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Evaluation of color stability of Pmma based provisional restorative materials reinforced with silica powder (0.5%)- An in vitro study

[1]Dr. Sneha Patil M, Postgrauate student, Head and Principal, Department of Prosthodontics, crown and bridge, Bapuji Dental College and Hospital, Davangere.

[2]Dr. Nandeeshwar. D. B, Professor, Head and Principal, Department of Prosthodontics, crown and bridge, Bapuji Dental College and Hospital, Davangere.

Corresponding Author: Dr. Sneha Patil M, Postgrauate student, Head and Principal, Department of Prosthodontics, crown and bridge, Bapuji Dental College and Hospital, Davangere.

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Abstract

Background: Provisional restorations (PR) are interim restorations in FPD, which protect the prepared teeth for limited period of time until fabrication of final prosthesis. They restore lost functions, esthetics and stabilize occlusion, help maintain periodontal tissue health and pulp vitality.

Objectives: To compare and evaluate 'Color stability' of three PMMA based provisional materials reinforced with and without silica powder (0.5%) after 'pumice' polishing and immersing in turmeric solution. Method: Total of 66 circular shaped specimens will be prepared for each provisional material (n=11) using customized metal mold (25mm in diameter x 2mm in thickness according to the ADA NO. 27). The materials will be manipulated using manufacturer's instructions. For the control groups silica powder will not be added. Then the specimens will be stored in water bath at 37 0C for 24 hr. Then the baseline reading will be recorded using 'Spectrophotometer' in the form of L*a*b*. Then the samples will be immersed in turmeric solution for 3 weeks. Then, the color reading will be recorded in the same manner as baseline readings after 3 weeks.

Results: The color stability of 6 groups differed significantly. Based on mean values the least color stable Group is Group IIC and the highest color stable Group is Group IB.

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Keywords: Provisional restorations (PR), PMMA (Poly methyl meth acrylate), CIE (Commission Internationale de l' Eclair age), Color stability, Staining, polishing.

Introduction

Provisional restorations (PR) are interim restorations in FPD, which protect the prepared teeth for limited period of time until fabrication of final prosthesis. Interim prosthesis can be used to restore lost functions, improve esthetics, to stabilize occlusion, they also protect teeth from thermal stresses, mechanical fracture, evaluate parallelism of abutments, prevent migration of abutment teeth and opposing teeth in edentulous area, help to maintain periodontal tissue health and pulp vitality and they are used as diagnostic reference for the definitive prostheses.[1]

Interim restorations are usually constructed by acrylic or composite resins. Provisional restoration materials available for use in fixed prosthodontic treatment are; autopolymerising Polymethyl meth acrylates, Poly ethyl meth acrylates, Bis acrylics, Micro filled resins, Polyvinyl meth acrylates and Urethane meth acrylates. However, PMMA based provisional materials are very commonly used as they are economic, easy availability, ease of smoothing and polishing, increased strength and color stability.[1,2]

Several studies have shown mean duration of use of provisional restorative materials is approximately 20 to 30 days; however, clinical delay, diseases and financial consideration may prolong the period for which a provisional restoration is in use and may lead to substantial color alterations.[2,3]

Color stability of the provisional restorative material relates not only to the chemi co physical properties of the resin but also the patient's habits.3 These materials are susceptible to discoloration caused by oral rinses, food colorants and beverages such as tea, coffee, soya sauce, tannin, red wine, turmeric or chlorhexidine based oral rinses. This can lead to patient dissatisfaction, poor acceptance and cause additional expense for replacement during long term treatment.4 The alteration in color of provisional restoration is based on different factors such as; water sorption, oral hygiene, diet pattern, chemical reactivity and surface smoothness of the restoration.[4,5]

The alteration in color can be evaluated with various instruments. Since instrument measurements eliminate the subjective interpretation of visual color comparison, Spectrophotometers and Colorimeters have been used to measure color change in dental materials.[4]

Several studies have been done on efficiency of polishing system, on staining solutions and reinforcement of silica powder at different concentration to improve mechanical properties.[1,2,3,4] There is no study available which shows reinforcement of the Silica powder (0.5%) in provisional restoration material which could improve 'Color stability'. Hence, the present invitro study is aimed to evaluate and compare the 'Color stability' of three PMMA based provisional restorative materials reinforced with silica powder (0.5%) after 'pumice' polishing and immersing in 'turmeric' solution.

