical degradations., acetal polymers exhibit repetitive and orderly structural units that give them their sharp melting points as opposed to amorphous solids [34]According to this study the results noted that statistically non-significant difference in color change in re-injection acetal resin, when comparing the control group and re-injection groups. The result of this study indicated that acetal resin can be re-injection with different percentages and for several times without any color change. Because the material used in this research is new and the idea of research for re-injection of the substance is also new, so there is no previous research on this subject, and therefore we did not have citations for other research.

Conclusion:

Within the limitations of the present study, the color change was statistically non-significant differences between all studied groups. Acetal resin can be re-injection with different percentages and for several times without any color change, according to this study re-injection acetal is recommended.

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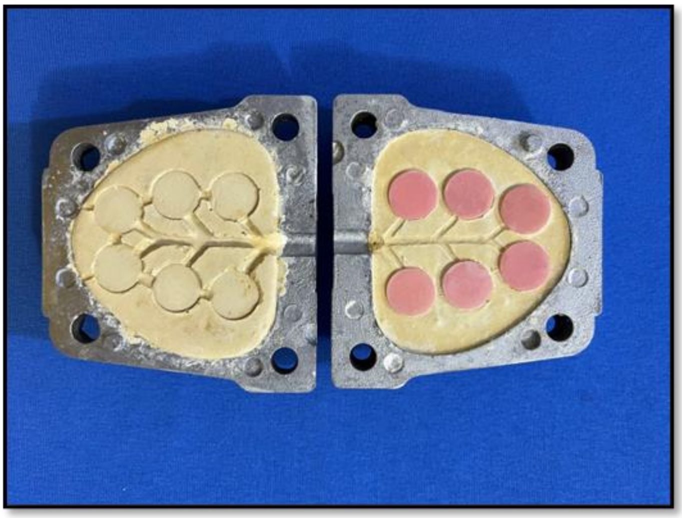

Fig. (1): Mold preparation to injection acetal resin

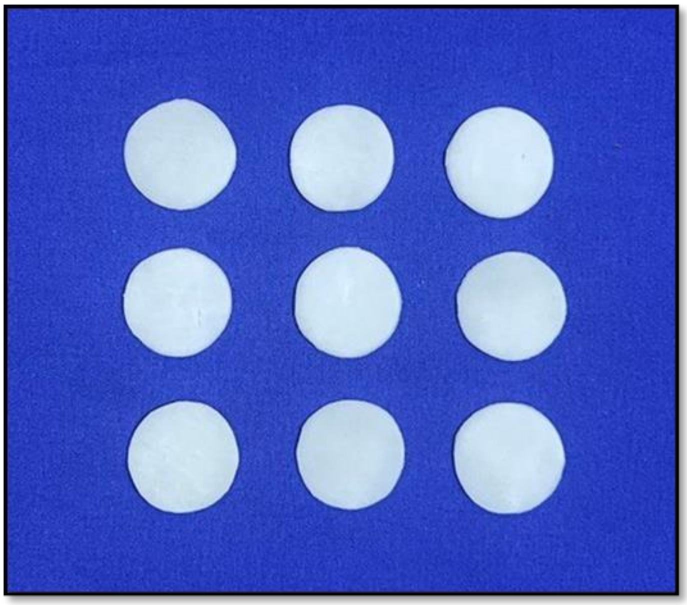

Fig. (2): Specimens of control groups (100% new acetal materials) after finishing and polishing

