AN IN VITRO STUDY TO COMPARE THE EFFECTS OF DIFFERENT COLOUR CHANGING ORTHODONTIC ADHESIVES AND DIFFERENT RESIN REMOVAL TECHNIQUES ON ENAMEL COLOUR.

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ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

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This is to certify that the dissertation titled **"AN INVITRO STUDY TO COMPARE THE EFFECTS OF DIFFERENT COLOUR CHANGING ORTHODONTIC ADHESIVES AND DIFFERENT RESIN REMOVAL TECHNIQUES ON ENAMEL COLOUR"** is a bonafide work done **DR.ANEETA JOHNY,** Postgraduate student, during the course of the study for the degree of **MASTER OF DENTAL SURGERY** in the speciality of **DEPARTMENT OF ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS,** Vivekanandha Dental College for Women, Tiruchengode, during the period of 2015-2018.

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TITLE OF DISSERTATION	An invitro study to compare the effects of different colour changing orthodontic adhesives and different resin removal techniques on enamel colour.
PLACE OF STUDY	Elayampalayam, Tiruchengode, Namakkal district.
DURATION OF THE COURSE	3 Years (2015-2018)
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Dr. Aneeta Johny

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INTRODUCTION

INTRODUCTION

Orthodontics, the specialty field of Dentistry, aligns the malaligned teeth, corrects the deformed skeletal base in their formative stages and impart the beauty of symmetry along with restored function. Unlike the yester years, beauty has been given great importance in one's social as well as personnel life. As a reflection of this concept, more and more patients are taking up orthodontic treatment to enhance their smile and hence the overall attractiveness.

According to Yoann Lopez et al[1], an ideal dentition makes it 4.8 times, a person more attractive to the sexual counterpart. Anna Sophia Silvola[2] found that Improvement in aesthetic satisfaction due to the treatment of severe malocclusion improves oral health–related quality of life, particularly by decreasing psychological discomfort and psychological disability.

Pieter Van der Geld et al[3] stated that the colour of teeth is a critical factor in satisfaction with smile appearance. Mon Mon Tin Oo [4] also evaluated the influence of teeth colour on the overall attractiveness of smile.

Orthodontic treatment involves bonding and debonding of brackets, the removal of adhesives using various techniques, which cause enamel roughness. There are enamel loss by etching, surface alteration due to decalcification and microcracks and scratches caused by the clean-up procedures. The acid etching causes dissolution of inter-prismatic material in the enamel, producing a roughened and porous layer[5, 6]. Phosphoric acid etching produces a rough, etched surface with the typical honeycomb pattern. Bonding

brackets to such a surface results in thick resin tags that range in the depth from 5-50 μm through scanning electron microscope [7]. The resin tags penetrated in the dentinal tubules get discoloured due to intrinsic and extrinsic staining [8]. Irregular enamel surface fails to reflect the scattering wavelength from the dentin [9]. All of which together contribute to the enamel colour changes.

Enamel colour changes can be assessed using 2 methods: visual determination and instrumental method. Though visual determination is frequently used, it is highly subjective and cannot be quantified. In the quest for accurate determination of the colour and quantification of colour changes, various instrumental measurement devices were introduced. Spectrophotometers, Tristimulus colorimeters, Spectroradiometers and Digital colour analyzers are some of the commercially available instrumental measuring devices, which make use of Munsell system for quantification [10].

There are a plethora of orthodontic adhesives and resin removal systems available in the market, claiming the superiority of each over the other. Different authors have evaluated the enamel colour changes following orthodontic treatment. Till date, there have been no combination of adhesive and resin removal system found, which completely eliminated the enamel colour change.

It is always the responsibility of a clinician to deliver the best possible result to the patient through the treatment. The current study is comparing two colour changing orthodontic adhesives and two resin removal systems, to find a better combination of which produce the least enamel colour change.

Colour changing orthodontic adhesives, unlike the regular adhesives, helps in better removal of flash during the bracket placement, helping in leaving as less as possible adhesive remaining on the tooth surface after the orthodontic treatment.

AIM AND OBJECTIVES

AIM OF THE STUDY

The aim of this in-vitro study was to compare the effects of different colour changing orthodontic adhesives and resin removal systems on the enamel colour change immediately after the orthodontic treatment and 30 days post orthodontic treatment.

OBJECTIVES

1. To assess the enamel colour change following the usage of two different colour changing orthodontic adhesives.
2. To find out a resin removal system which contribute to minimal enamel colour change when used along with different colour changing adhesives.
3. To find a better combination of an adhesive and a resin removal system which causes minimal enamel colour change post treatment.

REVIEW OF LITERATURE

REVIEW OF LITERATURE.

Mark Daniel Puss [11] (1969) evaluated the enamel loss due to removal of orthodontic resin after bonding with filled and unfilled resins using various clean up techniques. Unfilled resins were removed using hand instruments alone. Among the rotary instruments used, high speed bur and green rubber wheel caused more enamel loss than slow speed bur.