Materials and methodology

Sample size determination

Sample size was calculated for the primary objective comparing the average 'Color stability' using Spectrophotometer between six groups. Following formula was used;[26]

$$n = 2\left(\sigma \frac{z_{1-\alpha/(2\tau)} + z_{1-\beta}}{\mu_A - \mu_B}\right)^2$$

Where

n is sample size

σ is standard deviation = 0.7

μ is expected mean (μA = 1.85 & μB = 1.5)

α is Type I error = 5%

τ is the number of comparisons to be made = 6

β is Type II error, meaning 1−β is power = 80%

Calculated sample size was 63 and rounded to 66. In each specimen group sample size of 11 was considered.

Methods of collection of data

Source of data

• All the materials was collected or purchased through scientific chemical or dental suppliers.

• 'Turmeric powder' was purchased from local commercial shops.

Materials

For specimen preparation

• Three PMMA autopolymerising provisional restorative materials

(DPI – A2 shade, for crown & bridge work and tooth reproduction, manufacture date – October 2020 and expiry date – November 2023)

(Pyrax – A2 shade, SC-10, manufacture date – August 2020 and expiry date – September 2024)

(Acry C &B - A2 shade, ruthinium group, manufacture date – March 2020 and expiry date – April 2024)

• Polishing agent: Pumice (VIP Pumice powder) using prophy brush.

• Staining agent: Turmeric solution (Everest)

• Silica powder (0.5%) (Astrra chemicals)

• Sterile plastic containers

• Distilled Water

• Computer controlled CM -3310d Spectrophotometer (MINOLTA)

• Custom made metal mold (25mm in diameter x 2 in thickness according to the ADA NO. 27).

Methodology

Preparation of the specimens

Total of 66 circular shaped specimens were prepared for each provisional material (n=11) using customized metal mold (25mm in diameter x 2mm in thickness according to the ADA NO. 27). The materials were dispensed, manipulated and polymerised according to manufacturer's instructions.4 0.5 g of powder polymer was added to 0.25ml of liquid monomer , to this 0.5% by wt. of silica powder was added and mixed with a clean stainless steel spatula, when the mixture reached the dough stage, it was packed slowly into the customized metal mold ; a glass slab was then seated over the mold to pack the mix and to help remove the excess material; the specimen were allowed to polymerize for 15 minutes at room temperature.24 The excess flash material was removed. For the control groups silica powder was not added. The samples with defects were excluded from the study. Before exposure to the staining agent and polishing, baseline reading was recorded using 'Spectrophotometer' using CIE (Commission Internationale de l'Eclairage) L*a*b*, where L* refers to the lightness coordinate with value ranges from zero (black) to 100 (white). The values a* and b* are chromaticity coordinates in the red-green axis and the yellow-blue axis respectively. Measurements were repeated 3 times for each specimen and the mean values of the L*, a*, and b* data were calculated.[4]

Then the specimens were stored in water bath at 37 0C for 24 hr. 24 The specimens were finished to the desired dimensions with 600 grit abrasive paper for 10 seconds. 24 The surfaces of the specimens were polished using micromotor hand piece operating at 15,000 rpm was used for all polishing procedures.27 Specimens were polished for 15 seconds after application of coarse pumice, flour of pumice (VIP Pumice powder) using prophy brush, followed by rinsing with distilled water to remove any debris before immersing in Turmeric solution for 2 minutes thrice a day for 3 weeks. [21,27]

Preparation of the staining solution

Turmeric solution was prepared by adding 0.5g turmeric in 150 ml of distilled water.28The solution was

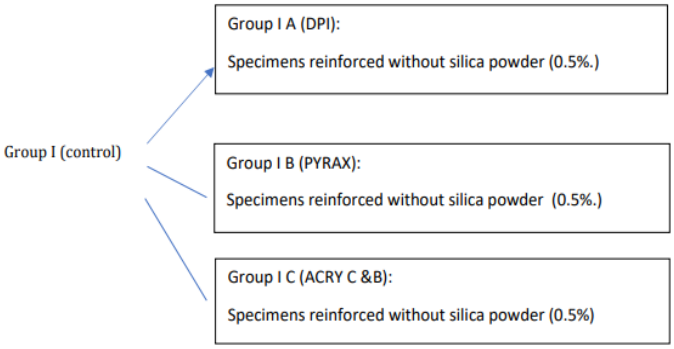
maintained in a dark environment at 370 C ± 10 C to simulate the conditions in an oral cavity. 21The staining solutions was changed twice a day throughout three weeks. [21]

