COMPARATIVE EVALUATION OF EFFECTS OF TWO CHEMICALLY DIFFERENT MOUTH RINSES ON THE COLOUR STABILITY AND SURFACE TOPOGRAPHY OF THREE ESTHETIC VENEERING MATERIALS - AN IN VITRO STUDY

Dissertation submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the Degree of

MASTER OF DENTAL SURGERY

BRANCH I

PROSTHODONTICS AND CROWN & BRIDGE

APRIL 2011

CERTIFICATE

This is to certify that the dissertation titled "**COMPARATIVE EVALUATION OF EFFECTS OF TWO CHEMICALLY DIFFERENT MOUTH RINSES ON THE COLOUR STABILITY AND SURFACE TOPOGRAPHY OF THREE ESTHETIC VENEERING MATERIALS - AN IN VITRO STUDY** " is a bonafide record work done by **Dr. S. SANGEETHA** under our guidance and to our satisfaction during her post graduate study period between 2008 – 2011.

This Dissertation is submitted to **THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the Degree of **MASTER OF DENTAL SURGERY – PROSTHODONTICS AND CROWN & BRIDGE, BRANCH I.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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INTRODUCTION

Rehabilitation of the partially edentulous mouth with fixed partial denture has been a mainstay of treatment modalities over the years. This predictable nature is mainly attributed to the restorations which are secured permanently to the underlying teeth, roots or on implant abutments. Contemporary dental treatments not only focus on restoring the patient's mastication, but also at improving general well being and quality of life, especially in terms of esthetics.

Ever since the introduction of lost wax technique by Taggart, there was an increased usage of cast restorations.[2] Cast restorations are mainly constructed from noble metal alloys or base metal alloys. Gold alloys were initially used in the casting of inlays, onlays crowns, FPD's and frame works for removable partial dentures.[2] They were mainly used due to their biocompatibility and ease of use.[2] Gold alloys dominated the precious metal use in dentistry. However, their use decreased after more economical alloys were developed with significantly better mechanical properties.

The base metal alloys were used as an alternative to noble metal alloys as they have improved mechanical properties but the esthetic properties was still lacking because of the visibility of the metal alloy. The all cast fixed restorations made up of noble metal alloys and base metal alloys have desirable mechanical properties but they lack in esthetic properties. [2]

The increased demand in esthetics by the patients have resulted in the diminution of all metal-alloy restorations and led to the development of metal ceramic restorations in which metal alloy substructures are veneered with tooth

colored veneering materials. The esthetic outcome of a dental restoration predominantly depends on the color and optical properties of the veneering material employed.[43]

The commonly used tooth colored veneering materials are acrylic resin, ceramics and composite resin based materials.[24] The advantages of acrylic resin include ease of fabrication, ability to retain the glossy surface and good initial esthetics. However, they had their own disadvantages like polymerization shrinkage, large thermal dimensional change, high wear rate and eventual discoloration.[3]

Ceramics when used as a veneering material or as high strength ceramic frameworks, have demonstrated their high esthetic qualities of the restoration which resulted in lesser plaque accumulation.[13] However, they have some drawbacks such as lengthy complicated procedures of fabrication, brittleness and general abrasiveness for the opposing dentition.[13] Some of these characteristics have led to the use of an alternative veneering material like composite resin.

Resin composites addressed some of the shortcomings of the ceramics like less abrasiveness, less brittleness and easy fabrication procedures along with acceptable esthetics.[13] Dental restorative composite materials can be either direct or indirect resin composites. Direct composite materials involve use of traditional composite applied directly on the prepared tooth. These materials were originally intended for use in anterior restoration where esthetics is the main concern and currently used in posterior region also.[4] One major problem that still exists with direct technique is the effect of polymerization shrinkage which results in

improper sealing of tooth restorative material interface, leading to sensitivity problems, recurrent caries and discoloration.[3]

Indirect resin composites or laboratory cured composites were introduced mainly to overcome the limitations of traditional direct composites. The potential advantage of these materials is that a slightly higher degree of polymerization is obtained which improves the physical properties and resistance to wear.[3] Indirect composite resin materials are being widely used as a viable alternative to porcelain as a veneering material for the metal supported restorations.[26] However, long term clinical studies are required to ascertain the longevity of these materials in the oral environment.

In the anterior visible zone, fractured ceramo-metal restoration is considered as an esthetic emergency and requires immediate attention as it leads to an esthetic and functional compromise. The use of ceramic repair composite material becomes important at this juncture as porcelain processing which requires high temperature firing where new porcelain cannot be added to the existing restoration intra-orally. Various types of materials like acrylic resins have been used as ceramic repair composite material. Composite resin has become the material of choice for ceramic repair procedure due to their improved mechanical properties, better shade matching and ease of manipulation.[8] The clinical success of the ceramic repair is almost entirely dependent on the integrity of the bond between ceramic-metal substrate and composite resin.[37]

Ever since the introduction of nanotechnology to dentistry, nanocomposites have been developed with the advantages of reduced polymerization shrinkage, increased mechanical properties, improved optical

characteristics and better gloss retention.[8] Wear resistance of nanocomposites has been shown to be comparable or superior to that of conventional composite resins.[8] The use of nanocomposites as a ceramic repair material has been reported in the literature.

Staining or discoloration may compromise the required esthetic results of veneering materials and thereby interfere with the longevity of the restoration. These esthetic veneering materials especially composite resin may undergo a transition in color when exposed to various staining agents such as tea, coffee, soda, mouth rinses, nicotine smoke etc...[8] Porcelain is resistant to discoloration and optical properties closely simulate that of the natural teeth.[14] In-vitro studies have shown that some topically applied fluoride agents cause surface changes of dental materials including porcelain, GIC, and composite restorations.[22] Resistance to staining of esthetic materials to a major extent will depend on the patient's oral hygiene maintenance.[19] The use of mouth rinse is an adjunct in controlling the development and progression of periodontal disease and dental caries.[4] They are also prescribed and used largely in the maintenance of fixed dental restorations. Commercially available mouth rinses are either alcohol based, fluoride based, or chlorhexidine gluconate based mouth rinses.[8]

Fluoride incorporated in mouth rinses have an anti-carious effect, prevent demineralization and enhance remineralization of carious and non-cavitated enamel.[17] However frequent use of fluoride mouth rinses may produce deleterious effects on the optical properties and surface characteristics of esthetic veneering materials such as glass containing ceramics and composite resins. Fluoride mouth rinses are capable of producing perceptible color change of veneering materials

because fluoride has the ability to etch silica which is a major component of veneering materials.[10, 12]

Non-fluoride mouth rinses are also commonly used. Non-fluoride mouth rinse mostly contains main ingredients such as alcohol. It has been reported that alcohol in the mouth rinses softens the composite resin restoration[47] and causes staining.[8]The solvent effects of alcohol containing mouth rinses on composite resins could contribute to changes in esthetics and surface topography. [12]

Previous studies have been conducted largely on the effect of mouth rinses on the color stability and hardness of traditional composite resins[4,3,17,18], there are very limited studies on the effects of use of different composition of mouth rinses on the color stability and surface topography of veneering materials like ceramic, ceramic repair composite (newer nano composite) and indirect composite resin materials. In view of the above, the present in-vitro study was conducted with the aim of comparatively evaluating the effects of two chemically different mouth rinses on the color stability and surface topography of three esthetic veneering materials namely ceramic veneering material, ceramic repair composite material and indirect composite resin material. The two mouth rinses employed in this study were fluoride and non-fluoride mouth rinses.

The objectives of the study included the following:

1. To evaluate the color stability of all the test samples after immersion in artificial saliva. (control group)
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INTRODUCTION

Rehabilitation of the partially edentulous mouth with fixed partial denture has been a mainstay of treatment modalities over the years. This predictable nature is mainly attributed to the restorations which are secured permanently to the underlying teeth, roots or on implant abutments. Contemporary dental treatments not only focus on restoring the patient's mastication, but also at improving general well being and quality of life, especially in terms of esthetics.

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REVIEW OF LITERATURE

Crispin BJ, Caputo AA. (1979)[11] On his work on colour stability of temporary restorative materials have mentioned that most materials used for prosthetic treatment are subject to absorption of colour fluids and this process of absorption and adsorption of liquids depend on environmental conditions .They have also mentioned that pigmented colourant solution can discolour the synthetic resins.

Prayitno and Addy (1979)[29] stated that the combination of dietary chromogens contained mainly in tea, coffee and Chlorhexidine can cause a surface precipitation reaction without the formation of metal sulphides.

Chan, Fuller, Hormati (1980)[9] also stated that colour stability of the provisional fixed prostheses relates not only to the chemical and physical properties of the resin but also the patients habits. Tea, Soy Sauce, Tannin, Red wine, Curry , Licorice , Cocoa, Coffee and Chlorhexidine based oral rinses, all tend to stain natural teeth and discolour the provisional fixed prostheses to an even greater extent, largely because of material porosity.

Fujimoto J. et al (1980)[16] conducted a study to determine whether commercially available fluoride solutions would etch the glazed porcelain under laboratory conditions. The prepared samples were then exposed to APF solutions for varying time periods. The surfaces changes were then exposed to APF solution for varying time periods. The surfaces changes were noted visibly and also by SEM analysis. The results showed that visibly notable changes were seen and also confirmed by SEM studies. The amount of roughness increased as a function of the length of

immersion to APF gel. SEM revealed 2 types of particles – large irregularly shaped particles and submicron sized particles partially buried in the surface.

Schlissel E R, Melnick LW (1980)[33] studied the effect of several commercially available fluoride preparations on the surface smoothness of self-glazing porcelain. Porcelain fused to metal crowns was subjected to 3 types of fluoride preparations with varying pH and fluoride concentrations. The results showed that APF gel caused significant surface roughness at 3 months, while at 12months the glaze was completely destroyed. Neither the APF rinse nor neutral rinse caused etching of porcelain surfaces.

Thompson V P. et al (1980)[42] conducted a study to determine the cumulative effect of topical fluoride applications on dental porcelain restorations. Ceramic specimens were immersed in fluoride solutions for varying time periods and their average weight loss was determined. The results showed that the weight loss was approximately linear with time. The loss of glaze was distinctly visible when viewed through light microscopy and in SEM studies. Topical fluoride caused etching and roughened the porcelain surfaces within clinically significant time periods.

Lacy a. Et al (1982)[23] studied the effect of 20 minute application of five topical fluoride preparations. The ceramic specimens were baked, exposed to the solutions and subjected to SEM. The resultsof SEM photographs indicated significant corrosion of porcelain surfaces by APF gel and thera-flur. ph did not appear to be directly related to the observed degree of corrosion. The over glazed porcelain revealed sites of selective etching which were morphologically different than the autoglazed porcelains.

Copps D P et al (1984)[10] conducted a study to determine various low fusing porcelains were affected by five common fluoride rinses and gels. Specimen holders were made by induction casting a Ni-Cr alloy into phosphate bonded molds produced from injection – molded wax patterns containing three 4x4x4mm wells. All porcelains were baked ground with porcelain-reducing wheel and autoglazed to a glossy surface. Selected specimens were glazed with over glaze. Half of each specimen covered with wax wafer served as control while other half was exposed to fluoride solution. The results of the study showed that APF preparations over porcelain restorations should be used with a caution. The over glazed porcelain specimens were susceptible to corrosion by APF preparations. The use of SnF2 and neutral fluoride preparation did not affect this dental porcelain.

Jones D A. (1985)[20] conducted a study to determine whether high potency low frequency APF gel could pose a risk to glazed porcelain restorations. Twelve circular buttons of vita porcelain were baked. The right and left half of each disk was smoothened and baked at 920ºC to a natural glaze. The right side of each disk was instrumented to remove the glaze, refine at 900ºC with an over glaze. The specimens were divided into two groups each containing 5 specimens were immersed in 1.23% APF gel and 0.4% SnF2 gel. The remaining 2 served as control one was immersed in 0.2% neutral NaF rinse and other in tap water. The results showed that porcelain specimens immersed in APF gel were adversely affected and thus not be used where glazed porcelain restorations are present.

Power JM, Ferracane, Moser, Greener (1985)[28] stated that causative factors that may contribute to the change in colour of aesthetic restorative materials include stain accumulation, dehydration, water sorption, leakage, poor boning and surface roughness, wear or chemical degradation, oxidation of the reacted carbon-carbon double bonds that produces coloured peroxide compounds ,and continuing formation of the colour degradation products.

Ruyter, Asmussen (1986)[31] studied surface staining of restorative materials. Provisional materials may change colour under these conditions as a result of complex interaction of a number of factors, including, but not limited to, incomplete polymerisation, water sorption, surface reactivity and patient's diet and oral hygiene regimen.

Sposetti V J. et al (1986)[40] prescribed topical fluorides for patients after undergoing radiotherapy for head and neck tumors. These acidic solutions could etch and roughen the ceramic and enamel after repeated applications. The authors conducted a study to investigate the long –term effect of different fluorides; to identify the chemical makeup of the affected surfaces to reveal the surfaces morphology of the porcelain samples and to suggest a mode of prevention and alternative method of prescribing topical fluoride for patients with existing restorations. Porcelain specimens of 7x7x3mm³ were prepared according to manufacturer instructions. Specimens were then exposed to four commercial fluoride gels for varying lengths of time, then examined for sem and x-ray diffraction followed by a chemical analysis with energy dispersive analysis of x-ray (EDAX). The results showed that all fluoride preparations caused etching and pitting of porcelain surfaces, the degree of etching being related to the

concentration, pH and duration of immersion. Crystal deposition was seen in both x-ray diffraction data and sem micrographs. Hence, patients undergoing home fluoride treatment with porcelain restorations are advised to use a neutral product that has low viscosity and low fluoride concentration.

Wunderlich R C. et al (1986)[45] conducted a study to evaluate the effect of commercial topical fluoride on the surface of porcelain-fused-to-metal restorations with SEM and surface roughness tracings. Samples of 10mm metal structures with 0.6mm porcelain baked over it according to manufacturer instruction were polished and reglazed to create flat surfaces. Specimens were then exposed to 6 topical fluoride preparations. Surfaces roughness was measured using Surf-analyzer followed by SEM evaluation. The results of the study showed statistically significant differences in roughness found in surfaces exposed to 1.23% APF gel and 8%SnF2. No significant differences in roughness for 2% NaF solution or 0.4% SnF2 gel were seen.

Jack H.Koumjian et al (1991)[21] evaluated the in vivo discolouration of seven resins over a 9-week period. Resin specimens were prepared placed in the facial flange of maxillary complete denture and the lingual flange of the mandibular complete dentures. Patients were given tooth brushes and tooth paste and told not to use any chemical agents for cleansing the dentures. Observations were made at 1, 5, and 9 weeks. No change was detected at the first two evaluations. At the9-week evaluation, four materials, True Kit, Duralay,Trim, and Protemp, showed significantly less staining than did the other three resin tested. All materials tested were acceptable from the stand point of colour stability for short term (five weeks or less) provisional restoration.

Wozniak, Muller, KhoKhar, Nordbo(1991)[47] have suggested that extrinsic factors for discolouration include staining by adhesion or penetration of colourants as a result of contamination of exogenous sources ,eg., coffee and tea, nicotine, beverages and coloured solutions .One or more of these factors may contribute to visibly detectable or aesthetically unacceptable colour change of the prosthesis.

Sebnem Buyukilmaz, Eystein Ruyter, Dr.Philos(1994)[7] conducted a study on colour stability of denture base polymer. One light polymerised, Three heat polymerised denture base polymers were exposed to tea, coffee, water ,at 50˚C±1˚C as well as artificial sunlight and water, and evaluated for colour stability. Coffee and Tea stained the denture base material superficially. They concluded that all materials were relatively colour stable when immersed in water at 50 C˚±1 degree C. The materials behaved differently when exposed to artificial sunlight and water.

Roberto Scotn, Saverio Cario Mascellani, Francesca Forniti(1997)[35] conducted an in-vitro stability of acrylic resins for provisional restorations. They evaluated colour variation of four types of acrylic resin for provisional fixed prostheses using computerised spectrophotometer before and after 20th and 30th day cycle of immersion in four staining solution. Four acrylic resins used for provisional fixed restorations were: Cold Pac, Trim, Protemp and Mixacry II. Thirty two specimens for each resin were divided into four subgroups of eight elements and immersed in the four staining solutions(synthetic saliva ,synthetic saliva and tea ,synthetic saliva and coffee ,and synthetic saliva and Chlorhexidine in 0.12% water solution),and then placed in four thermostatic baths at 37degree±1˚C.All specimens were measured for each resin before immersion

(baseline).After the 20th and 30th days ,the specimens were analysed by computerised spectrophotometry and compared .Only the Cold Pac resin was colour stable in all staining solutions ,while the others showed colour changes from the different staining solutions.

R. Duane Douglas (2000)[14] evaluated and characterized the colour stability of various new generation indirect resins (ceramic-polymers) when subjected to accelerated aging. Four new generation indirect resin systems, 1 direct resin system, and 1dental porcelain control were subjected to accelerated aging for a period of 300 hours. Initial specimen colour parameters were determined in the Commission International de 1'Eclairage lab (CIELAB) colour order system with a colorimeter. Colour changes (ΔE) were calculated between baseline colour measurements and measurements made after 152 and 300 hours of accelerated aging. After 300 hours of accelerated aging, colour changes of the indirect resins ranged between .062 and 3.40ΔE units. Two of the products tested demonstrated colour stability that was not significantly different from the porcelain control.