Fig .(3): Process of cutting old acetal material by using cutter

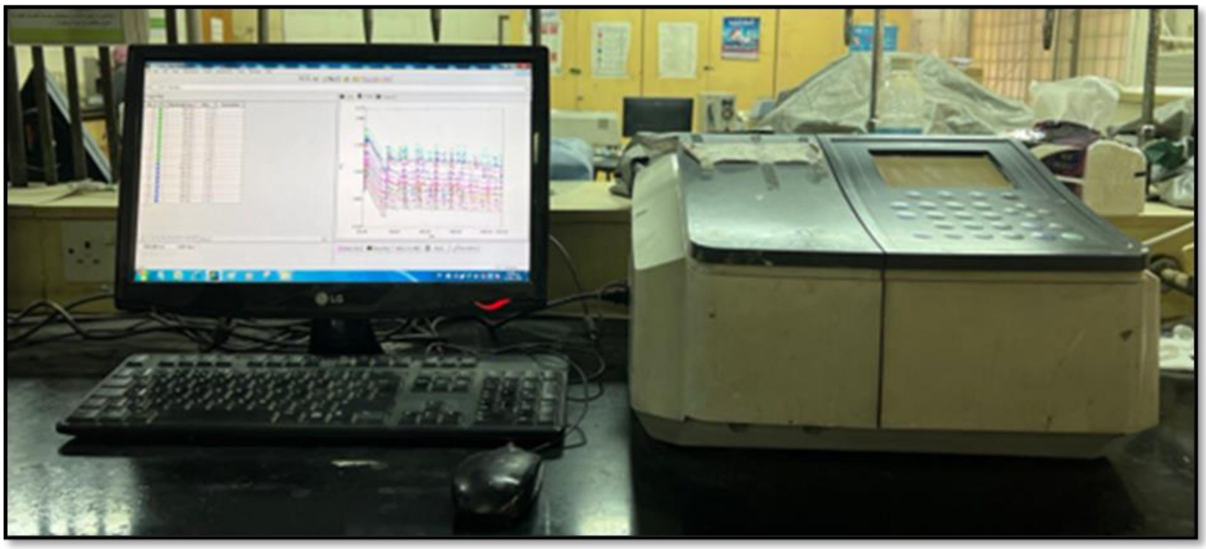

Fig. (4): The spectrophotometer device used for testing color stability

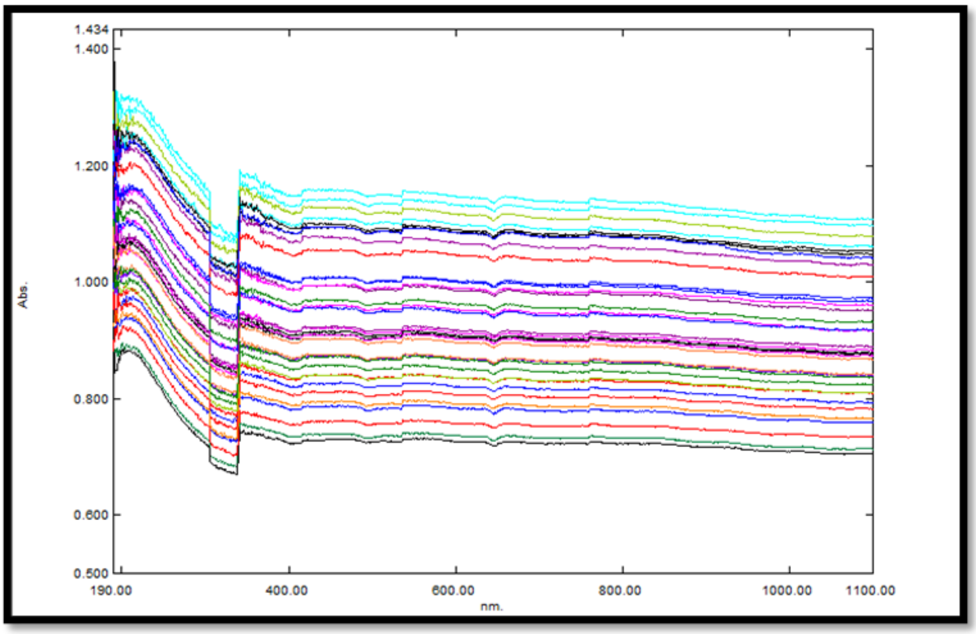

Fig . (5): The absorbance sensitivity analysis with all groups samples of acetal materials