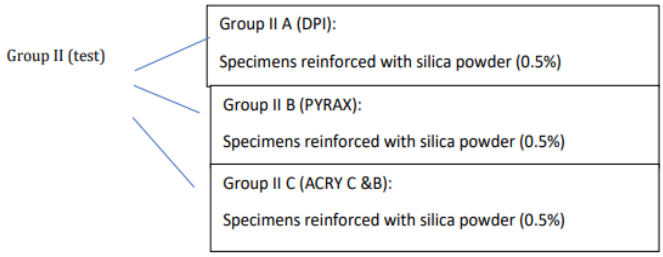
Grouping the specimens

For the convenience of study, specimens were divided into main two groups as,

Group I – Specimens reinforced without silica powder (0.5%)

Group II – Specimens reinforced with silica powder (0.5%) The 2 main groups were further divided into 6 subgroups where (n=11);





Then the samples were immersed in turmeric solution for 2 minutes thrice a day after immersion in turmeric solution, then the specimens were immersed in water bath.[21] Like this, all specimens were exposed for 3 weeks. 21 After 3 weeks of exposure in the staining solution, the specimens were rinsed with distilled water for 5 minutes and blotted dry with tissue paper before color measurement.[4]

Then, the color reading was recorded in the same manner as baseline readings after 3 weeks. Color difference was calculated from the mean ΔL*, Δa*, and Δb* values for each specimen with the formula

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

where ΔL*, Δa*, and Δb* are the differences in L*, a* and b* values before and after immersion in staining solution at time interval of 3 weeks.8 This procedure was done by the same person throughout the study.

Statistical analysis

Collected data was entered in excel software and analysed using 'R' software version 3.2.3. 'Color stability' was presented as mean and standard deviation. One-way ANOVA test was used to compare mean of six groups (the normality in the data was checked for using Shapiro Wilks test). $P < 0.05$ was considered as statistically significant.

Results

The present study was conducted to evaluate and compare the color stability of provisional materials before and after reinforcing with silica powder after immersion in turmeric solution.

In this study a total of 66 sample were evaluated. The results obtained were tabulated and statistical analysis was performed by one-way.

ANOVA test for quantitative analysis among the groups and Post hoc Tukey's test to compare the significant differences between the individual groups. A p value of < 0.05 was considered significant for the analysis.

Table 1: showing the comparison of ΔE values among the six groups using ANOVA (the normality in the data was checked for using Shapiro Wilks test).

This table shows color change (ΔE) mean values, standard deviation and standard error of all the materials.

Inference

• The color stability of 6 groups differed significantly.

• Based on mean values the least color stable Group is Group IIC, followed by Group IIB, Group IC, Group IIA and Group IA.

• The highest color stable Group is Group IB.

• p value was statistically significant.

Table 2: showing post-hoc comparison among individual groups. This shows comparison of one group with rest other groups and also shows mean difference and the p value being statistically significant or not.

Inference

• The color stability was statistically different for Group IA and Group IIC and Group IIC was significantly less color stable than Group IA (the value being 0.038).

• The color stability was statistically different for Group IB and Group IIC and Group IIC was significantly less color stable than Group IB (the value being 0.000).

• The change in colour stability was significantly different for the 6 groups.

A further post-hoc analysis revealed that the change was significantly greater for the 6th group that is (Group II C) compared to that in the first (Group IA) and the second (Group IB) groups.

graph 1: Graph showing the mean ΔE values of 6 groups where ACRY C &B specimens reinforced with silica powder were least color stable and Pyrax specimens reinforced without silica powder were highest color stable.

Discussion

The role of provisional restoration used for indirect restorative and prosthodontic procedures has changed dramatically in the past several years. An interim dental prosthesis that maintains esthetics, provides masticating surfaces, and protects the hard and soft tissues prior to the delivery of the final prosthesis.

Gujjari AK, Bhatnagar VM, Basavaraju RM conducted study in the year 2013 in which they evaluated the color stability of poly (methyl methacrylate) (PMMA) and bis-acrylic composite based provisional crown and bridge auto-polymerizing resins exposed to tea, coffee, cola, and food dye. The study revealed that PMMA is more color stable than bis-acryl composite based resin.