Alessandro Vichi et al (2004)[43] test the influence of exposure to water on the color stability of three structurally different resin-based composites. Six comparable Vita shades of three different resin-based composite systems were selected. The samples were studied with a spectrophotometer equipped with an integrating sphere. For color determinations, a 50% gray card was used as background, and the data were recorded in the CIE L*a*b system. Opacity was calculated as the ratio of the reflectance of a specimen disk when backed by a black standard that when backed by a white standard. After the initial measurements, the samples were stored for 30 days in a 60 8C water bath and then

measured again under the same conditions. The color shifts were calculated using the formula:

$$\Delta E = [(L1 - L2)) + (a1 - a2) + (b1 - b2)]^{1/2}$$

If the value $\Delta E > 3{:}3$ is taken as the limit for clinical appreciation of color variation, Spectrum showed a mismatch for all the selected shades, all the shade shifts of Tetric Ceram lay within this limit, whilst 67% of the Z100 samples showed a mismatch. Between Tetric Ceram and Z100 no significant difference could be demonstrated, although the overall results were best for Tetric Ceram. The parameter that was most affected was the Lp value, while the ap value was scarcely influenced. The bp values for Tetric and Z100 decreased only a little, whilst this value for Spectrum showed a more perceptible increase (to yellow). There was no clear pattern of color shifts between clearer and darker colors, and no unmistakable differences were noted between A and B based colors. The Opacity of all tested materials increased after water aging, but Tetric Ceram B3 showed a decrease. Some values were particularly high, especially for Spectrum TPH; the A2 shade showed an increase in opacity of 29.7%. A Statistically significant difference was found between Spectrum and Tetric Ceram/Z100, while between Tetric Ceram and Z100 there was no statistically significant difference. As for color, there was no evidence of different and consistent behavior of the clearer and darker colors, and the A and B based colors.

Patricia Villalta, investigate the effects of 2 staining solutions and 3 bleaching systems on the color changes of 2 dental composite resins.

Arthur S. K. Sham, (2004)[38] determine the color stability of 5 provisional prosthodontic materials before and after immersion in distilled water or coffee for

20 days or exposure to ultraviolet (UV) light for 24 hours. Color was measured as CIE L*a*b* with a colorimeter before and after the immersion or UV exposure. Luxatemp and Integrity (bis-acryl-methacrylate–based resins) demonstrated acceptable color stability and were the most color-stable provisional prosthodontic materials tested compared to the methyl/ethyl methacrylate–based resins.

Diab M;Zaazou M.H, et al(2007)[12] investigated the effect of five commercially available mouth rinses on the micro hardness and colour stability of two composite restorative materials . Each group of specimen was immersed after curing in distilled water for 24 hours, removed and blotted dry, then subjected to either micro hardness measurement using Vicker's micro-hardness tester or colour measurement using spectrometer for the base line readings determination. Following that, each group was immersed in 20ml of the assigned treatment solution and incubated at 37˚C for 24 hours. The specimens were then removed, rinsed and blotted dry and re-subjected to micro hardness or colour measurement. The change in hardness value and in colour difference was calculated for each sample. The results revealed that, all the mouth-rinses tested decreased the hardness of both tested resin-composite. The highest reduction in the hardness of both resin-composite restorative materials was found on using alcohol-containing mouth-rinses. All tested mouth rinses produced a colour change in both tested resin-composite. However, the greatest perceptible colour change was observed on using sodium fluoride containing mouth rinses with both resin-composite.

Adriana Postiglione Buhrer Samara et al (2008)[32] assessed the colour stability five aesthetic restorative materials immersed in a coffee solution. They were

Direct Composite Resin Tetric Ceram, Indirect Composite Resin Targis, Indirect Composite Resin Resilab Master, Indirect Composite Resin belleGlass and Porcelain. The specimens were immersed in a coffee staining media for 15 days and stored under the controlled temperature of 37˚C±1˚C in the dark. The evaluation were made after 1, 7, and 15 days by means of the reflectance spectrometry. It was concluded Direct Composite Resin Tetric Ceram and Indirect Composite Resin Resilab Master showed significantly higher discolouration than the other groups. Indirect Composite Resin Targis and Indirect Composite Resin belleGlass showed intermediary pigmentation while Porcelain showed the smallest changes…..

Cigdem Celik et al (2008)[8] evaluated the effects of 3 commercially available mouth-rinses on the colour stability of 4 different resin based composite materials. They were a nano-fill composite Filtek Supreme XT; a packable low shrinkage composite, AeliteLS Packable; nanoceramic composite resin Ceram-X:a micro-hybrid composite ,and Aelite All-Purpose Body. The specimens were incubated in distilled water at 37˚ for 24 hours. The baseline colour values of each specimen were measured with a colorimeter according to the CIELAB colour scale. After baseline colour measurements, 10 randomly selected specimens from each group were immersed in 1 of the 3 mouth rinses and distilled water as control. The specimens were stored in 20ml of each mouth rinse for 12 hours. After immersion the colour values of all specimens were measured and the colour change value ΔE*ab was calculated .all specimens displayed colour changes after immersion and there was a statistically significant difference among restorative materials and mouth rinses (P□.05) however the change was not visually perceptible

(ΔE*ab□3.3). The interaction between the effect of mouth-rinses and type of restorative materials was not statistically significant (P□.05).

Fernanda de Carvalho Panzeri Pires-de-Souza, (2009)[25] evaluated the effects that the number of firings and type of substrate have on the color stability of dental ceramic submitted to artificial accelerated aging. Metal ceramic (Verabond II + IPS d.SIGN) and allceramic (IPS d.SIGN) were divided into 3 groups (n=10), and submitted to 2, 3, or 4 firings (±900°C),respectively, according to the manufacturer's instruction. Color readings were obtained with a spectrophotometer before and after artificial accelerated aging, and L*, a*, and b* coordinates and total color variation (ΔE) were analyzed. For metal ceramic specimens, differences for the L* coordinates were significant (*P*<.05) only for the group submitted to 3 firings. With respect to the all-ceramic specimens, smaller L* coordinates were obtained for greater a* and b* coordinates, indicating that the greater the number of firings, the darker and more reddish/yellowish the specimen. All ΔE values, for all groups, were below 1.0. All-ceramic specimens submitted to 3 and 4 firings presented ΔE means differing statistically (*P*<.05) from those of the metal ceramic group. The type of substrate and number of firings affected the color stability of the ceramic material tested. Artificial accelerated aging did not produce perceptible color stability changes (ΔE<1.0).

Motoko Nakazawa (2009)[25] evaluated the colour stability of two indirect composite materials(Sinfoy and Pearlest) polimerized with different polymerization systems. Disk specimens were prepared with their proprietary systems(visio and Pearlcuresyastem) or with a metal halide light polymerization unit (Hyper LII) for 60,120,and 180s. After storage at 37˚c for 24 hours, the

specimens were immersed in either purified water or tea. The colour changes between the baseline evaluation and after 4 weeks was determined with a dental chromameter, (shadeEyeNCC) using black and white backgrounds. CIE1976L*a*b* values were determined , and they were converted into ΔE*ab values. The ΔE*ab value of the Sinfony material immersed in tea was the highest when the material polymerized with the proprietary Visio system. The Pearlest materiel immersed in the purified water and tea was not affected substantially by the polymerization systems.

Triantafillos Papadopoulos et al (2010)[26] Four indirect composites (Gradia, Signum, HFO and Adoro) were used. Lange Microcolor Data Station colorimeter (Braive Instruments, Liege, Belgium) was used to measure specimen colour before and after aging. Measurements were performed according to the CIE L*a*b* system, and the mean L*, a* and b* values for each material were calculated. The equation $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ was used to measure the total colour change (ΔE), where ΔL*, Δa* and Δb* are the differences in the respective values before and after aging. Colour changes were found to be within accepted values of perceptibility and clinical acceptance after accelerated aging, and no statistically significant differences were found in ΔL*, Δa*, Δb* and ΔE among the materials tested.

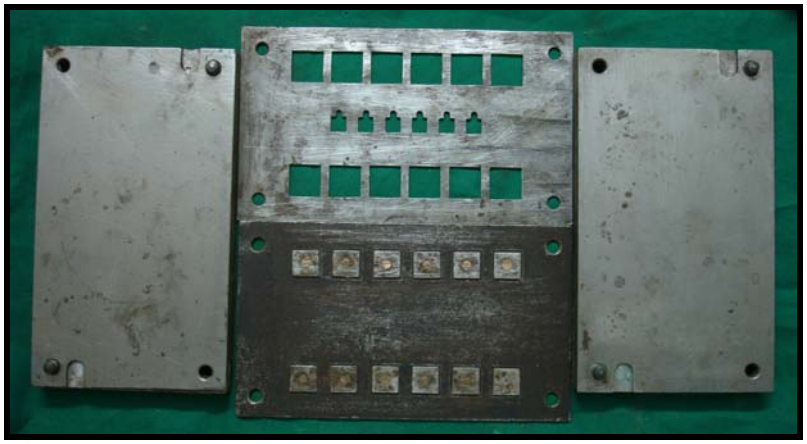


Fig. 1 Custom-made Metallic mold and metallic plates

a) Base b) Middle plate I c) Middle plate II d) Lid

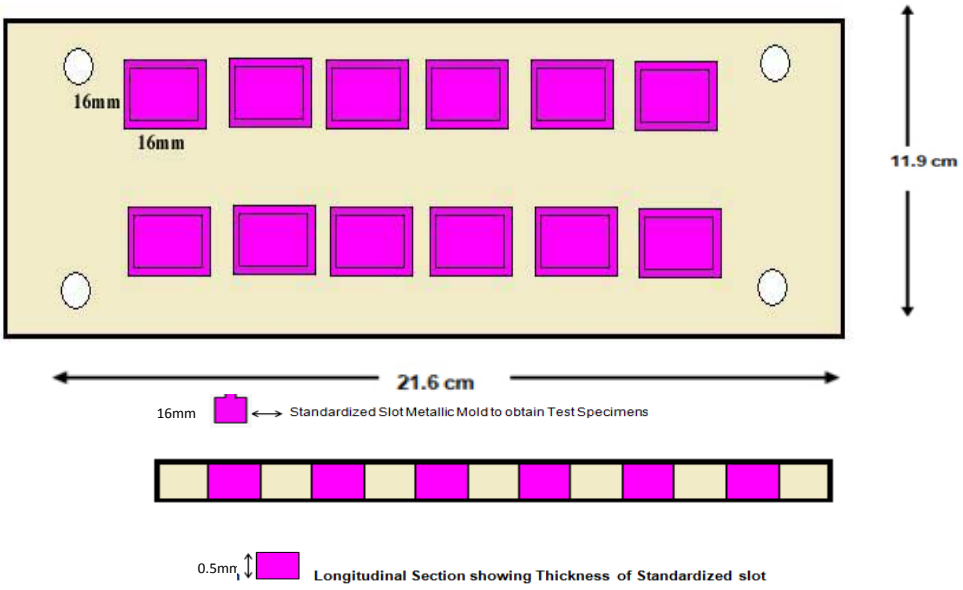


Fig. 2 Line diagram of middle plate I

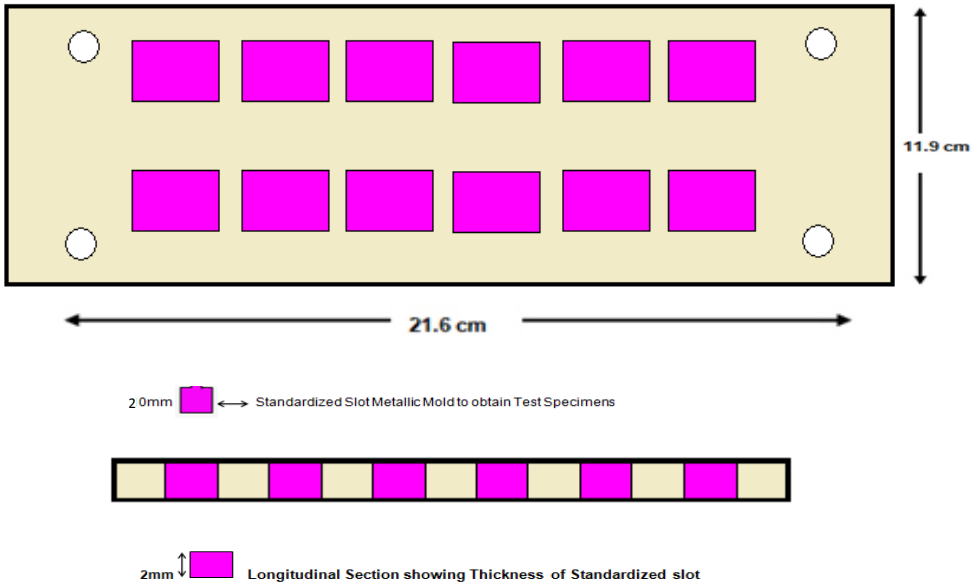


Fig. 3 Line diagram of middle plate II

Fig. 4 a) Petroleum jelly b) Pattern resin

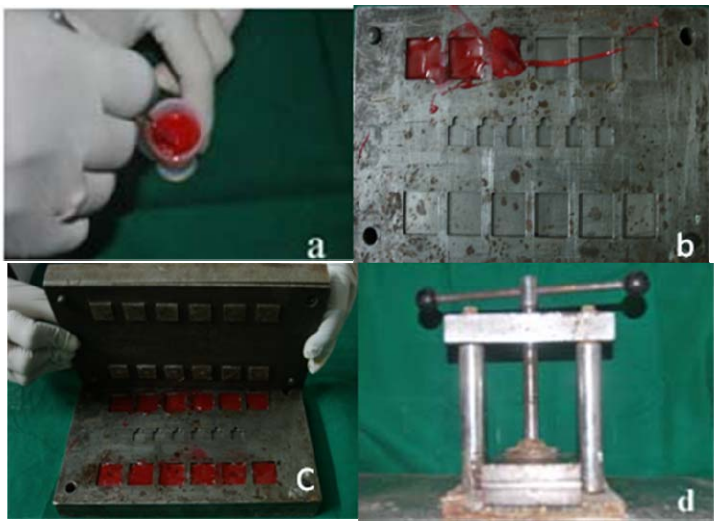


Fig. 5 Procedure employed in making the resin patterns

a) Manipulation of pattern resin

b) Filling the slots with pattern resin

c) Closing with the lid d) Bench press

Fig. 6 Standardized resin patterns

Fig. 7 Materials employed for casting of metal substructure.