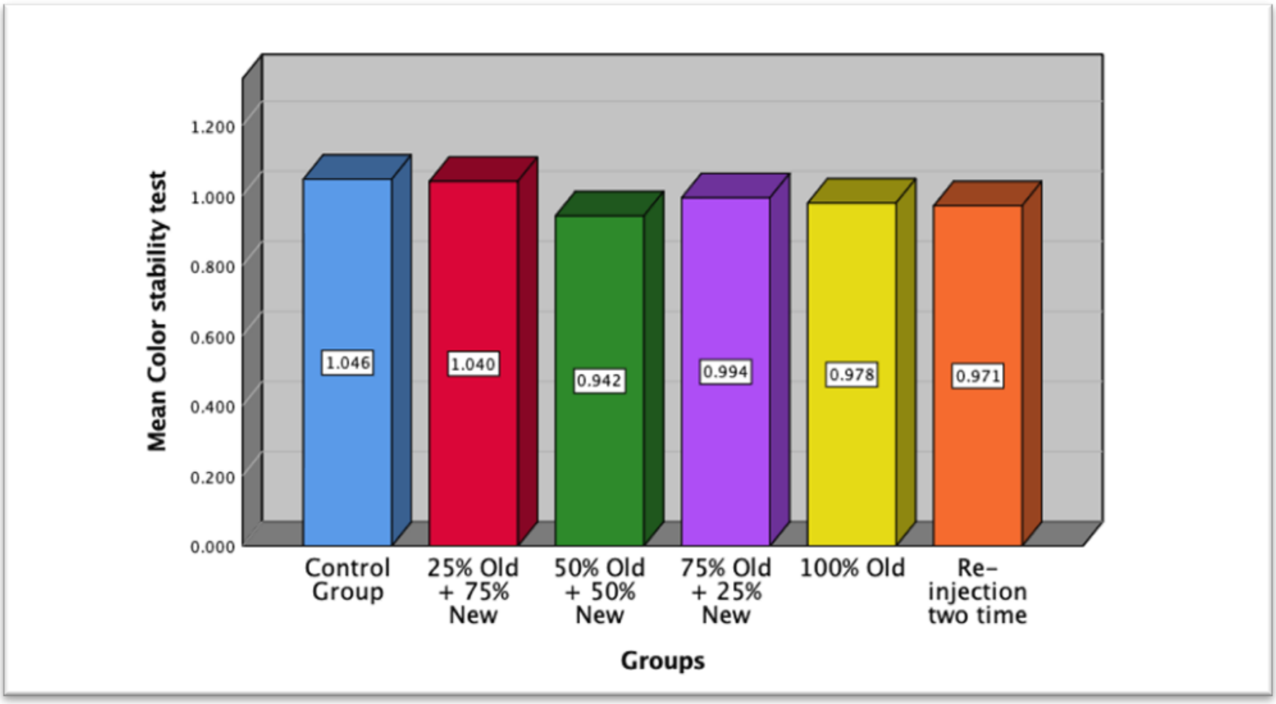

Fig. (6): Simple bar mean of color stability test between control group and other experimental groups

Table (1) :Descriptive statistics of color stability test for all studied groups

Color stability test							
	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Control Group	1.04644	0.094283	0.0314	0.97397	1.11892	0.928	1.160
25% Old + 75% New	1.04044	0.076499	0.0255	0.98164	1.09925	0.929	1.127
50% Old + 50% New	0.94200	0.115241	0.0384	0.85342	1.03058	0.763	1.127
75% Old + 25% New	0.99367	0.137277	0.0457	0.88815	1.09919	0.757	1.160
100% Old	0.97844	0.060165	0.0200	0.93220	1.02469	0.882	1.075
Re-injection two time	0.97089	0.098475	0.0328	0.89519	1.04658	0.813	1.134

Table (2): One-Way AVOVA to compare the color stability between control and re-injection groups.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.075	5	.015	1.503	.206
Within Groups	.481	48	.010		
Total	.557	53			

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