Haselton DR, Diaz-Arnold AM, Dawson DV conducted study in the year 2005, they evaluated the color change that occurred when 12 provisional crown polymethyl methacrylate (PMMA) and bis-acrylic composite resins and FPD resins. They concluded that, most of the methacrylate resins, demonstrated insignificant color change for the solutions tested. Reason behind this being chemistry of both the materials, most bis-acryl polymers are more polar than PMMA polymers and therefore have a greater affinity towards water and other polar liquids. Hence PMMA polymers are more color stable than bis acryl polymers.[13]

Sathe S, Karva S, Borle A et al conducted study in the year 2019 evaluated the effect of three polishing agents on staining of provisional restorative material. The results of this study showed that the samples which were polished with pumice were the least stained. They justified that this could be because of the fineness of the flour of pumice which is a very finely grounded derivative.

Keerthna M, Jain AR conducted a study in the year 2018 evaluated the color stability of temporary crown materials after subjecting to four staining solutions Tea, Coffee, Coca cola and Turmeric solution. The study revealed that staining potential of turmeric seems be the highest followed by coffee, tea, and coca cola.

As mentioned, PMMA is the most frequently used material for interim fixed prostheses but it is a glassy and fragile material that demonstrates low fracture toughness. For this reason, various attempts have been made in order to enhance the fracture toughness of

PMMA restorations through metal wires, fibers (glass, aramid and carbon graphite), various oxides (aluminium, zirconium, titanium, magnesium) and nanodiamonds etc. Incorporation of wires or fibers affect the esthetics and also requires availability of space which may restrict the application of metal wires. Carbon fibers attain black color that limits their use. Reinforcing PMMA with nanofillers can be more efficient in strengthening PMMA, due to its large surface area, yield strength and rigidity. Recently, Topouzi et al used SiO2 nanoparticles to reinforce a PMMA acrylic resin and reported a significant increase of fracture toughness. [1]

This in vitro study intended to evaluate whether reinforcing PMMA provisional material with silica powder would improve color stability or not. Out of 3 groups which were reinforced with silica powder (0.5%) only ACRY C & B was statistically different and it was significantly less color stable than other groups. For this reason more materials have to be reinforced with silica powder (0.5%) to conclude whether reinforcing with silica powder (0.5%) is improving color stability or not.

One of the limitations of this study is that since it is an in vitro study done under experimental conditions, in vivo variables like role of saliva, other staining agents apart from turmeric solution, masticatory force which could affect mechanical factors which in turn could affect color stability were not considered and further research should be done for the same.

Conclusion

within the limitations of this study and from the results obtained the following conclusions can be drawn.

• The color stability of 6 groups differed significantly.

• Based on the results, reinforcement of silica powder (0.5%) to ACRY C &B did not improve color stability as it showed least color stability.

• And also PYRAX without reinforcement of silica power (0.5%) showed greater color stability.

• Hence it can be concluded that, the addition of silica powder (0.5%) does not improve color stability.

Clinical implication

• According to the present study, PYRAX without silica powder (0.5%) reinforcement can be used as provisional restorative material for the treatment of fixed partial dentures, as it is more color stable than other study groups.

Photographs

Fig 1: Showing the materials used for the study

Fig 2: Showing the armamentarium used for the study.

Fig 3: Showing CM-3310d Spectrophotometer (Minolta).

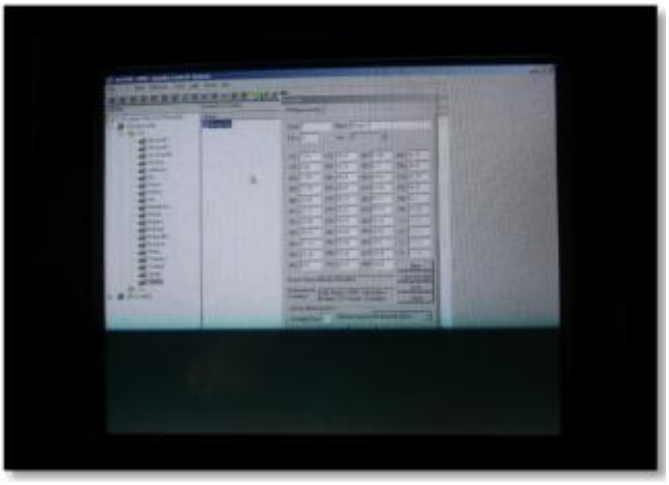


Fig 4: Computer showing color values of sample being measured.