a) Sprue Wax 2.5mm diameter b) Surfactant

c) Investment ring and crucible former

d) Phosphate bonded investment material e) Investment liquid

f) Separating discs (0.7mm) g) Base metal – nickel chromium alloy

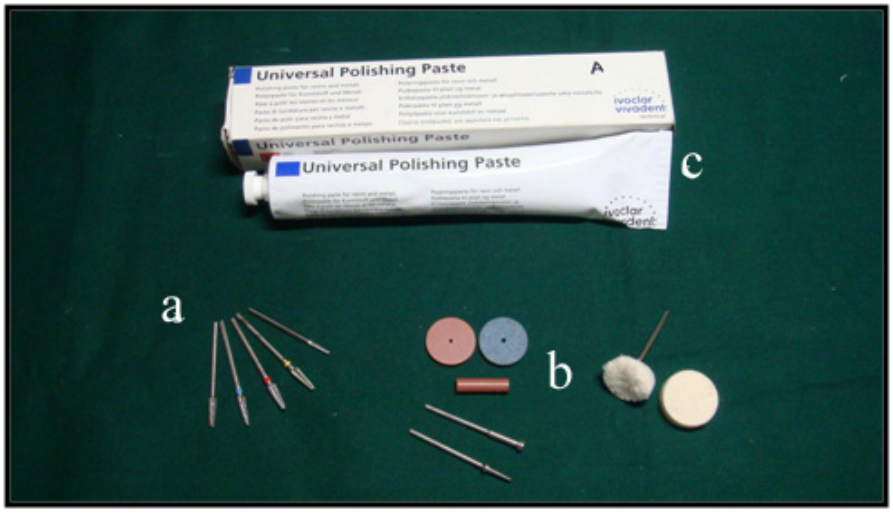


Fig. 8

a) Metal trimming burs b) Metal polishers

c) Metal polishing paste

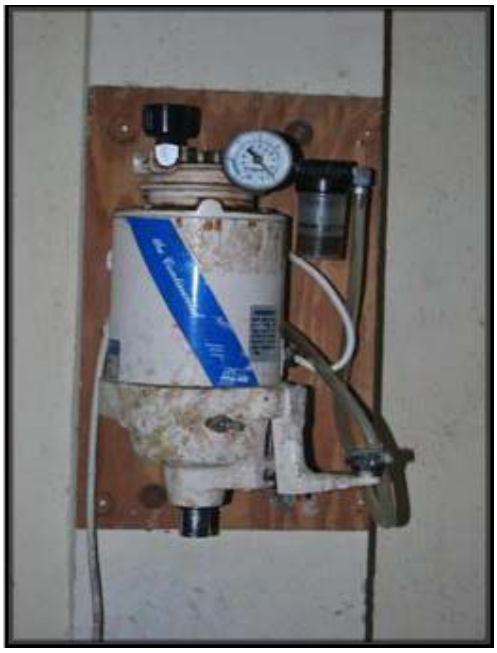


Fig. 9 Vacuum mixer

Fig. 10 Burnout Furnace

Figure.11 Induction casting machine

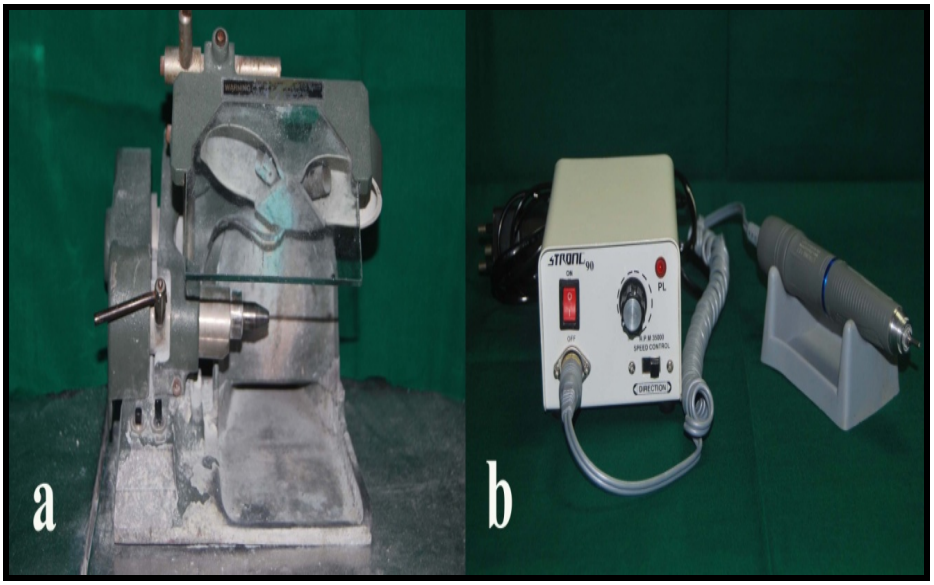


Fig. 12

a) Alloy grinder

b) Micromotor

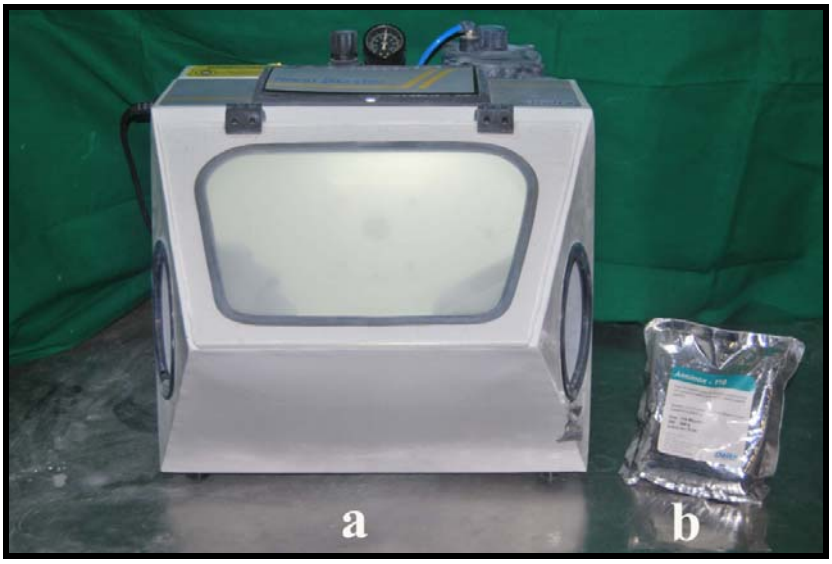


Fig. 13

a) Sandblaster

b) Aluminum oxide power

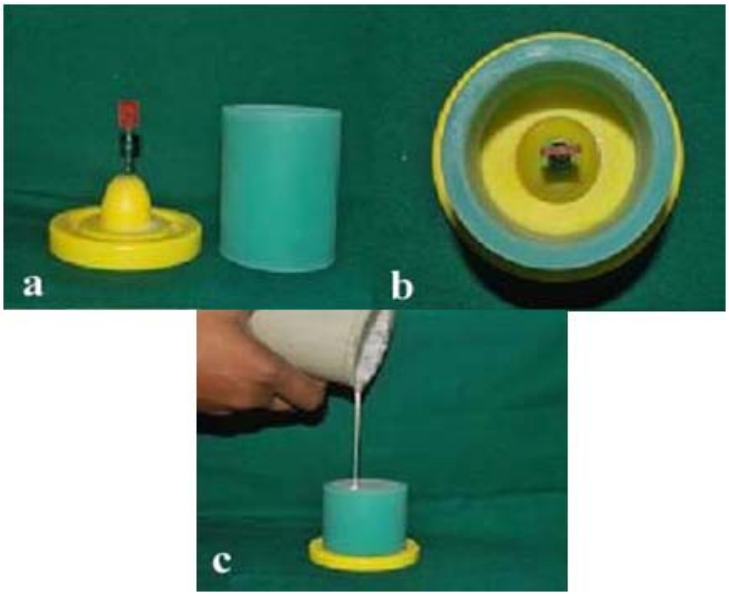


Fig. 14 Procedure employed for investing of resin patterns

a) Pattern attached to crucible former

b) Pattern position in the sili ring

c) Investing the pattern

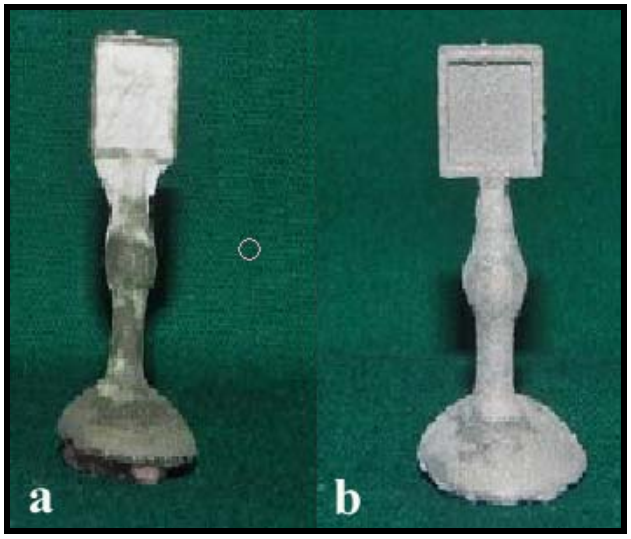


Fig. 15

a) Divested casting

b) Sandblasted casting

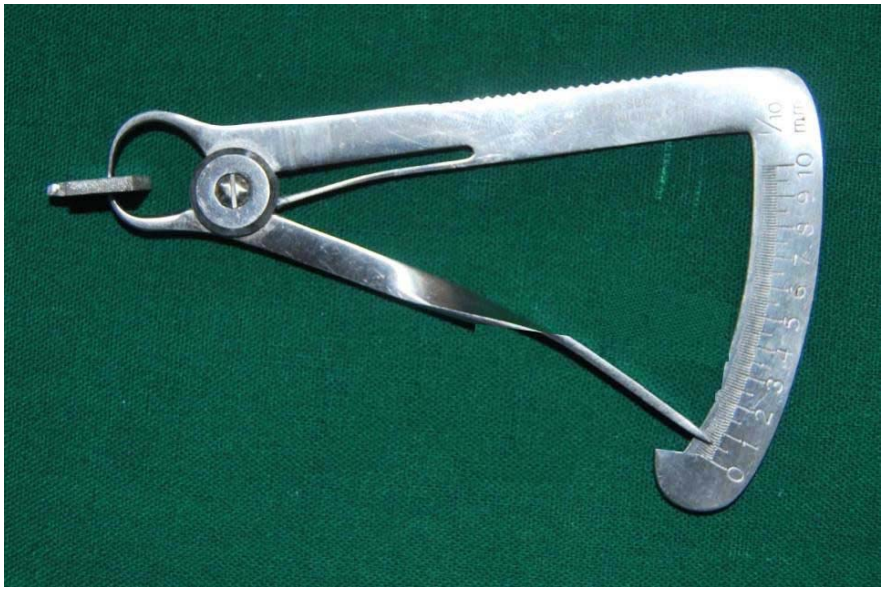


Fig. 16 Thickness of metal substructure

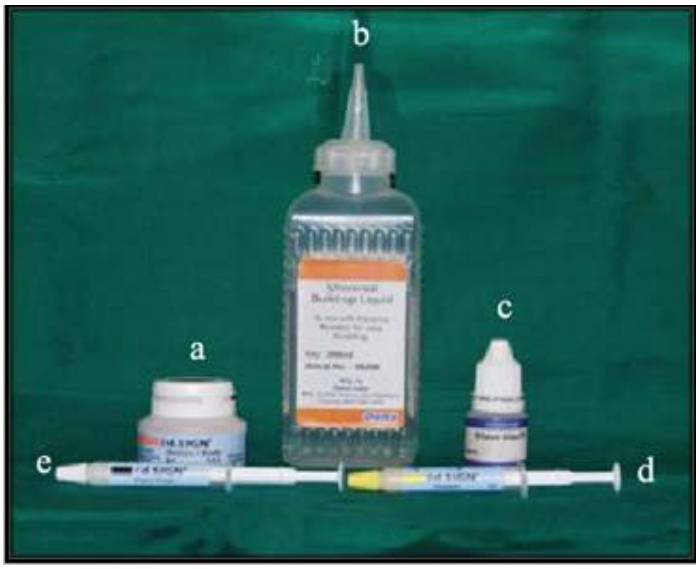


Fig. 17 Materials employed for veneering ceramic to metal substructure

a) Ivoclar d-sign ceramic powder b) Ceramic build up liquid

c) Glaze liquid d) Opaquer e) Glaze paste

Fig. 18

a) Ceramic separating blade b) Tissue paper

c) Sintered diamond burs d) Glass slab

e) Ceramic brush

Fig. 19 Ceramic furnace

Fig. 20 Samples after ceramic veneering

Fig. 21 Materials employed for veneering ceramic repair composite to metal substructure

a. Bonding agent b. Ceram X Mono c. Opaquer and Porcelain conditioning

Fig. 22 Light cure unit

Fig. 23 Samples after ceramic repair composite veneering

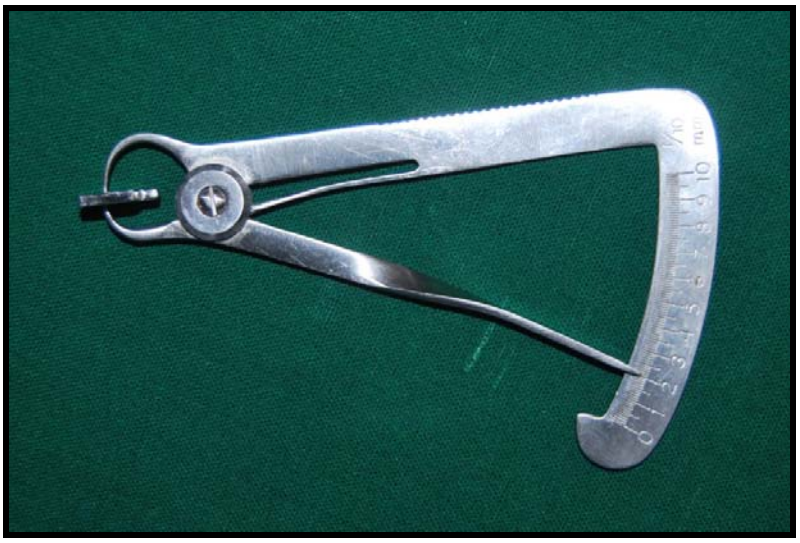


Fig. 24 Thickness of sample after ceramic repair composite veneering

Fig. 25 Materials employed for veneering indirect composite resin to metal substructure

a.SR Opaquer b.SR Dentin c.SR Link d. SR Gel e.SR Thermo guard

Fig. 26 luminant 100

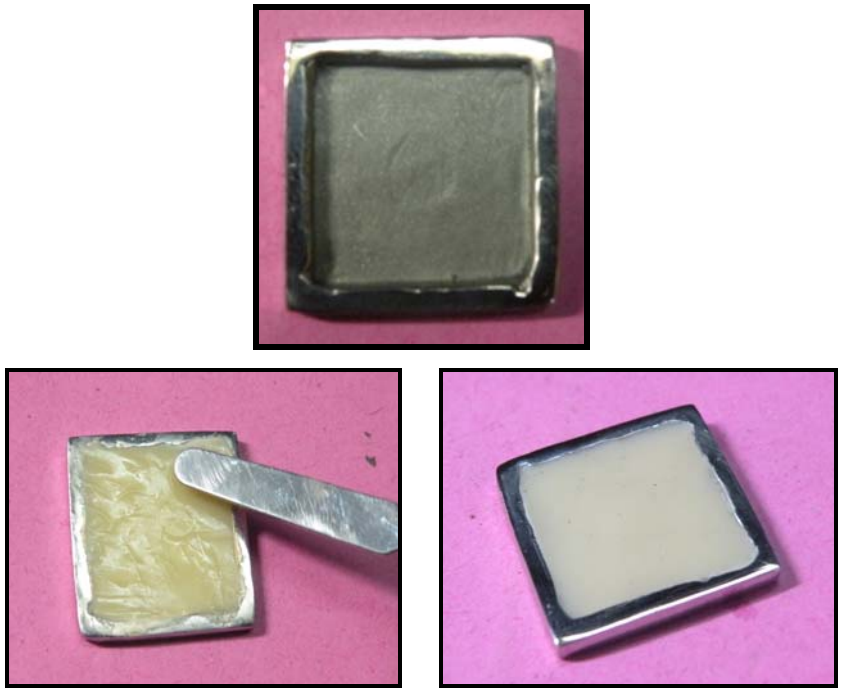


Fig. 27 Samples after indirect composite resin veneering

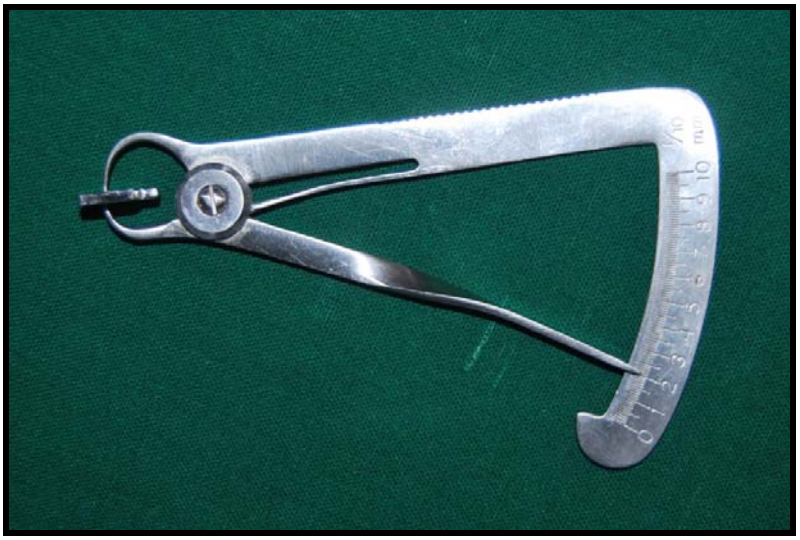


Fig. 28 Thickness of sample after ceramic repair composite veneering

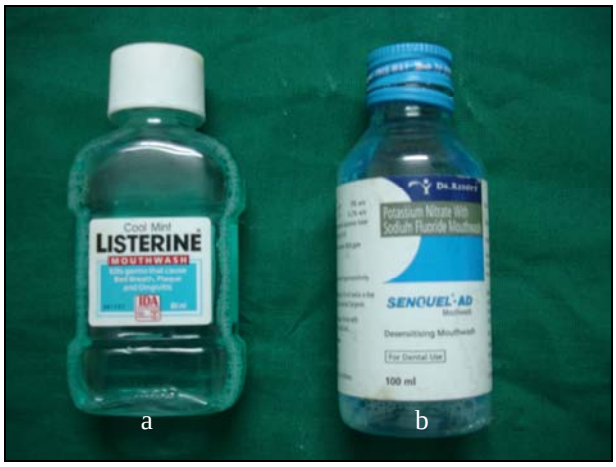


Fig. 29 a) Listerine b) Senquel - AD

Fig. 30 Samples immersed in artificial saliva

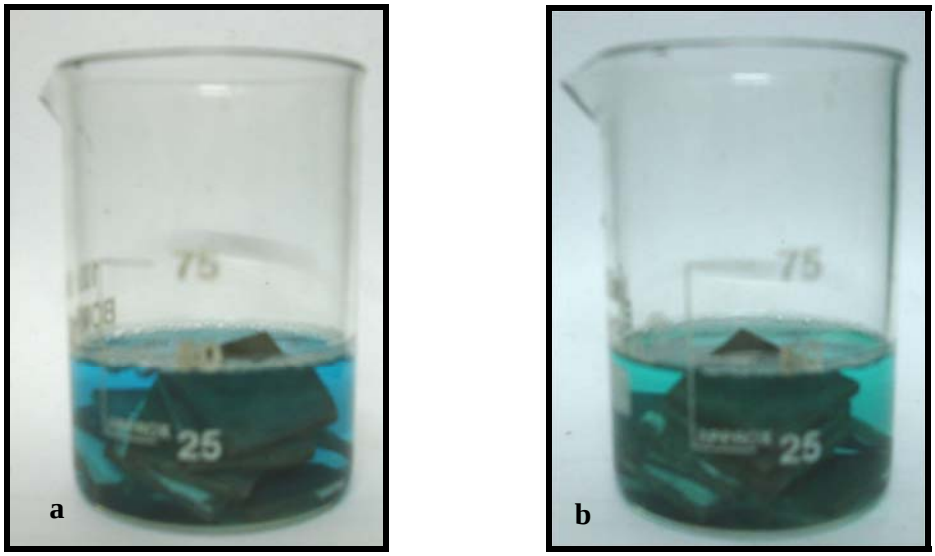


Fig. 31

a) Samples immersed in fluoride mouth rinse

b) Samples immersed in non - fluoride mouth rinse

Fig. 32 Spectrophotometer

Fig. 33 Scanning Electron Microscope

Fig. 34 Gold sputtered test samples

MATERIALS AND METHODS

The present in-vitro study was conducted to comparatively evaluate the effect of two chemically different mouth rinses on the color stability and surface topography of three esthetic veneering materials.