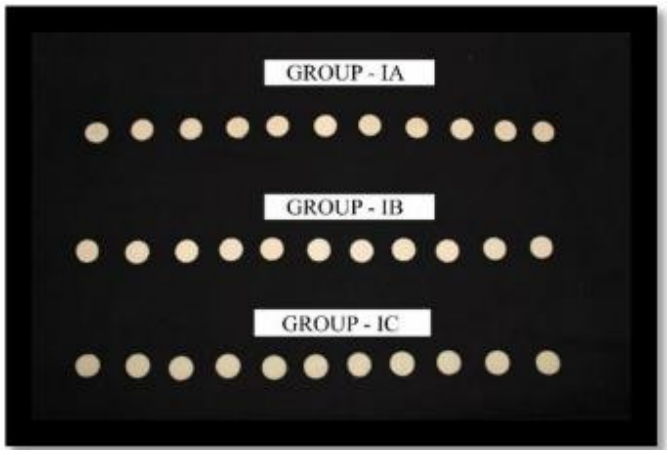


Fig 5: Showing the Group I (control) Samples of DPI, PYRAX and ACRY C & B before pumice polishing and staining in turmeric solution.

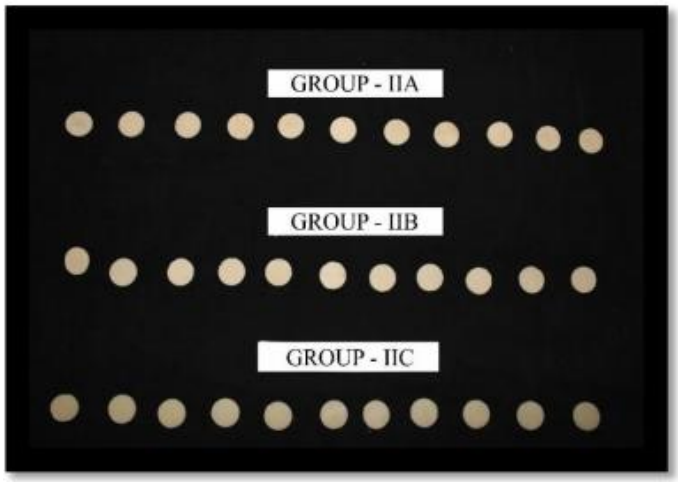


Fig 6: Showing the Group II (test) Samples of DPI, PYRAX and ACRY C & B before pumice polishing and staining in turmeric solution.

Fig 7: Showing the Group I (control) Samples of DPI, PYRAX and ACRY C & B staining in turmeric solution.

Fig 8: Showing the Group II (test) Samples of DPI, PYRAX and ACRY C & B staining in turmeric solution.

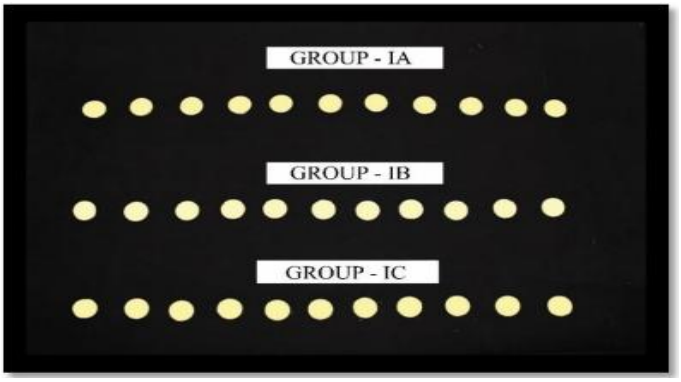


Fig 9: Showing the Group I (control) Samples of DPI, PYRAX and ACRY C & B After pumice polishing and staining in turmeric solution.

Fig 11: Showing the sample placed in Spectrophotometer along with readings.