The following materials were used for this study:

1. Metallic mold for obtaining standardized test samples (Custom-made) (Fig. 1)
2. Pattern resin (GC Corporation, Tokyo, JAPAN) (Fig.4a)
3. White petroleum jelly (Tejpal and Co., INDIA) (Fig.4b)
4. Sprue Wax (Bego, GERMANY) (Fig.7a)
5. Surfactant spray(Uni coat, Delta, INDIA) (Fig.7b)
6. Investment ring (Sili Ring, Delta, INDIA) (Fig.7c)
7. Phosphate bonded investment material (Bellasun Bego, GERMANY) (Fig.7d)
8. Investment liquid(Colloidal silica, Bego, Germany) (Fig.7e)
9. Base metal Nickel Chromium alloy(Bellabond Bego, GERMANY) (Fig.7g)
10. Aluminium oxide powder for sandblasting (110μm) (Delta, INDIA) (Fig.13b)
11. Separating discs 0.7mm thickness (Dentorium, New York, USA) (Fig.7f)
12. Metal trimmers (Edenta,Switzerland) (Fig.8a)
13. Metal polishers (Edenta,Switzerland) (Fig.8b)
14. Silicon carbide rubber points, white and grey (Dentsply/Caulk)

15. Metal polishing paste (Ivoclar Vivadent, Italy) (Fig.8c)

16. Custom-made artificial saliva (Fig.30)

Composition of artificial saliva:

- Sodium carboxymethylcellulose – 10g/l
- Potassium chloride – 0.62g/l
- Sodium chloride – 0.87g/l
- Magnesium chloride – 0.06g/l
- Calcium chloride – 0.17g/l
- Di-potassium hydrogen orthophosphate – 0.80g/l
- Potassium di-hydrogen orthophosphate – 0.30g/l
- Sodium fluoride – 0.0044g/l
- Sorbitol – 29.95g/l
- Methyl p-hydroxybenzoate – 1.00g/l
- Spirit of lemon – 5ml

Three veneering materials were used in this study

Ceramic veneering system employed

- Fluorapatite leucite ceramic (Ivoclar d sign, Ivoclar vivadent AG, Liechtenstein, A3 Shade – vita lumin) (Fig.17a)
- Ceramic slab (Vita, Bad Sachingen, Germany) (Fig.18d)
- Ceramic Holder (Ivoclar vivadent AG, Liechtenstein)
- Ceramic Honeycomb tray (Vita, Bad Sachingen, Germany)
- Ceramic brushes (Ivoclar vivadent AG, Liechtenstein) (Fig.18e)
- Tissue paper (Premier Aryco, India) (Fig.18b)

- Sintered diamond burs (Diatech dental AG, Heerburgg, Switzerland) (Fig.18c)

Ceramic repair composite Employed

- Ceramic conditioning agent (Angelus, Brazil) (Fig.21c)
- Opaque A3 shade (Angelus, Brazil) (Fig.21c)
- Bonding agent (Adper single bond 2, 3M ESPE, Germany) (Fig.21a)
- Ceram X mono (Nano Ceramic Composite, DENTSPLY De Trey GmbB, Germany) (Fig.21b)

Indirect veneering composite system employed –

- SR Adoro basic kits (Ivoclar vivadent AG, Liechtenstein) (Fig.25)
  - → SR Opaquer (Fig.25a)
  - → SR Dentin (Fig.25b)
  - → SR Link (Fig.25c)
  - → SR Gel (Fig.25d)
  - → SR Thermo guard (Fig.25e)

The following two chemically different mouth rinses were used for the study:

1. **Listerine – Non-fluoride mouth rinse (Johnson and Johnson limited, Mumbai)** (Fig.29a)

Thymol I.P. – 0.06%w/v

Eucalyptol PCx – 0.09% w/v

Menthol I.P. – 0.04% w/v

Ethanol (95%) I.P. –21.6%v/v

Color: Fast Green FCF

2. **Senquel – AD - Fluoride mouth rinse (Dr. Reddy laboratories LTD, Hyderabad)** (Fig.29b)

Potassium Nitrate BP – 3%w/v

Sodium fluoride IP – 0.2% w/v

Color: Brilliant Blue FCF

The following equipments were used for the study:

Laboratory equipments:

- Vacuum power mixer (the continental, whip mix, Kentucky, USA) (Fig.9)
- Burnout furnace (Technico, Technico laboratory products PVT, LTD, Chennai INDIA) (Fig.10)
- Induction casting machine (Fornax GEU, Bego, Germany) (Fig.11)
- Sand blaster (Basic professional, Renfert GmbH, Germany) (Fig.13a)
- Alloy grinder (Demco, dental maintenance Co., INC, California, USA) (Fig.12a)
- Dental ceramic furnace – Vita-Vacumat 100 (Vita, Bad Sackingen, Germany) (Fig.19)
- Micro motor (Micro motor strong series, saeshin precision Find. Co, Korea) (Fig.12b)
- Light cure unit (Confident, India) (Fig.22)
- Luminant 100 (Ivoclar vivadent AG, Liechtenstein) (Fig.26)

Testing equipment:

- Spectrophotometer (USB 2000, ocean optics, UK) (Fig. 32)
- Scanning electron microscope (JEOL, ASM 6360, JAPAN) (Fig.33)

Description of custom made metallic mold:

The present study was conducted with test samples having a metal substructure overlaid with veneering materials. To obtain standardized test samples with the dimensions as required by the testing equipment in this study, a custom metallic mould (Fig.1) was fabricated with stainless steel. It consists of four parts a) Base (Fig.1a), b) Middle Plate – I (Fig.1b) c) Middle Plate – II (Fig.1c) d) Lid (Fig.1d). The base portion consists of a thick flat plate which measures of 21.6mm X 11.9mm. Four rivets are placed at the corner of the base and corresponding holes are present in the middle plate and upper lid to aid in seating and orienting the subsequent plates precisely.

Middle plate – I had 12 square elevations with dimensions 16x16mm, with an elevation of 1.5mm from the plate (Fig.2). Middle plate – II was a 2mm thick plate which had 12 square windows, each measuring 20x20mm (Fig.3).When middle plate – II was seated over the middle plate I, each square projection on middle plate – I was located exactly at the centre of each window on the middle plate – II, which leaves a space of 1.5mm between the projection on middle plate - I and the periphery of the window on middle plate – II. Similarly the surface of the projection on middle plate – II was also at a distance of 0.5mm from the surface of the middle plate - II. This sort of a design helped in obtaining metal samples that had a depression of 16x16x1.5mm dimensions in the centre,

which formed the standardized space for the ceramic. Acrylic resin patterns of standardized dimensions were prepared with this mold, which were subsequently cast to obtain the metal substructure.

Fiber optic Spectrophotometer for color analysis:

The color of the ceramic veneering test samples in this study was analyzed by using the Fiber Optic Spectrophotometer (Fig.32) (USB 2000, ocean optics, UK). An oo II rad C software was used to analyze the data. CIE illuminant D65 was used in all color measurements. CIELAB (1976) color space was used for the color measurements. Glossy white and black tiles were used as the standards.

The Fiber Optic reflectance probes in the Spectrophotometer are ideal for measuring the absorption characteristics of solid surfaces, powdered substrates and liquid and are extremely valuable for a variety of applications where traditional spectrophotometers simply are not feasible. The reflectance probes cover the wavelength range in the visible range from 400nm-700nm and allows the user to perform an analysis on site at the location of the sample thus saving time and expense.

Two types of reflectance probes are available for measurement of color. The two varieties accommodate single and dual source configurations. In this present study Single Lamp Reflectance Probe was employed which consists of a single 400µm input fiber encircled by twelve 200µm source fibers providing 360 degrees of illumination of a spot approximately 1cm in diameter. The reflected light is then collected by the centrally located input fiber.

Description of Scanning Electron Microscopy (SEM) for surface texture analysis:

In the present in-vitro study the surface texture of the three veneering materials (ceramic veneering material, ceramic repair composite material, Indirect composite resin material) were analyzed for surface topographic changes using the Scanning Electron Microscope. (JEOL, ASM 6360, JAPAN) (Fig.33)

Electron Microscope uses a beam of highly energetic electrons (1 keV-1MeV) to examine objects on a very fine scale (0.2nm upwards). As the name suggests, SEM uses a scanned beam rather than a fixed beam and is used primarily for the examination of thick (i.e., electron opaque) samples. The samples to be magnified may have some conductivity and may get charged up and hence they are coated with a platinum or gold layer to prevent the charging and in order to increase the secondary emissions. Sometimes the samples may be coated with tungsten when a higher magnification is essential.

The incident electron probe scans the samples surface and the signals produced are used to modulate the intensity of a synchronously scanned beam on a Cathode Ray Tube (CRT) screen. The Electron which are back scattered from the sample are collected to provide (i) topographical information (i.e. detailed shape of the sample surface) if low energy secondary electrons ($\leq$ 50eV) are collected; (ii) atomic number and reorientation information if the higher energy, back scattered electrons are used, or if the leakage current to the earth is used. The magnification is given immediately by the ratio of the CRT scan size to the sample scan size.

Methodology

The methodology adopted for this in-vitro study has been divided into following stages:

I. Preparation of the test samples:

a) Preparation of auto-polymerizing resin patterns to obtain the cast-alloy substructure. (Fig.5)

- Fabrication of Custom-made metallic mold
- Fabrication of resin patterns

b) Fabrication and finishing of the nickel-chromium cast-alloy substructures. (Fig 14)

- Spruing the patterns
- Investing the patterns
- Pattern elimination
- Casting
- Divesting and finishing metal substructure

c) Grouping the test samples

d) Veneering of the metal substructure with the test veneering materials

1) Veneering with ceramic (Fig.20)
2) Veneering with ceramic repair composite (Fig.23)
3) Veneering with indirect composite resin (Fig.27)

II. Preparation of artificial saliva

III. Immersion of test samples in artificial saliva (Fig.30)

IV. Immersion of test samples in fluoride and non-fluoride mouth rinses (Fig.31)

V. Color measurements of the test samples

VI. Post immersion surface topography analysis

I. Preparation of test samples:

a) Preparation of auto-polymerizing resin patterns to obtain the cast-alloy substructure: (Fig.5)

The custom-made metallic mold as described previously, was used to fabricate standardized acrylic patterns. A thin coat of white petroleum jelly (Tejpal and Co., India) (Fig.4a) was applied over all the components of the metal mold on all sides. The middle plate – I and middle plate – II are placed over the base. Pattern resin was mixed as per manufacturer's instructions and filled into the slots of metallic mold formed by placing Middle Part – II over the Middle Part – I (Fig.5b). The lid of the metallic mold was placed over the middle plate II by aligning the rivets on the four corners (Fig.5c). The metallic mold assembly was held in position by placing it under a bench press till the resin patterns polymerized completely (Fig.5d). After the pattern resin polymerized, the upper lid was removed and resin patterns were retrieved from the mold. The patterns were checked for any defects and if found defective, were discarded and remade. In this manner a total of 63 resin patterns were fabricated.

The following steps were followed to obtain metal substructure from the resin patterns.

b) Fabrication and finishing of the nickel-chromium cast-alloy substructures: (Fig.14)

Sprue wax (Bego, Germany) (Fig.7a) of 2.5mm diameter and 3mm length were attached to the patterns. One end of the sprue was attached to the patterns and the other to the crucible former (Whip Mix, Germany). The pattern was sprayed with surfactant spray (Uni coat, Delta, India) (Fig.7b) to improve wetability of the pattern. Casting ring (Sili Ring, Delta, India) (Fig.7c) was

positioned around the sprued pattern on the crucible former. The sprued pattern was then invested with phosphate bonded investment material (Bellasun Bego, Germany) (Fig.7d) and mechanically mixed with investment liquid (Colloidal silica, Bego, Germany) using vaccum mix (Continental, Whip Mix, Kentucky, USA) (Fig.9). After 30 min of bench cooling the set investment mold was placed in the burn out furnace (Technico, Technico laboratory products PVT, LTD, Chennai INDIA) (Fig.10) along with the casting crucible at room temperature. Burn out of the pattern resin was done using a programmed preheating technique, i.e., the ring was kept in the furnace at room temperature and was heated continuously till 950ºC at the rate of 8ºC/min and held for 30min at 950ºC.Casting procedure was performed quickly to prevent heat loss from the ring resulting in the thermal contraction of the mold. The preheated casting crucible and the investment mold were taken out of the furnace and were placed in the casting machine (Fornax GEU, Bego, Germany) (Fig.11). Casting was done in an induction casting machine. The nickel-chromium alloy (Bellabond Bego, Germany) (Fig.7g) was heated sufficiently (melting point 1260-1350ºC casting temperature - 1500ºC) till the alloy ingot turned to molten state, and the crucible was released and centrifugal force ensured the completion of the casting procedure. Investment was allowed to cool down to room temperature. Divestment was done and casting was retrieved. The same procedure was carried out for all the samples. A total of 63 samples were obtained. All the metal substructures were subsequently finished and polished.

c) Grouping the test samples:

A total of 63 samples of metal substructures were finished and polished. The metal substructures were divided into 3 groups as GROUP-I, GROUP-II, &

GROUP-III, consisting of 21 samples each and were veneered with ceramic veneering material, ceramic repair composite material and indirect composite resin material respectively. All the 63 samples were immersed into artificial saliva and are considered as control group.

GROUP-I: Comprised of 21 test samples, Fluorapatite leucite ceramic (Ivoclar d sign, Ivoclar vivadent AG, Liechtenstein), A3 shade was veneered over metal substructure.

GROUP-II: Comprised of 21 test samples, Ceramic repair composite (Angelus, Brazil, Ceram X mono -NanoCeramic Composite, DENTSPLY De Trey GmbB, Germany) A3 shade was veneered over metal substructure.

GROUP-III: Comprised of 21 test samples, Indirect composite resin material (SR Adoro basic kits, Ivoclar vivadent AG, Liechtenstein) A3 shade was veneered over metal substructure.

CONTROL GROUP: All the 63 samples were immersed in artificial saliva.

GROUP-I samples were further divided into three subgroups and they were named as Ia, Ib, & Ic. Likewise each GROUP-II and GROUP-III samples were also randomly divided into three subgroups and they were named as IIa IIb, & IIc, and IIIa, IIIb, & IIIc.

GROUP-Ia: Comprises of one test sample of the control group, used for evaluating surface topography by SEM analysis.

GROUP-Ib: Comprises of 10 test samples of the control group immersed in fluoride mouth rinse. All the 10 samples were subjected to spectrophotometry evaluation. After spectrophotometry evaluation, one test sample of GROUP-Ib was randomly selected for evaluating surface topography by SEM analysis.

GROUP-Ic: Comprises of 10 test samples immersed of the control group in non-fluoride mouth rinse. All the 10 samples were subjected to spectrophotometry evaluation. After spectrophotometry evaluation, one test sample of GROUP-Ic was randomly selected for evaluating surface topography by SEM analysis.

GROUP-IIa: Comprises of one test sample of the control group, used for evaluating surface topography by SEM analysis.

GROUP-IIb: Comprises of 10 test samples of the control samples immersed in fluoride mouth rinse. All the 10 samples were subjected to spectrophotometry evaluation. After spectrophotometry evaluation, one test sample of GROUP-IIb was randomly selected for evaluating surface topography by SEM analysis.

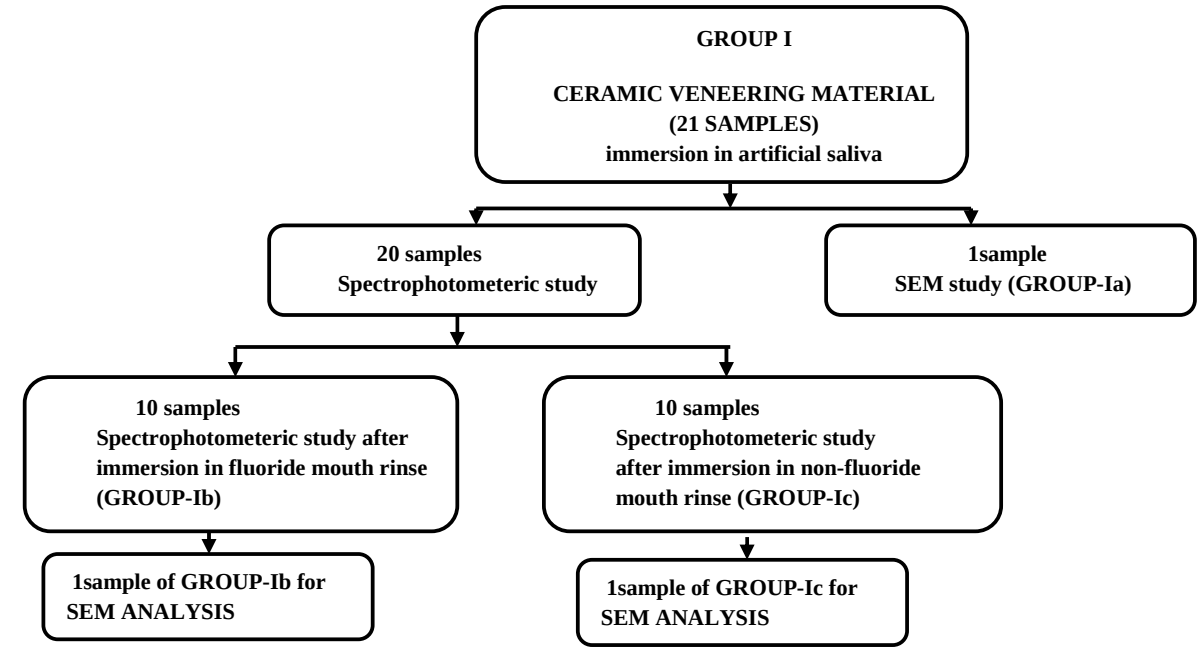
GROUP-IIc: Comprises of 10 test samples immersed of the control group in non-fluoride mouth rinse. All the 10 samples were subjected to spectrophotometry evaluation. After spectrophotometry evaluation, one test sample of GROUP-IIc was randomly selected for evaluating surface topography by SEM analysis.

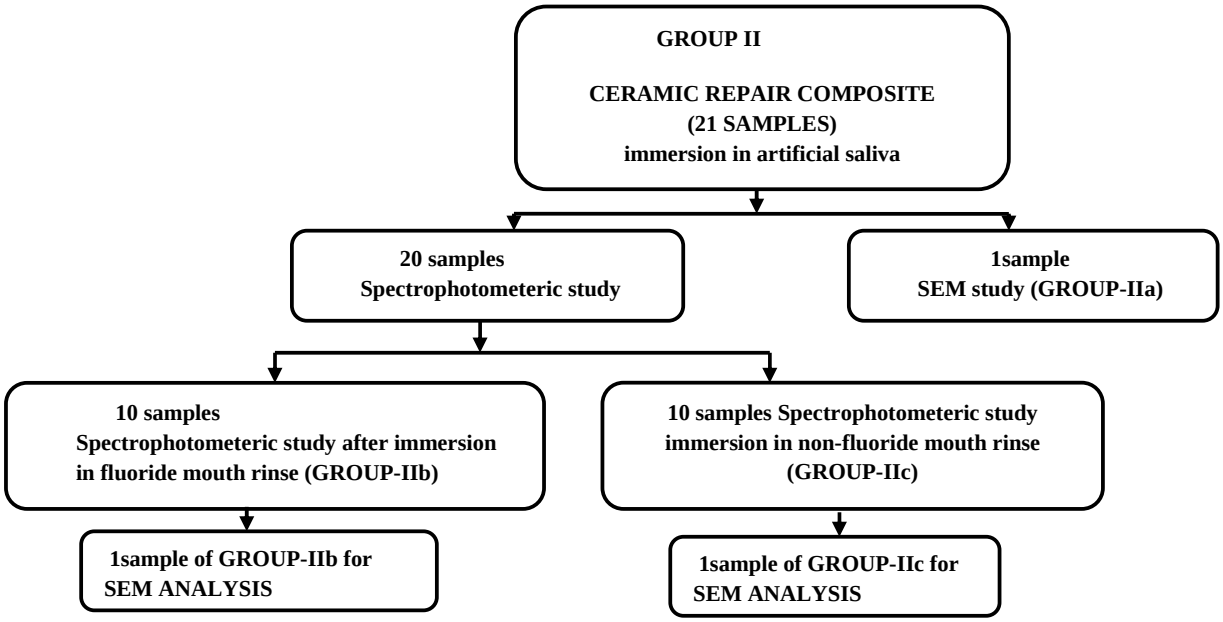
GROUP-IIIa: Comprises of one test sample of the control group, used for evaluating surface topography by SEM analysis.

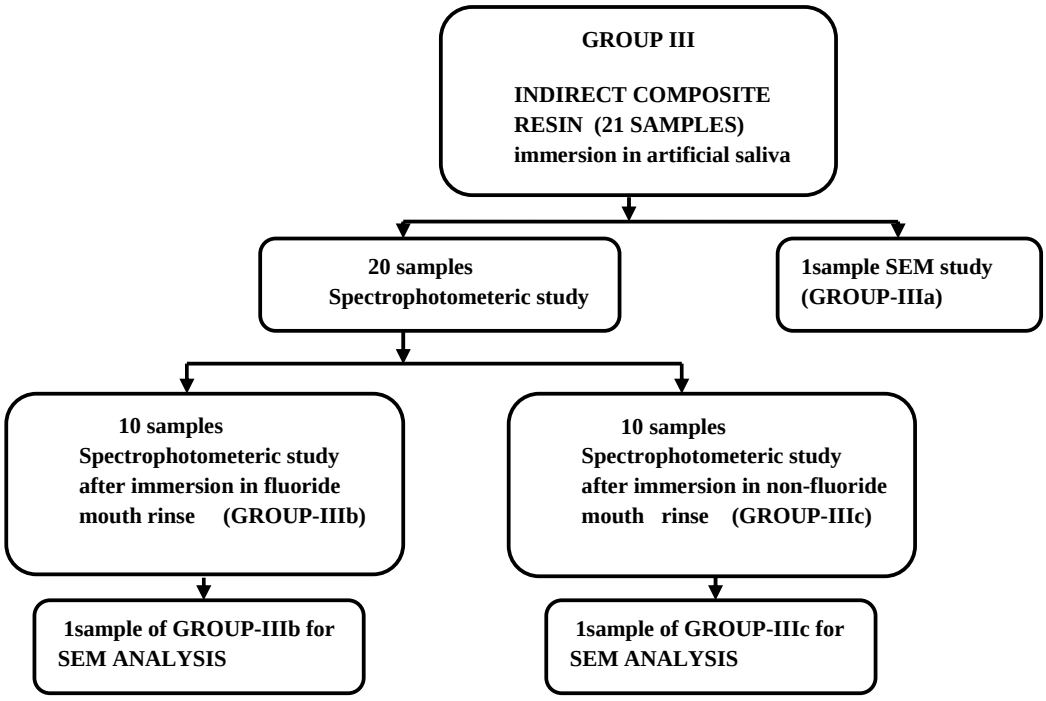
GROUP-IIIb: Comprises of 10 test samples of the control samples immersed in fluoride mouth rinse. All the 10 samples were subjected to spectrophotometry evaluation. After spectrophotometry evaluation, one test sample of GROUP-IIIb was randomly selected for evaluating surface topography by SEM analysis.

GROUP-IIIc: Comprises of 10 test samples immersed of the control group in non-fluoride mouth rinse. All the 10 samples were subjected to spectrophotometry evaluation. After spectrophotometry evaluation, one test sample of GROUP-IIIc was randomly selected for evaluating surface topography by SEM analysis.

Grouping the Samples:







d) Veneering of the metal substructure with the test veneering materials:

1) Veneering of the metal substructure with ceramic veneering material (GROUP-I) :

In this study, fluorapatite leucite ceramic (Ivoclar- d sign, Ivoclar Vivadent AG, Liechtenstein, and GERMANY) (Fig.17a) was employed for veneering the 21 samples of the metal substructure. A3 shade was used for veneering all the samples. Veneering of the ceramic was done in such a way that all the samples had a uniform thickness of 1.5 mm. This was achieved by adding ceramic flush with the rim of the metal substructure. All the test samples were fired in dental ceramic furnace – Vita Vacumat 100 (Fig.19) (Vita, Bad Sackingen, and GERMANY). The sequence of ceramic addition and firing was done as mentioned in Table 1. After the samples were veneered they were measured using an Iwanson's gauge to ensure that the required thickness of ceramic was achieved.

Table 1: Firing schedule for Fluorapatite Leucite ceramic Samples

Firings	T Max (^{o}C)	Preheat (mins)	Heat Up Rate (mins)	Peak temp (mins)	Vacuum Time (mins)
I Opaque	900	6	6	1	6
II Opaque	890	6	6	1	6
I/II Dentine	870	4-9	8	1	8
Auto Glaze	870	4	8	0.5-1	8

2) Veneering of the metal substructure with Ceramic repair composite (GROUP-II):

In this study, ceramic repair composite (Ceram X mono, Nano-ceramic composite, DENTSPLY De Trey GmbB, Germany) (Fig.21b) was employed for veneering the 20 samples of metal substructures which were sand-blasted and steam-cleaned for addition of ceramic repair composite. Hydrofluoric acid gel (Angelus, Brazil) was applied to the metal surfaces of the test samples as per manufacturer's instructions with the help of a nozzle provided along with the gel. Acid etching of the samples were done with 9.5% of the hydrofluoric acid (ceramic conditioning, Angelus, Brazil) for 4 minutes. Then the samples were cleaned with stream of water and were dried thoroughly with oil free compressed air. The cured opaque A3 shade (Angelus, Brazil) (Fig.21c) was painted on the metal surface with help of brush and was light cured according to the manufacturer's recommended protocol. The bonding agent (Adper single bond 2, 3M ESPE, Germany) (Fig.21a) was applied over the opaque layer and light cured as per manufacturer's recommendation. Veneering of the composite material (Ceram X mono, Nanoceramic composite, DENTSPLY De Trey GmbB, Germany) (Fig.21b) was done in such a way that all the samples had a uniform

thickness of 1.5 mm. This was achieved by adding composite material to flush with the rim of the metal substructure. Then composite was light cured for 60seconds (20 sec each from four sides). After the samples were veneered they were measured using an Iwanson's gauge to ensure that the required thickness of ceramic was achieved (Fig.24).

3) Veneering with indirect composite resin: (GROUP-III)

The indirect composite resin material (SR Adoro, Ivoclar Vivadent AG, Liechtenstein, and GERMANY, VITA LUMIN A3 shade) (Fig.25) was employed for veneering the 20 samples of the metal substructure. This system combines both light and heat sources for polymerization. Metal substructures were sandblasted and steam cleaned. The procedure for veneering starts with the application of bonding agent (SR Link, Ivoclar Vivadent AG, Liechtenstein, and GERMANY) (Fig.25c) and left dry for 2 minutes. After the completion of bonding, the opaque layer (SR opaquer, Ivoclar Vivadent AG, Liechtenstein, and GERMANY) (Fig.25a) was applied and light cured for 20 seconds. Glycerin based masking gel (SR gel, Ivoclar Vivadent AG, Liechtenstein, and GERMANY) (Fig.25d) was applied and to minimize the formation of oxygen inhibition layer. The final polymerization is carried in the Luminant 100 furnace (Ivoclar Vivadent AG, Liechtenstein, and GERMANY) (Fig.26) at 104ºc for 10 minutes. Next the dentin layering (SR dentine, Ivoclar Vivadent AG, Liechtenstein, and GERMANY) (Fig.25b) was done in increments. Each increment was light cured for 20 seconds. After completion of light curing, samples were covered with SR gel and final polymerization was done in the luminant 100 furnace at 104ºc for 25 min. Before placing in the furnace each time, diethylene glycol /water based paste (SR thermo Guard, Ivoclar Vivadent

AG, Liechtenstein, and GERMANY) (Fig.25e) was applied to all exposed parts, which provides a thermally absorbing (cooling) effect, thereby minimizing the internal tension at the interface between metal and veneering composite. After completion of polymerization, SR gel was removed from the sample under running water and air dried. All the samples had a uniform thickness of 1.5 mm. This was achieved by adding composite flush with the rim of the metal substructure. After the samples were veneered they were measured using an Iwanson's gauge to ensure that the required thickness of composite was achieved.

II) Preparation of Artificial Saliva:

The artificial saliva which was used in the study was custom-made in the laboratory using the ingredients mentioned in the list of materials used in the study. The constituents were mixed in 1 liter of distilled and non-ionized water one by one in a glass jar and were kept ready to be used for the test. Freshly prepared solution was employed for immersing the samples.

III) Immersion of test samples in artificial saliva: (Fig.30)

All the 63 samples of the metal alloy substructure with the three veneering materials were immersed in artificial saliva for 24 hrs to mimic oral environment were considered as control group (GROUP-I, GROUP-II, GROUP-III). One test sample from each group (GROUP-Ia, GROUP-IIa, GROUP-IIIa) was evaluated for surface topography using SEM analysis. The remaining 60 samples of the three veneering materials were immersed in two chemically different mouth rinses and subjected to fiber optic spectrophotometric evaluation to obtain basic color parameters (L*, a*, b*).

IV) Immersion of test samples in fluoride and non-fluoride mouth rinses: (Fig.31)

The number of samples immersed in mouth rinses accounted to 60, as previously used 3 samples for SEM analysis were discarded and could not be used further in the study.

The 60 samples were divided into three groups of 20 samples each corresponding to the three veneering materials used in the study. The 20 samples in each group were further divided into 2 subgroups with 10 samples in each group corresponding to the fluoride (GROUP-Ib, GROUP-IIb, GROUP-IIIb) and non-fluoride (GROUP-Ic, GROUP-IIc, GROUP-III) mouth rinses. All the test samples were immersed in the mouth rinse for a period of 12hours, which corresponds to rinsing the mouth two times per day for 1 year. The 20 samples of each group were then subjected to spectrophotometric evaluation to study the difference in color change among the three veneering materials tested with respect to the two different mouth rinses.

Table 2: Immersion protocol and significance

S.NO	Testing agent	Duration	Significance
1.	Artificial saliva	24hours	Mimic the oral environment
2.	Fluoride mouth rinse	12hours	Rinsing the mouth two times per day for 1 year
3.	Non-fluoride mouth rinse	12 hours	Rinsing the mouth two times per day for 1 year

v) Color measurements:

Method adopted for color measurements of the 60 test samples in artificial saliva followed by immersion in fluoride and non-fluoride mouth rinses,

is described as follows. The color measurements for the test samples were obtained with use of spectrophotometer. All data points were recorded using standard CIE color parameters. The resultant tristimulus values X, Y, Z are then the standard response of the eye to the red, green, and blue stimuli from the object.

In discussing the nature of the color difference between two objects it is helpful to employ the CIELAB colorimetric system. It is based on an approximately uniform three dimensional color space, which means that equal distances between objects in that space are perceived equally. The magnitude and direction or shift of the difference between two color stimuli can be identified. **L*** is the lightness coordinate and **a*** is the redness - greenness coordinate and **b*** is the yellowness – blueness coordinate. The colors of each opponent pair are indicated by the positive and negative values of **a***and **b***. The **L*, a***and **b*** values are derived from the tristimulus values X, Y, and Z. These formulas, as well as those for determining as perceivable color difference between two objects (ΔE) are seen as follows.

$$X = k\sum_{\lambda=400}^{700} R\lambda S\lambda x\lambda$$

$$Y = k\sum_{\lambda=400}^{700} R\lambda S\lambda x\lambda$$

$$Z = k\sum_{\lambda=400}^{700} R\lambda S\lambda x\lambda$$

where, k = 1

Calclulation of (CIELAB) L*, a* and b*:

From the tristimulus values the CIE L*a*and b* values were calculated by using CIE 1976 CIELAB equation.

$L^* = 116(Y/Yn)^{1/3} - 16$

$a^* = 500[(X/Xn)^{1/3} - (Y/Yn)^{1/3}]$

$b^* = 200[(Y/Yn)^{1/3} - (Z/Zn)^{1/3}]$

Where Xn, Yn and Zn are tristimulus values of reference white.

For the D**65** illumination at 2º observer

Xn = 95.017, Yn = 100.00 and Zn = 108.813

All these various parameters are measured and analyzed by the fiber optic spectrophotometer.

Color differences in CIELAB System:

In the CIELAB System, total color differences (ΔE) combines the differences of three independent variables namely:

The lightness difference in the L* axis expressed by ΔL*, the sign of the difference indicates the direction of the variation in relation to psycho sensorial perception.

Negative value means a shift to darker (black).

Positive value means a shift to lighter (white).

The red-green color differences in the a* axis, expressed by Δa*,

Δa* positive means more red.

Δa* negative means more green.

The yellow-blue color differences in the b* axis, expressed by Δb*,

Δb* positive means more yellow.

Δb* negative means more blue.

The L*a*and b* method of expressing color differences is very practical and is frequently used. Finally, the color difference (ΔE) of the samples after immersion in artificial saliva and fluoride and non fluoride mouth rinses was calculated by using 1976 CIE L*, a* and b* (CIELAB) color difference equation

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

Where,

$\Delta L = L^*sample - L^*standard$

$\Delta a = a^*sample - a^*standard$

$\Delta b = b^*sample - b^*standard$

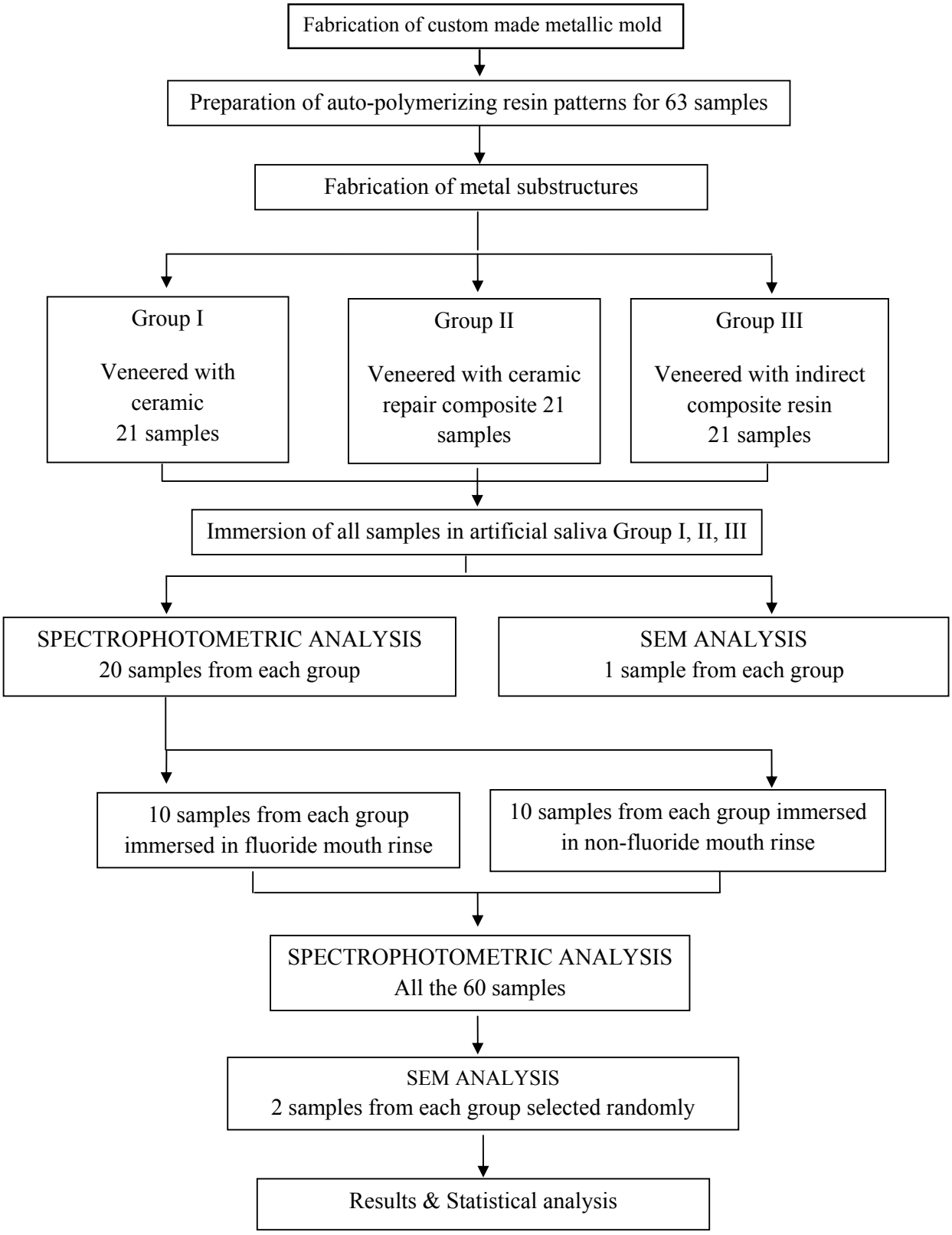
(Standard L*, a*, b* refers to values obtained after immersion in artificial saliva)

The measurements thus obtained for the twenty test samples of the each veneering systems were tabulated and statistically analyzed.