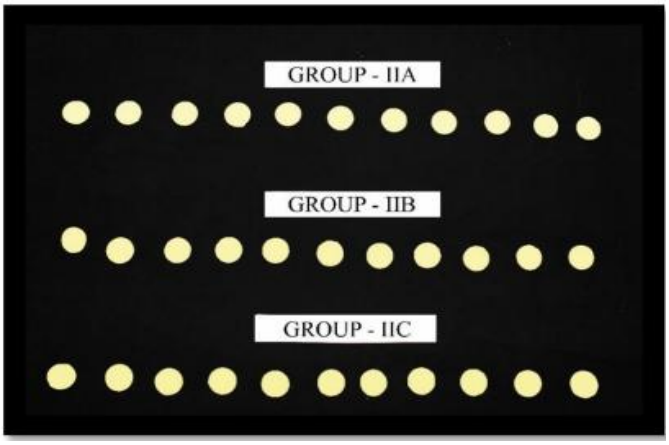


Fig 10: Showing the Group II (test) Samples of DPI, PYRAX and ACRY C & B after pumice polishing and staining in turmeric solution.

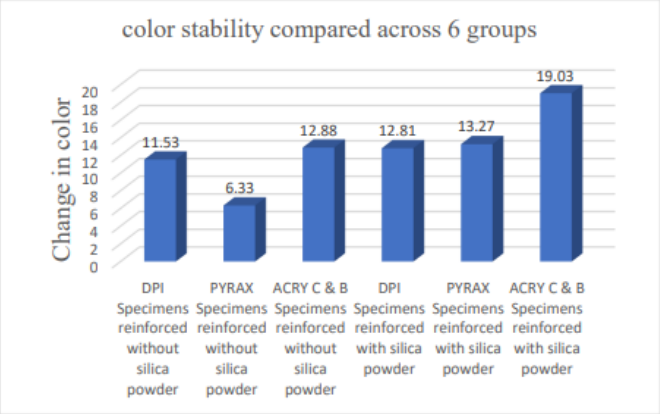
Table 1: Master table showing the Intergroup comparison of color change ΔE values measured for Group I (control) and Group II (test) specimens using ANOVA (the normality in the data was checked for using Shapiro Wilks test).

Group	Sample Size (N)	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
IA	11	11.5327	5.72798	1.72705	7.6846	15.3808
IB	11	6.3391	3.85509	1.16235	3.7492	8.9290
IC	11	12.8845	5.82819	1.75727	8.9691	16.8000
IIA	11	12.8191	6.19417	1.86761	8.6578	16.9804
IIB	11	13.2782	7.07761	2.13398	8.5234	18.0330
IIC	11	19.0327	5.37728	1.62131	15.4202	22.6452
Total	66	12.6477	6.67414	.82153	11.0070	14.2884
F statistic(p value)		5.458 (<.001)				

Table 2: Master table showing Post-hoc comparison of color stability among each of the six individual groups.

1st group	2nd group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
IA	IB	5.19364	.294	-2.0356	12.4229
	IC	-1.35182	.994	-8.5811	5.8774
	IIA	-1.28636	.995	-8.5156	5.9429
	IIB	-1.74545	.980	-8.9747	5.4838
	IIC	-7.50000*	.038	-14.7293	-.2707
IB	IA	-5.19364	.294	-12.4229	2.0356
	IC	-6.54545	.098	-13.7747	.6838
	IIA	-6.48000	.104	-13.7093	.7493
	IIB	-6.93909	.067	-14.1683	.2902
	IIC	-12.69364*	.000	-19.9229	-5.4644
IC	IA	1.35182	.994	-5.8774	8.5811
	IB	6.54545	.098	-.6838	13.7747
	IIA	.06545	1.000	-7.1638	7.2947
	IIB	-.39364	1.000	-7.6229	6.8356
	IIC	-6.14818	.139	-13.3774	1.0811
IIA	IA	1.28636	.995	-5.9429	8.5156
	IB	6.48000	.104	-.7493	13.7093
	IC	-.06545	1.000	-7.2947	7.1638
	IIB	-.45909	1.000	-7.6883	6.7702
	IIC	-6.21364	.132	-13.4429	1.0156
IIB	IA	1.74545	.980	-5.4838	8.9747
	IB	6.93909	.067	-.2902	14.1683
	IC	.39364	1.000	-6.8356	7.6229
	IIA	.45909	1.000	-6.7702	7.6883
	IIC	-5.75455	.193	-12.9838	1.4747
IIC	IA	7.50000*	.038	.2707	14.7293
	IB	12.69364*	.000	5.4644	19.9229
	IC	6.14818	.139	-1.0811	13.3774
	IIA	6.21364	.132	-1.0156	13.4429
	IIB	5.75455	.193	-1.4747	12.9838

Graph 1: showing Intergroup comparison of color change ΔE values measured for Group I (control) and Group II (test) specimens.



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