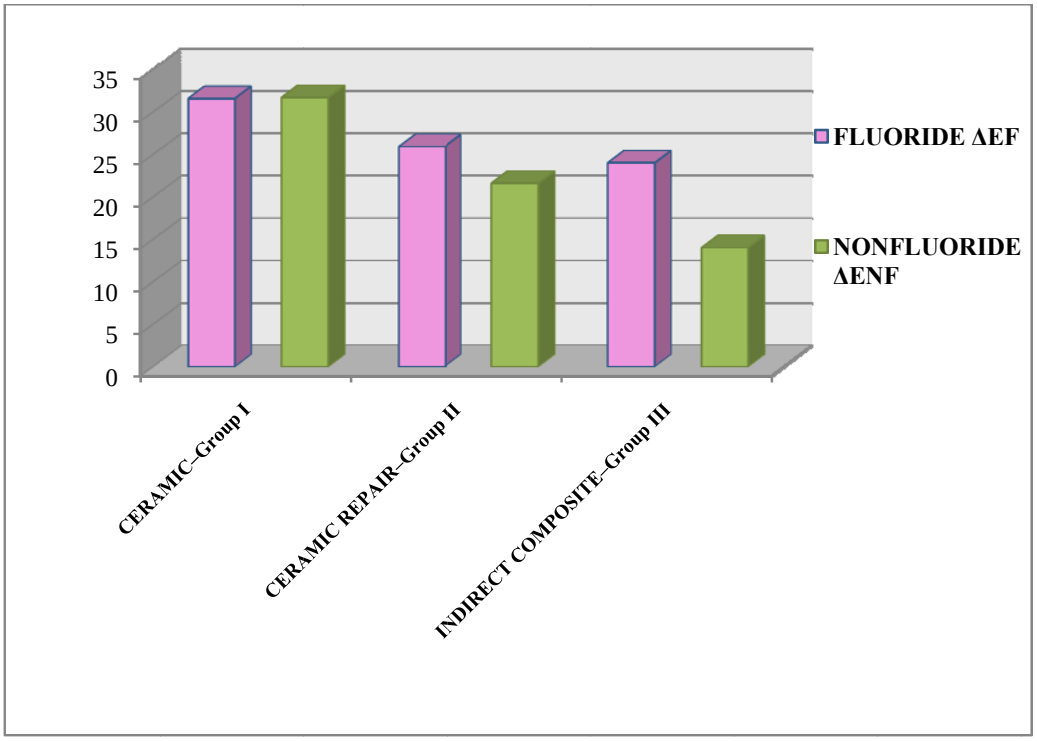
VI) Post immersion surface topography analysis:

After the spectrophotometric evaluation of all the 60 samples, 2 samples from each group were selected randomly to evaluate surface topography using SEM analysis, with one sample obtained from fluoride mouth rinse and other from non-fluoride mouth rinse. The Photo micrographs were obtained at a magnification of 1000x. The images were studied for the quality of the surface of the samples. The effects of each test agent on the surface of three groups of the test samples were also studied from the images.

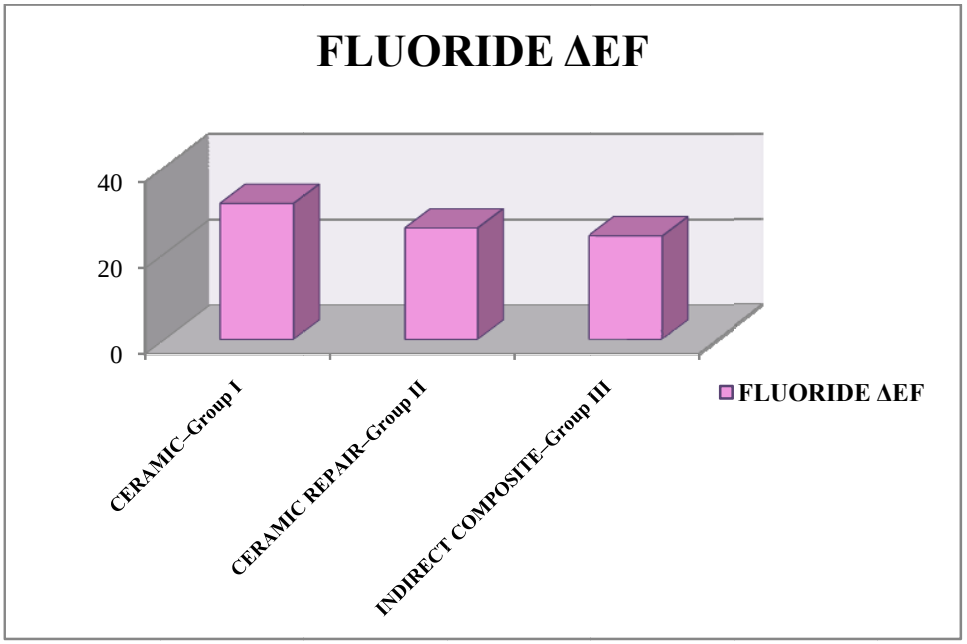
Flow Chart of Methodology

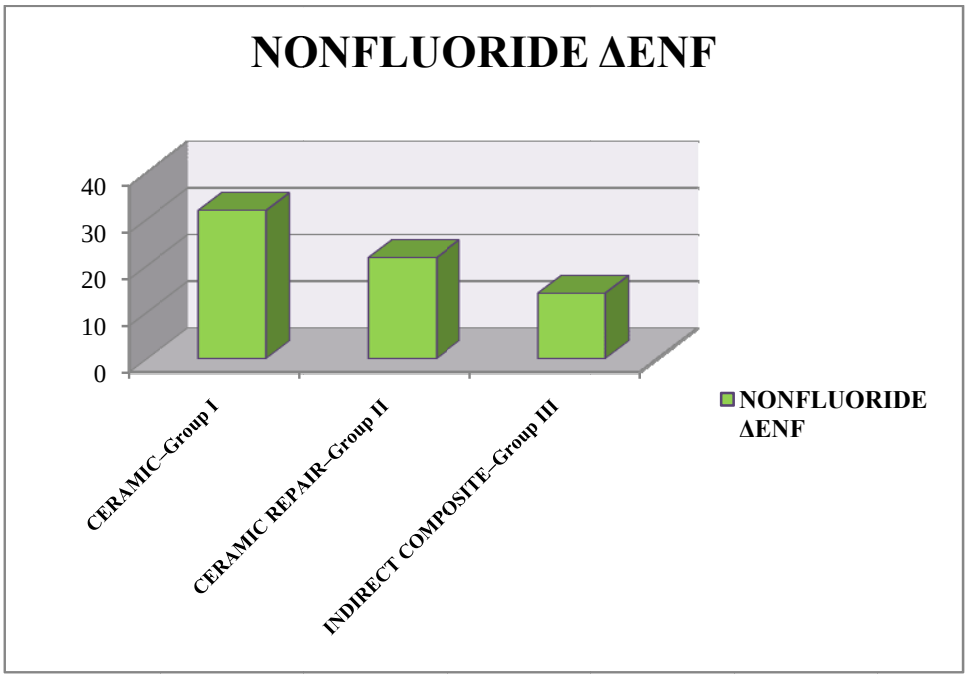


Graph 1: Test of significance for the mean color differences in CIELAB system of Ceramic veneering material - Group I, Ceramic Repair composite -Group II, and Indirect Composite Resin Materials -Group III after immersion in Fluoride and Non-Fluoride Mouth Rinses



Graph 2: Test of significance for the mean color differences in CIELAB system between Ceramic veneering material - Group I, Ceramic Repair composite -Group II, and Indirect Composite Resin Materials -Group III after immersion in Fluoride and Non-Fluoride Mouth Rinses





QUALITATIVE ANALYSIS OF SURFACE TEXTURE OF

ESTHETIC VENEERING MATERIALS

Fig. 35: GROUP – I CERAMIC VENEERING TEST SAMPLES

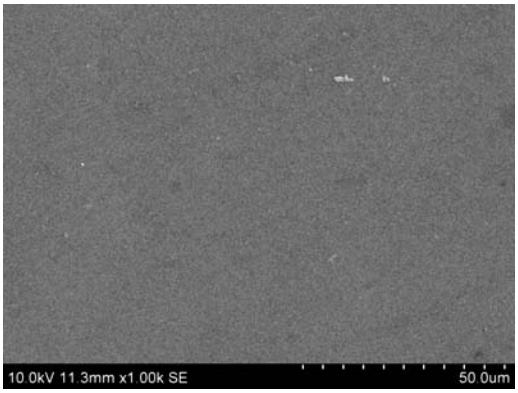


FIG. 35a: GROUP I a - CERAMIC VENEERING MATERIAL
AFTER IMMERSION IN ARTIFICIAL SALIVA

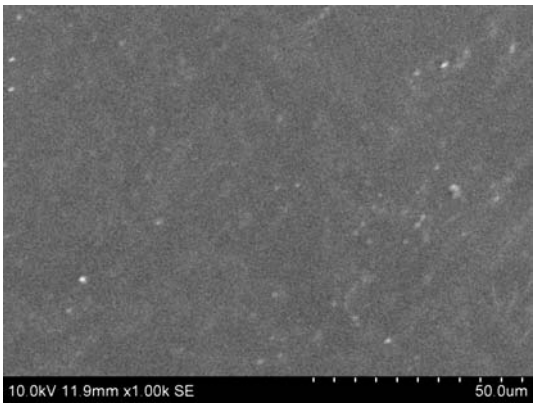


FIG. 35b: GROUP I b - CERAMICVENEERING MATERIAL
AFTER IMMERSION IN FLUORIDE MOUTH RINSE

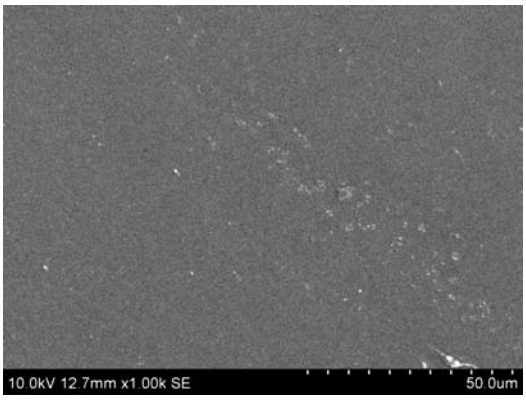


FIG. 35c : GROUP Ic - CERAMICVENEERING MATERIAL
AFTER IMMERSION IN NON - FLUORIDE MOUTH RINSE

INFERENCE: Surface of the ceramic veneering material as observed under SEM (1000x) after immersion in artificial saliva shows smooth surface with very few surface irregularities. In contrast, surface texture after immersion in fluoride and non-fluoride mouth rinses, exhibited surface irregularities which were more marked in samples immersed in fluoride mouth rinses.

Fig.36 : GROUP – II CERAMIC REPAIR COMPOSITE TEST SAMPLES

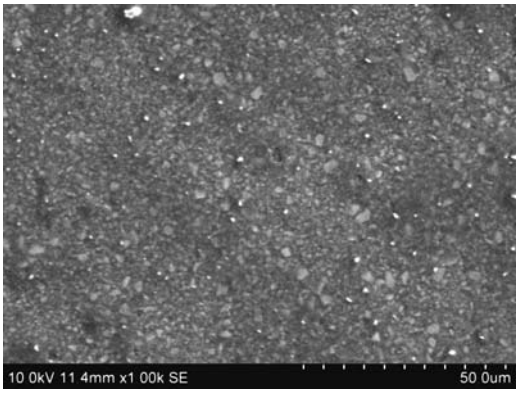


FIG.36a: GROUP II a - CERAMIC REPAIR COMPOSITE MATERIAL AFTER IMMERSION IN ARTIFICIAL SALIVA

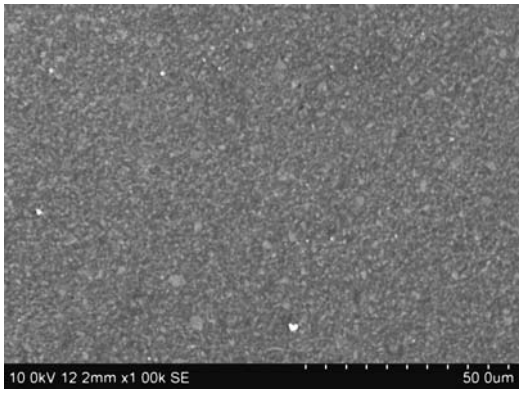


FIG. 36b: GROUP II b – CERAMIC REPAIR COMPOSITE MATERIAL AFTER IMMERSION IN FLUORIDE MOUTH RINSE

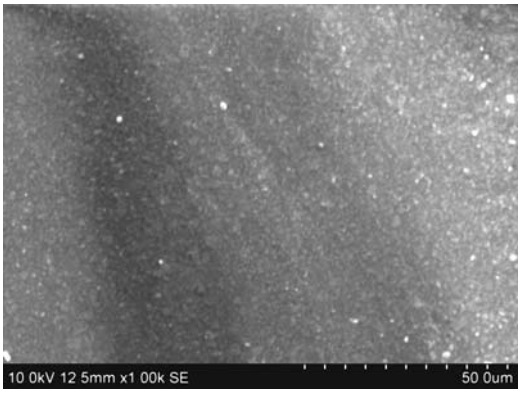


FIG. 36c :GROUP II c- CERAMIC REPAIR COMPOSITE MATERIAL AFTER IMMERSION IN NON - FLUORIDE MOUTH RINSE

INFERENCE: Surface of the ceramic repair material as observed under SEM (1000x) after immersion in artificial saliva shows moderate number of granularity. In contrast, surface texture after immersion in fluoride and non-fluoride mouth rinses, exhibited surface imperfection. Samples immersed in non-fluoride mouth rinses exhibited surface disruption with isolated areas of color dilution (milkiness)

Fig.37: GROUP – III INDIRECT COMPOSITE RESIN TEST SAMPLES

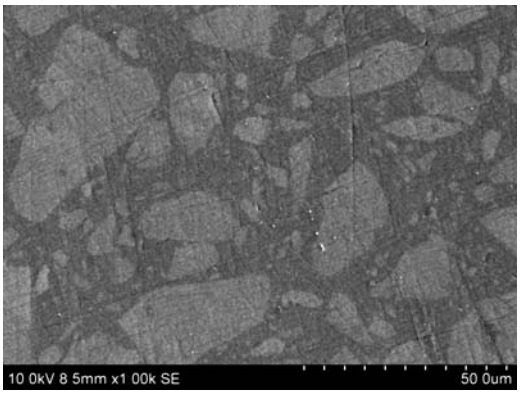


FIG. 37a: GROUP III a – INDIRECT COMPOSITE RESIN MATERIAL
AFTER IMMERSION IN ARTIFICIAL SALIVA

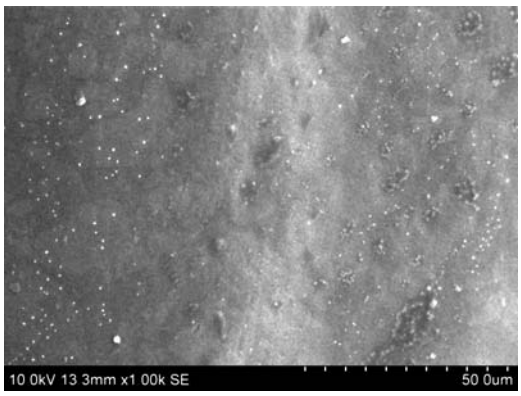


FIG. 37b: GROUP III b – INDIRECT COMPOSITE RESIN MATERIAL
AFTER IMMERSION IN FLUORIDE MOUTH RINSE

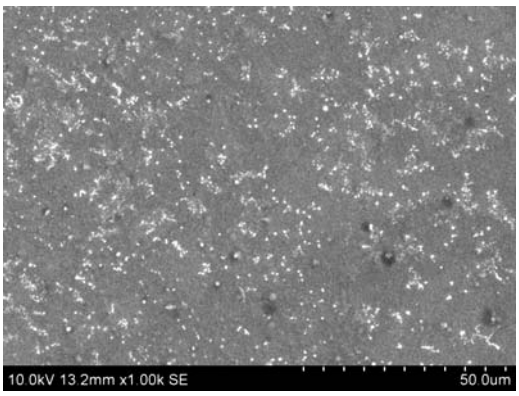


FIG. 37c :GROUP III c- INDIRECT COMPOSITE RESIN MATERIAL
AFTER IMMERSION IN NON - FLUORIDE MOUTH RINSE

INFERENCE: Surface of the indirect composite resin material as observed under SEM (1000x) after immersion in artificial saliva shows moderate number of granularity. In contrast, surface texture after immersion in fluoride and non-fluoride mouth rinses, exhibited surface irregularities with isolated areas of color dilution (milkiness). Samples immersed in fluoride mouth rinses exhibited surface disruption with distinct pits and irregular voids.

RESULTS

The present in-vitro study was conducted to comparatively evaluate the effect of two chemically different mouth rinses on the color stability and surface topography of three esthetic veneering materials. A total of 63 samples were utilized for the study. This study comprised of 3 main test groups - GROUP-I Ceramic Veneering material, GROUP-II Ceramic repair composite material, GROUP-III Indirect composite resin material. All the 63 test samples were immersed in artificial saliva and considered as the control group. Each group contained 21 test samples, were fabricated to investigate the color stability and surface topography after immersion in fluoride and non-fluoride mouth rinses. GROUP-I samples were further divided into three subgroups and they were named as Ia, Ib & Ic. Likewise, the GROUP-II and GROUP-III samples were also randomly divided into three subgroups and named as IIa, IIb & IIc and IIIa, IIIb & IIIc.

CONTROL GROUP: Total 63 test samples were immersed in artificial saliva.

GROUP-Ia: 1 test sample of the control group with ceramic veneering material for SEM analysis.

GROUP-Ib: 10 test samples of control group with ceramic veneering material for spectrophotometric and SEM analysis, after immersion in fluoride mouth rinse.

GROUP-Ic: 10 test samples of control group with ceramic veneering material, for spectrophotometric and SEM analysis, after immersion in non-fluoride mouth rinse.

GROUP-IIa: 1 test sample of control group with ceramic repair composite composite material for SEM analysis.

GROUP-IIb: 10 test samples of control group with ceramic repair composite material for spectrophotometry and SEM analysis, after immersion in fluoride mouth rinse.

GROUP-IIc: 10 test samples of control group with ceramic repair composite material for spectrophotometry and SEM analysis, after immersion in non-fluoride mouth rinse.

GROUP-IIIa: 1 test sample of control group with indirect resin composite material for SEM analysis.

GROUP-IIIb: 10 test samples of control group with indirect resin composite material for spectrophotometry and SEM analysis, after immersion in fluoride mouth rinse.

GROUP-IIIc: 10 test samples of control group with indirect resin composite material for spectrophotometry and SEM analysis, after immersion in non-fluoride mouth rinse.

All the 63 samples were immersed in artificial saliva for 24 hrs to mimic oral environment (control group). One test sample from each group selected randomly (GROUP-Ia, GROUP-IIa, GROUP-IIIa) were used to evaluate the surface topography using SEM analysis after immersion in artificial saliva. The remaining 20 samples from each group were subjected to spectrophotometry evaluation to obtain color parameters (L*, a*, b*) following immersion in artificial saliva and prior to immersion in the test agents.

20 samples of each group were immersed in 2 test agents (fluoride and non-fluoride mouth rinses) for 12hrs with 10 samples in each agent. The color parameter (L*, a*, b*) of the samples after immersion in test agents were recorded using spectrophotometry. Mean and standard deviation was obtained for each group and

tabulated. The color parameters of the test samples after immersing in the test agents of each group were compared with that of the control group to evaluate color difference using CIELAB system.

The results were subjected to statistical analysis. The SPSS 10.0 software package was used for statistical analysis. Student t test was used to compare the color stability of test agents within the groups. One way analysis of variance (ANOVA) was used to compare the color stability of test agents between the groups. The $p<0.05$ was considered as the level of significance.

After spectrophotometric evaluation of all 60 samples from each group were selected randomly to evaluate surface topography using SEM analysis, with one sample obtained from fluoride mouth rinse and other from non-fluoride mouth rinse.

I) COLOR MEASUREMENTS:

Tables 3, 4, 5, 6 and 7 shows the basic data of the results obtained using standard CIE color parameters for color of Ceramic veneering material, Ceramic repair composite Material, and Indirect Composite Resin Materials, after Immersion on Artificial Saliva, Fluoride and Non-Fluoride Mouth Rinses.

Table 3: CIE color parameters of Ceramic veneering material–Group I, Ceramic repair composite–Group II, after immersion in Artificial Saliva (control group)

S.NO	CERAMIC VENEERING MATERIAL–Group I			S.NO	CERAMIC REPAIR COMPOSITE –Group II		
	L*	a*	b*		L*	a*	b*
1	61.213	-0.36	7.73	1	46.96	-0.63	6.18
2	60.21	-0.5	6.14	2	43.071	0.9	8.7
3	64.141	-0.71	6.31	3	52.34	-1.3	2.97
4	62.02	-0.55	7.11	4	40.59	0.12	7.07
5	59.805	-0.76	6.22	5	48.53	-0.09	5.05
6	68.32	-1.94	3.66	6	64.73	-0.73	3.47
7	61.85	-1.31	5.87	7	45.135	-0.12	6.65
8	62.964	-1.54	5.02	8	59.53	-0.94	4.53
9	68.689	-1.33	2.35	9	79.76	-2.82	-0.06
10	87.68	-1.93	5.08	10	43.89	-1.33	6.1
11	73.033	-2.44	3.19	11	43.51	-1.93	7.51
12	65.045	-1.23	4.99	12	40.23	-2.44	6.65
13	57.45	-1.67	5.345	13	49.03	0.97	7.82
14	66.07	-1.59	6.78	14	57.39	-0.5	-0.28
15	69.87	-0.98	6.32	15	66.05	-0.71	-0.85
16	64.523	-0.843	6.54	16	55.167	-0.55	-0.82
17	63.71	-0.75	7.09	17	67.89	-0.76	-0.64
18	65.67	-1.34	3.38	18	65.18	-1.89	5.72
19	58.09	-0.63	7.2	19	47.38	0.85	5.16
20	68.953	-1.89	2.98	20	58.90	-1.34	6.78

Table 4: CIE color parameters of Indirect Composite Resin Material–Group III after immersion in Artificial Saliva (control group)

S.NO	INDIRECT COMPOSITE RESIN–Group III		
	L*	a*	b*
1	65.15	-3.27	-0.34
2	53.37	-1.2	3.02
3	85.119	-4.69	-1.04
4	43.61	-0.75	5.82
5	69.71	-4.59	-1.4
6	49.023	-2.42	0.81
7	56.42	-3.36	-1.08
8	57.342	-2.35	2.36
9	88.06	-5.29	-4.22
10	78.5	-2.85	1.64
11	92.81	-3.24	0.43
12	90.23	-3.07	-0.15
13	85.119	-3.12	-0.36
14	85.66	-4.27	-0.01
15	68.55	-3.24	-2
16	80.814	-4.56	-2.05
17	87.98	-4.27	1.32
18	84.99	-5.16	-1.18
19	67.69	-3.57	3.25
20	70.456	-3.82	1.17

Key: CIE color parameters (L*- *Measure of value*, a* - *Measurement of color in red-green axis*, b* - *Measurement of color in blue-yellow axis*)

Table 5: CIE color parameters of Ceramic veneering material after immersion in Fluoride (Group-Ib) and Non-Fluoride (Group-Ic) containing Mouth Rinses.

SNO	FLUORIDE–GROUP Ib		
	L*	a*	b*
1	98.346	-0.28	9.35
2	97.14	-0.85	7.5
3	97.718	-1.32	6.1
4	95.445	-1.18	7.51
5	98.48	-0.45	6.65
6	96.63	-0.99	7.82
7	95.86	-1.26	5.98
8	97.59	-1.30	9.83
9	96.32	-0.82	8.62
10	98.09	-0.64	6.72

S.NO	NON-FLUORIDE–GROUP Ic		
	L*	a*	b*
1	94.699	-0.77	8.9
2	96.25	-0.46	8.83
3	97.409	-0.59	7.95
4	98.43	-0.72	6.95
5	97.18	-0.65	7.87
6	95.86	-0.78	9.16
7	97.32	-0.89	8.78
8	96.69	-0.53	6.89
9	98.56	-0.48	7.98
10	95.09	-0.41	8.28

Key: CIE color parameters (L*- ***Measure of value*****, a* -** ***Measurement of color in red-green axis*****, b* -** ***Measurement of color in blue-yellow axis*****)**

Table 6: CIE color parameters of ceramic repair composite material after immersion in Fluoride (Group-IIb) and Non- Fluoride (Group-IIc) Mouth Rinses.

SNO	FLUORIDE–Group IIb			S.NO	NON-FLUORIDE–Group IIc		
	L*	a*	b*		L*	a*	b*
1	66.36	1.4	23.29	1	67.183	1.89	17.4
2	69.17	1.55	22.26	2	69.92	1.92	19.94
3	69.904	1.71	20.81	3	69.211	1.24	18.94
4	67.372	1.3	22.14	4	66.021	0.68	17.28
5	65.92	1.55	20.83	5	67.29	1.32	19.26
6	67.69	1.38	22.57	6	70.406	0.74	17,98
7	70.456	1.69	23.29	7	68.023	1.67	18.58
8	69.78	1.5	21.89	8	69.28	1.78	18.57
9	67.29	1.43	22.66	9	65.92	1.49	19.62
10	68.123	1.39	21.54	10	67.57	1.58	16.93

Key: CIE color parameters (L*- *Measure of value*, a* - *Measurement of color in red-green axis*, b* - *Measurement of color in blue-yellow axis*)

Table 7: CIE color parameters of Indirect Composite Resin Material after immersion in Fluoride (Group-IIIb) and Non- Fluoride (Group-IIIc) Mouth Rinses.

SNO	FLUORIDE GROUP IIIb			NON-FLUORIDE GROUP IIIc		
	L*	a*	b*	L*	a*	b*
1	87.936	-4.27	-1.81	94.09	-5.57	-3.76
2	88.996	-5.16	-3.57	88.63	-1.34	3.25
3	88.475	-5.72	-3.82	91.529	-1.99	1.17
4	84.051	-1.75	5.49	89.424	-0.52	4.82
5	87.98	-4.27	5.08	89.696	-1.32	3.19
6	84.99	-3.24	3.19	94.72	-1.18	4.99
7	89.85	-4.56	4.99	88.85	-0.45	5.345
8	90.78	-4.27	5.345	91.92	-0.99	-3.12
9	86.081	-5.16	6.78	92.52	-1.26	-4.27
10	85.52	-3.57	6.32	87.78	-1.30	-3.24

Key: CIE color parameters (L*- *Measure of value*, a* - *Measurement of color in red-green axis*, b* - *Measurement of color in blue-yellow axis*)

Color differences in CIELAB System:

The color difference (ΔE) of the samples after immersion in artificial saliva and fluoride and non-fluoride mouth rinses was calculated by using 1976 CIE L*, a* and b* (CIELAB) color difference equation

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

Where,

$\Delta L = L^*sample - L^*standard$

$\Delta a = a^*sample - a^*standard$

$\Delta b = b^*sample - b^*standard$

(Standard L*, a*, b* refers to values obtained after immersion in artificial saliva)

The measurements thus obtained for the twenty test samples of the each veneering systems were tabulated and statistically analyzed.

According to CIE color parameters

L* is the measure of value

a* is the measurement of color in red-green axis

b* is the measurement of color in blue-yellow axis

ΔE is the color change of different samples / same sample at different instances

ΔL difference in the L* value of different samples / same sample at different instances

Δa difference in the a* value of different samples / same sample at different instances

Δb difference in the b* value of different samples / same sample at different instances

ΔEF differences in the color of three veneering materials after immersion in fluoride mouth rinse

ΔENF differences in the color of three veneering materials after immersion in non-fluoride mouth rinse

Table 8: CIE color change of ceramic veneering material after immersion in Fluoride mouth rinse (Group Ib).

S. No.	ΔL	Δa	Δb	ΔE
1	37.133	-0.08	1.62	37.168
2	36.93	0.35	1.36	36.956
3	35.577	0.61	0.21	33.583
4	33.425	0.63	0.4	33.43
5	38.675	0.31	0.4	38.67
6	28.31	-0.95	4.16	28.629
7	34.01	0.05	0.1	34.01
8	34.626	0.24	4.81	34.959
9	27.631	-0.51	6.27	28.33
10	10.41	-1.29	1.64	10.61

Table 9: CIE color change of ceramic veneering material after immersion in Non-Fluoride mouth rinse (Group Ic).

S. No.	ΔL	Δa	Δb	ΔE
1	21.66	1.67	5.71	22.46
2	31.205	0.77	3.84	31.449
3	39.959	1.08	2.605	40.05
4	32.36	0.87	0.17	32.37
5	27.31	0.33	1.55	27.35
6	31.337	0.063	2.62	31.44
7	33.61	0.14	1.69	33.65
8	31.02	0.81	3.51	31.22
9	46.47	0.15	0.78	40.47
10	26.137	1.48	5.3	26.70

Table 10: CIE color change of ceramic repair composite material after immersion in Fluoride mouth rinse (Group IIb).

S. No.	ΔL	Δa	Δb	ΔE
1	19.4	2.03	17.11	25.94
2	26.099	0.65	13.56	29.41
3	17.564	3.01	17.84	25.21
4	26.702	1.18	15.07	30.75
5	17.39	1.64	15.78	23.53
6	2.96	2.11	19.1	19.44
7	25.321	1.81	16.64	30.35
8	10.28	2.44	17.36	20.32
9	12.17	4.25	22.72	26.12
10	24.233	2.72	15.44	28.86

Table 11: CIE color change of ceramic repair composite material after immersion in Non-Fluoride mouth rinse (Group IIc).

S. No.	ΔL	Δa	Δb	ΔE
1	23.673	3.82	9.89	25.93
2	29.69	4.36	13.29	32.81
3	20.181	0.27	11.12	23.09
4	8.631	1.18	17.56	19.60
5	1.24	2.03	20.11	20.25
6	15.239	1.29	18.8	24.23
7	0.133	2.43	19.22	19.37
8	4.1	3.67	12.85	13.97
9	18.54	0.64	14.46	23.52
10	8.67	2.92	10.15	19.23

Table 12: CIE color change of indirect composite resin material after immersion in Fluoride mouth rinse (Group IIIb).

S. No.	ΔL	Δa	Δb	ΔE
1	22.786	1	1.47	22.85
2	35.626	3.96	6.59	36.64
3	3.356	1.03	4.86	5.99
4	40.441	1	0.31	40.45
5	18.27	0.32	6.48	19.38
6	35.967	0.82	2.38	36.05
7	33.43	1.2	6.07	33.99
8	33.438	1.92	2.985	33.625
9	1.979	0.13	11	11.17
10	7.02	0.72	4.68	8.467

Table 13: CIE color change of indirect composite resin material after immersion in Non-Fluoride mouth rinse (Group-IIIc).

S. No.	ΔL	Δa	Δb	ΔE
1	1.28	2.38	4.19	4.98
2	1.6	1.73	3.4	4.13
3	6.41	1.13	1.53	6.68
4	3.764	3.75	4.83	7.18
5	21.146	1.92	5.19	21.85
6	13.906	-3.38	7.04	15.94
7	0.87	3.82	4.025	31.54
8	6.93	4.17	1.94	8.31
9	24.83	3.69	7.52	26.20
10	17.324	-2.5	4.41	18.05

Table 14: Test of significance for the mean color differences in CIELAB system of Ceramic veneering material- Group I, Ceramic repair composite-Group II, and Indirect Composite Resin Materials -Group III after immersion in Fluoride and Non-Fluoride Mouth Rinses.

SNO	IMMERSION SOLUTION	CERAMIC VENEERING MATERIAL GROUP I		P VALUES	CERAMIC REPAIR COMPOSITE– Group II		P VALUES	INDIRECT COMPOSITE– Group III		P VALUES
		MEAN	SD		MEAN	SD		MEAN	SD	
1	FLUORIDE ΔEF	31.6	8.1	0.97	25.9	3.9	0.62	24	12.9	0.58
2	NON-FLUORIDE ΔENF	31.7	5.5		21.6	5.6		14	9.7	

p-value<0.05 is considered statistically significant at 5% level.

Inference:

Statistically significant difference is not evidenced within the ceramic, ceramic repair composite and indirect composite groups after immersion in fluoride and non-fluoride mouth rinses.

Table 15: Test of significance for the mean color differences in CIELAB system between the Ceramic veneering material -Group I, Ceramic repair composite-Group II, and Indirect Composite Resin Materials -Group III after immersion in Fluoride and Non-Fluoride Mouth Rinses.

MMERSION SOLUTION	(I) VENEERING MATERIALS	(J) VENEERING MATERIALS	MEAN DIFFERENCE (I-J)	STD. ERROR	SIG.
FLUORIDE	CERAMIC VENEERING MATERIAL – GROUP I	CERAMIC REPAIR COMPOSITE GROUP-II	5.6415	4.08337	0.364
	CERAMIC VENEERING MATERIAL – GROUP I	INDIRECT COMPOSITE RESIN GROUP-III	6.7733	4.08337	0.239
	CERAMIC REPAIR COMPOSITE GROUP-II	INDIRECT COMPOSITE RESIN– Group III	1.1318	4.08337	0.959
NON - FLUORIDE	CERAMIC VENEERING MATERIAL – GROUP I	CERAMIC REPAIR COMPOSITE GROUP-II	10.0779	3.23962	0.012
	CERAMIC VENEERING MATERIAL – GROUP I	INDIRECT COMPOSITE RESIN GROUP-III	17.2299	3.23962	0.000
	CERAMIC REPAIR COMPOSITE GROUP-II	INDIRECT COMPOSITE RESIN– Group III	7.1520	3.23962	0.088

p-value<0.05 is statistically significant at 5%level.

INFERENCE :

1) Statistically significant difference is not evidenced within the ceramic veneering material(GROUP-I), ceramic repair composite composite(GROUP-II) and indirect composite resin (GROUP-III) after immersion in fluoride mouth rinse.
2) Statistically significant difference is evidenced on comparison of ceramic veneering material (GROUP-I) with ceramic repair composite composite(GROUP-II) & indirect composite resin (GROUP-III) after immersion in non-fluoride mouth rinse, there is no statistical significant difference evidenced between ceramic repair composite and indirect composite resin materials.

DISCUSSION

The success of a fixed partial denture is dependent on biological factors, mechanical factors and esthetic factors. Esthetic factors play a dominant role mainly when rehabilitating anterior esthetic zone. Shade matching determines the final outcome of the restoration and in addition the sustainability of the color and maintenance of the surface characteristics is equally important for the longevity of the restoration.[32] The selection of the esthetic veneering material is primarily governed by the optical properties which should provide a stable color match and also maintain the surface texture over a period of time. Dental ceramics have established themselves as an ultimate esthetic veneering material because of their ability to mimic the natural tooth appearance, good wear resistance and color stability.[18] Although ceramic have high compressive strength and resist discoloration which is superior to other veneering materials, they have a number of undesirable characteristics like time consuming and technically demanding fabrication and abrades the natural tooth.[18]

In order to resolve some of the problems associated with dental ceramics, the composite resin veneering materials have been employed using direct and indirect resin based system. Recently introduced nanoceramic composites replace traditional composites due to their filler sizes ranging from 0.01 to 0.004 μm.[8] Nano composite have many advantages such as reduced polymerization shrinkage, increased mechanical properties and improved optical properties. Wear resistance of nano composites has been shown to be comparable or superior to that of micro filled and micro hybrid of composite resins.[8]

Over the last few years development of indirect resins based composite resin has given the dental profession the possibility of fabricating adhesive esthetic veneers for anterior teeth.[18]

In spite of obtaining a stable color match by proper selection of esthetic veneering materials and improved processing techniques, it has been found that optical properties and surface topography continues to change during the course of time. Several authors have attributed the change due to interaction of various chemical agents that come in contact with the veneering materials. These agents may be used either by dentists for the therapeutics purpose or these agents may be in the form of food substances consumed by the patients.

The use of mouth rinses is highly recommended to patients in order to control caries and periodontal diseases. In addition expanded use of mouth rinses are widely prescribed for the implant maintenance.[4] Patients are often encouraged to use fluoride mouth rinses when caries activity is at higher rates. Fluoride are also been shown to alter the bacterial metabolism and also the potential to combat periodontal diseases, but at the same time it causes deleterious effects on dental ceramic.

By composition dental ceramics contains large volume of glass component that can be easily etched and pitted by the presence of fluoride ions.[40] Repeated applications of fluoride can alter the surface texture of dental ceramics. The acidity of the fluoride can causes etching of silica is a major component of dental ceramics.[40] Composite resins are susceptible to discoloration that may be intrinsic or extrinsic. Intrinsic factors involve the alternation of resins matrix itself or the interface of matrix

and fillers or hydrolysis in resin matrix itself. Resin matrix is a major component of composite materials has been reported to play critical role in color stability and affected by different pH of solution and alcohol concentration.[18] Alcohol based mouth rinses has been reported to produce surface discoloration of esthetic veneering materials mainly composite resin based materials. According to the study by Weiner and Penugonda, ethanol in the concentration of 21.6% was considered to produce softening effect on composite resin.[47] Also irreversible processes such as leaching of material components have been shown to occur in the presence of ethanol. Extrinsic factors of discoloration include staining by absorption /adsorption of colorings agents as a result of contamination from various exogenous sources.[18]

Due to the increased consumption of various agents such as beverages and mouth rinses, their effect on the color properties and surface topographies of the esthetic veneering materials has not been documented. Many studies have reported the effect of various agents on the optical properties and surface qualities of traditional composite resin and feldspathic ceramic.[18] The effect of various mouth rinses on the color stability and surface topography of fluorapatite leucite ceramics, nanoceramic composites and urethane dimethacrylate based indirect resin was not been adequately documented. Keeping the above the consideration in mind, the present in-vitro study was conducted to comparatively evaluate the effect of the two chemically different mouth rinses on color stability and surface topography of three esthetic veneering materials.

A total of 63 samples were utilized for the study. This study comprised of 3 main test groups - GROUP-I Ceramic Veneering material, GROUP-II Ceramic repair composite material, GROUP-III Indirect composite resin material. All the 63 samples of the metal alloy substructure with the three veneering materials were immersed in artificial saliva were considered as control group (GROUP-I, GROUP-II, GROUP-III). One test sample from each group (GROUP-Ia, GROUP-IIa, GROUP-IIIa) was evaluated for surface topography using SEM analysis. The remaining 20 samples from each group were subjected to spectrophotometry evaluation to obtain color parameters (L*, a*, b*) following immersion in artificial saliva and prior to immersion in the test agents.

20 samples of each group were immersed in 2 test agents (fluoride and non-fluoride mouth rinses) with 10 samples in each agent. The color parameter (L*, a*, b*) of the samples after immersion in test agents were recorded using spectrophotometry. Mean and standard deviation was obtained for each group and tabulated. The results were subjected to statistical analysis.

After the spectrophotometric evaluation of all the 60 samples, 2 samples from each group were selected randomly to evaluate surface topography using SEM analysis, with one sample obtained from fluoride mouth rinse sand other from non-fluoride mouth rinse. The Photo micrographs were obtained at a magnification of 1000x. The images were studied for the quality of the surface of the samples.

Results of color change using spectrophotometer evaluation shows the mean total color change ΔE of Group(Ib) 31.6 of ceramic veneering samples after immersion in fluoride mouth rinse was equally closer to the mean total color change ΔE Group(Ic) 31.7 of the ceramic veneering samples after immersion in non-fluoride mouth rinse. This statistics indicates, the Group I samples does not show greater variation in color, irrespective of the test agents used.

The total mean color change exhibited by ceramic repair composite ΔE, when immersed in fluoride mouth rinse was found to be 25.9 and a marginally lesser color difference when immersed in non-fluoride mouth rinse 21.6. This study used Ceram X (nano composite) as the veneering material for ceramic repair. A nanoceramic resin composite, comprises organically modified ceramic nano particles and glass fillers and a resin matrix that is replaced by a matrix full of highly dispersed methacrylate modified poly siloxane particles.[8] The staining susceptibility may be attributed to these structural differences. In a previous study, conducted by Celik. C et al, on the colour stability of CeramX (NanoCeramic Composite) using alcohol free mouth rinses, exhibited mean colour change ΔE=3.52 lesser than colour change observed for NanoCeramic Composite resin used in the study after immersion in fluoride mouth rinse.[8]

Indirect veneering composite Group III (b) exhibited a total mean color change ΔE=24 when immersed in fluoride mouth rinse and lesser mean color change ΔE=14, after immersion in non-fluoride mouth rinse.

Previous studies have shown the presence of hydroxyl group in the resin matrix, renders the indirect composite resin more susceptible to water absorption and solubility. In contrast sr adoro consists of new aromatic, aliphatic UDMA with the absence of hydroxyl group; thereby the material becomes less susceptible to water absorption.[43] An early study done on color stability of five esthetic materials when immersed in a coffee solution displayed lower discoloration for Targis (indirect composite resin material). This could be attributed to the method of polymerization where light and heat source are used and this helps in the higher degree of conversion of residual monomer which influences the staining potential of the material to some extent.[32] Similar method of polymerization was employed with Indirect Composite resin (SR Adoro) in this present study.

The statistical analysis results using independent student t test, shows there is no statistically significant difference in the total mean color change among the veneering materials tested after immersion in fluoride and non-fluoride mouth rinses.

On comparing the color stability of test agents among the veneering materials using one way analysis of variance ANOVA at the level of significance $p<0.05$.

A statistically significant color difference was observed when comparing the ceramic veneering material (GROUP-I) with ceramic repair composite (GROUP-II) and indirect composite resin (GROUP-III) materials in non-fluoride mouth rinse with P-value of 0.012 and 0.000 respectively. However the color variation observed among the veneering materials (GROUP-I, GROUP-II, GROUP-III) when immersed in fluoride mouth rinse was not statistically significant.

The increased color difference observed in ceramic veneering material when immersed in non-fluoride mouth rinse could be attributed to the fact that the mouth rinse used in this study was not diluted with saliva nor samples were dried before subjecting to spectrophotometric studies as in realife situation. These could have led to retention of a superficial layer of mouth rinse exhibiting higher values.

Irrespective of mouth rinses used in this study, ceramic veneering material showed almost similar mean color changes. The other variables which could have influenced the color differences are PH of the test agents, immersion period and coloring agents used in the mouth wash.[40, 17]

On comparing the groups, ceramic repair composite (Group II) with indirect composite resin Group III, the mean color change was not statistically significant when immersed in fluoride and non- fluoride mouth rinses.

Qualitatively evaluation of surface topography using SEM analysis:

In the present study, qualitative evaluation and comparison of surface topography of three esthetic veneering materials using scanning electron microscope for observing differences in the surface texture of the test samples after immersion in artificial saliva, fluoride and non-fluoride mouth rinses showed the following results.

Surface topography of ceramic veneering samples Group I:-

The surface of finished ceramic veneering material test samples after immersion in artificial saliva (Group Ia) for 24 hours showed homogeneous smooth surfaces with very fine irregularities.

The surface texture of ceramic veneering test samples after immersion in fluoride mouth rinses (GroupIb) showed a rough surface with increase in number of pits and scattered voids, thus exhibiting the etched pattern.

The ceramic veneering material test samples after immersion in non- fluoride mouth rinses (Group Ic) showed reduction in number and size of surface voids with very fine granularity.

Earlier studies have concluded the interaction of fluoride on ceramic restorations producing surface roughness, which renders the surface prone for staining. The concentration and the viscosity of the fluoride determine the etched pattern. In an in-vitro study by Richard C.W. 1.23% acidulated phosphate fluoride gel and 8% stannous fluoride found to produce statistical significant surface roughness[45]. This present study used fluoride mouth rinse with the concentration of 0.2% and leucite containing fluorapatite ceramic

Surface topography of ceramic repair composite material (Group II)

The surface of ceramic repair composite material after immersion in artificial saliva (Group IIa) produced a large uneven granular surface. The surface topography of test sample immersed in fluoride (Group IIb) mouth rinse, exhibited few voids and decreased surface roughness when compared to test samples immersed in non – fluoride (Group IIc) mouth rinse.

Surface topography of indirect composite resin (Group III)

The surface of the indirect composite resin test samples after immersion in artificial saliva (Group IIIa) produced fine granular surface.

The surface topography of test samples immersed in fluoride mouth rinse shows increase in surface roughness and larger voids as compared to test samples immersed in non – fluoride mouth rinse exhibited reduction in number of voids and increased number of pits.

In this study main ingredients present in non- fluoride mouth rinse is ethanol(21.6%) which is reported in early studies to produce rough surfaces on nanoceramic composites[8].

The indirect veneering composites used in this study (SR Adoro) contain silicon dioxide as main filler and this component is found to undergo etching when treated with fluoride mouth rinse.

Most of the studies conducted previously on color stability using CIELab system considered $\Delta E = 3.3$ as the upper limit of color change which is clinically acceptable. The results obtained in this study for evaluating color stability yielded $\Delta E = 31.6$ for ceramic veneering material immersed in fluoride mouth rinse and $\Delta E = 31.7$ for ceramic veneering material immersed in non-fluoride mouth rinse. Indicating the color change is insignificant when tested in both the mouth rinses. The ceramic repair composites and indirect composite resin samples exhibited a difference in color change with ΔE values lesser than ceramic veneering material.

The inference of the result emphasis that it is difficult to entirely correlate laboratory finding with clinical behavior of any restorations since several factors play a role in the oral environment that cannot fully simulate laboratory conditions. Therefore to draw a correlation between the clinical studies and lab measurements, further in vivo clinical evaluation is suggested. Further, more studies are required to test the color stability and surface topography of veneering materials with various mouth rinses.

CONCLUSION

The following conclusions were drawn from the data obtained in the present in- vitro study of evaluating the effect of two chemically different mouth rinses on the color stability and surface topography of three esthetic veneering materials.

1. The mean color parameter with respect to three esthetic veneering materials after immersion in artificial saliva (control group),

   The color parameters of all the test samples after immersion in artificial saliva were obtained and tabulated (Table 3, 4, 5, 6, & 7). The L*, a*, b* values of each sample were used to determine ΔE value which represents the total color change of that control sample. These ΔE values were used to determine the mean ΔE values of the test samples of these three veneering materials after immersion in two mouth rinses.

2. The mean color change with respect to ΔE of ceramic veneering material after immersion in fluoride (Group I b) and non-fluoride (Group I c) mouth rinses were found to be 31.6 and 31.7 respectively.
3. On comparative evaluation of the mean color change with respect to ΔE of ceramic veneering material when immersed in fluoride and non-fluoride mouth rinses, it was found to be statistically insignificant. (P-value> 0.05).
4. The mean color change with respect to ΔE of ceramic repair composite material after immersion in fluoride (Group II b) and non-fluoride (Group II c) mouth rinses were found to be 25.9 and 21.6 respectively.

5. On comparative evaluation of the mean color change with respect to ΔE of ceramic repair composite material when immersed in fluoride and non-fluoride mouth rinses, it was found to be statistically insignificant. (P-value > 0.05).
6. The mean color change with respect to ΔE of indirect composite resin material after immersion in fluoride (Group III b) and non-fluoride (Group III c) mouth rinses were found to be 24 and 14 respectively.
7. On comparative evaluation of the mean color change with respect to ΔE of indirect composite resin material when immersed in fluoride and non-fluoride mouth rinses, it was found to be statistically insignificant. (P-value > 0.05).
8. On comparison of the three veneering materials tested in fluoride did not show any statistically significant results. However in non fluoride mouth rinse, the ceramic veneering material (Group I c) exhibited statistically significant higher color changes, when compared to ceramic repair composite (Group II c) and indirect composite resin (Group III c). However, on comparison of ceramic repair composite with indirect composite resin material there was no statistical significance.
9. Qualitative evaluation of the surface topography of the three veneering materials after immersion in artificial saliva as observed under SEM (1000x) revealed:
    a. Ceramic veneering material (Group I a)-smooth surface with very few surface irregularities.
    b. Ceramic Repair composite (Group II a)-uneven surface imperfections with larger voids

c. Indirect Composite Resin (Group III a)-surface showing fine and moderate number of granularity.

10. Qualitative evaluation of the surface topography of ceramic veneering material after immersion in fluoride (GROUP-Ib) and non-fluoride mouth rinses(GROUP-Ic) as observed under SEM (1000x), exhibited surface irregularities which were more marked in sample immersed in fluoride mouth rinse.
11. Qualitative evaluation of the surface topography of ceramic repair composite material after immersion in fluoride (GROUP-II b) and non-fluoride (GROUP-II c) mouth rinses as observed under SEM (1000x), exhibited surface imperfections. Sample immersed in non-fluoride mouth rinse exhibited surface disruption with isolated areas of color dilution (milkiness).
12. Qualitative evaluation of the surface topography of indirect composite resin material after immersion in fluoride (GROUP-IIIb) and non-fluoride mouth (GROUP-IIIc) rinses as observed under SEM(1000x), exhibited surface irregularities with isolated areas of color dilution (milkiness). Sample immersed in fluoride mouth rinse exhibited surface disruption with distinct pits and irregular voids.
13. Qualitative evaluation of the surface topography of all the test samples as observed under SEM (1000x), exhibited
    a. Ceramic repair composite test sample showed maximum surface irregularities followed by indirect composite resin and least surface irregularities with ceramic veneering material after immersion in artificial saliva. (Between GROUP-I a, GROUP-II a, GROUP-III a)

b. Indirect composite resin test sample showed greater surface imperfections with larger granular voids and pits followed by ceramic repair composite material and least surface changes with ceramic veneering material after immersion in fluoride mouth rinse. (Between GROUP-I b, GROUP-II b, GROUP-III b)

c. Ceramic repair composite sample showed greater surface imperfections with scattered voids throughout the surface and isolated areas of color dilution (milkiness) followed by indirect composite resin and least surface changes with ceramic veneering material after immersion in non-fluoride mouth rinse. (Between GROUP-I c, GROUP-II c, GROUP-III c)

SUMMARY

This in-vitro study was done to comparatively evaluate the effects of two chemically different mouth rinses on the color stability and surface topography of three esthetic veneering materials.

A total of 63 resin patterns were fabricated using custom metallic mold, invested and cast in nickel chromium alloy. The metal substructure thus obtained were finished, sandblasted and divided into three groups with 21 samples for each veneering material tested. The three veneering material tested include, Group-I (ceramic veneering material), Group-II (ceramic repair composite material) and Group-III (indirect composite resin material). Vita lumin A3shade was used as a common shade for the three veneering materials tested. All the test samples were immersed in artificial saliva and used as control for the study. One sample from each veneering material test group was selected and subjected to SEM analysis and subsequently not used for further study.

The remaining 20 samples from each group were subjected to spectrophotometric study and further divided into two subgroups, with each subgroup consisting of 10 samples and immersed in fluoride and non-fluoride mouth rinses used in the study. These samples were then analyzed for color change using fiber-optic spectrophotometer and CIEL*a*b* specification system, which were then subjected to surface texture analysis. The result obtained were tabulated and statistically analyzed.

The results obtained from the present study indicates that on comparative evaluation, the effect of two chemically different mouth rinses on color stability of three esthetic veneering materials does not show any statistically significant color change. On comparison among the three veneering materials tested, there was no statistically significant color change after immersion in fluoride mouth rinse. However in non fluoride mouth rinse, the ceramic veneering material (Group I c) exhibited statistically significantly higher color changes, when compared to ceramic repair (Group II c) and indirect composite (Group III c). On comparison of ceramic repair with indirect composite resin material in non-fluoride mouth rinse, there was no statistical significance.

Qualitatively evaluation of surface topography of all the test samples were assessed under (1000x) with scanning electron microscopy. Ceramic repair composite test sample showed maximum surface irregularities followed by indirect composite resin and least surface irregularities with ceramic veneering material after immersion in artificial saliva. On immersion in fluoride mouth rinse, all the test samples showed marked surface disruption compared to samples immersed in non-fluoride mouth rinse. However, color changes observed were similar irrespective of mouth rinses used. The choice of mouth rinses for controlling oral diseases, should not only based on the efficacy of the mouth rinse, but also on its surface interaction with the restoration in the oral cavity. Further studies simulating oral environment should be conducted to evaluate the effects of various mouth rinses on different veneering materials.

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