Bjorn U Zachrisson [12](1977) did a post treatment evaluation of direct bonding in Orthodontics. Bonding was done using different combination of resins and sealants. Adhesive removal was done using ETM pliers (Monrovia, California) and a plain cut tungsten carbide bur at low speed. Enamel surface appearance was normal when plain cut tungsten carbide rotated at low speed was used for adhesive removal.

John Gwinnet et al [13] (1977) assessed the clinical applications of microscopic evaluation of enamel after debonding. For bonding of brackets, an unfilled polymethacyrlate, a lightly filled resin and a heavily filled composite were used. Resin removal was done using ligature cutter, green stone, white stone with pumice, sand paper disc and pumice, green rubber wheel with pumice, tungsten carbide finishing bur with pumice at high speed, plain cut steel finishing bur at low speed with pumice, acrylic steel bur at low speed with pumice were used. Highly filled resin was difficult to debond than unfilled and lightly filled resin. Green rubber was found to be producing least enamel damage.

Burapavong et al [14] (1978) studied the enamel surface characteristics on removal of bonded orthodontic brackets. Brackets were attached to tooth surface by a chemical cure and light cure adhesive system. After the bracket debonding, residual resin was removed using hand scaler, green stone and ultrasonic scaler. Each one with and without pumice polishing. Hand scaler and ultrasonic scalar was found to be restoring the enamel surface to its initial self after pumicing.

Retief and Denys [15] (1979) assessed the finishing of enamel surfaces after debonding of orthodontic attachments. The attachments were fixed using a lightly filled adhesive, Dyna bond adhesive system. Different adhesive removal systems were used like direct bonding bracket remover, starlite scalar tip, finishing diamond at high speed, 12 fluted carbide bur at high speed, stainless steel bur, soflex disc, medium fine and super fine, ceramiste wheels. 12 fluted carbide bur readily removed the adhesive but left with parallel grooves which was not restored with final pumice polishing. Usage of soflex and ceramiste wheels showed progressive decrease in surface irregularities with satisfactory final polishing using pumice.

Bjorn U Zachrisson [5] (1979) evaluated the enamel surface appearance after various debonding techniques. The brackets were attached using diacrylate resin adhesive and adhesive resin residue was removed using fine diamond fissure bur, green rubber wheel, sand paper disc(coarse, medium, fine), plain cut tungsten carbide fissure bur, spiral fluted tungsten carbide bur, rubber polishing disc, polishing cups, soflex disc

(medium, fine, superfine) and pumice (fine) in rubber cup. Tungsten carbide bur (plain cut/ spiral fluted) at low speed produced the finest scratch pattern and least enamel loss.

Sandison [16] (1981) evaluated the tooth surface appearance after debonding. The gross adhesive remaining were removed using sharp scaling instrument and finer residue were cleansed using Tungsten carbide bur at high speed. Final polishing was carried out with pumice slurry and rotating brush. The debonded area showed increased susceptibility to staining. There were areas of horizontal fracture on the buccal surface attributed to debonding force.

Betrand D Rouleau et al [17] (1982) studied the enamel surface after clinical treatment and removal of orthodontic brackets. Enamel roughness was highest after adhesive removal by hand scaler followed by 12 fluted tungsten carbide bur and least roughness was produced by ultra-fine tungsten carbide bur at high speed with water spray. Final polishing using pumice was found to be beneficial but deep scratches were not removed efficiently with it.

Johnston and Kao [9] (1989) assessed the appearance match by visual observation and clinical colorimetry. Colour measurement by a colorimeter was found to be showing a consistent colour evaluation in contrast to human observation under

controlled condition. The lack of clear delineation between visual evaluation criteria and colour difference by instrumental colorimetery ascertain that the other factors besides colour difference influence the visual perception of a match or mismatch between dental structures.

Samir Bishara et al [18] (1990) compared different debonding techniques for ceramic brackets. The enamel loss was assessed through Scanning Electron Microscopy analysis and found that the average amount of enamel loss was greatest with high speed resin removal technique. There was considerable amount of enamel loss when slow speed and ultra- sonic removal techniques were used.

R. G. Oliver et al [19] (1992) compared different techniques of residual adhesive composite removal following debonding in aspects of time taken and surface enamel appearance. Hand scaler followed, ultrasonic scaler, pneumatic band driver, low speed tungsten carbide fissure bur followed by medium and fine Aluminium oxide impregnated disc for polishing were used for cleaning the enamel surface after debonding. All the groups were given a final polishing using rubber cup and pumice slurry. The fastest cleaning was achieved when pneumatic chisel was used and ultra-sonic scaler was the slowest. Slow tungsten carbide bur with Aluminum oxide disc produced the least enamel damage.

Keith V Krell at al [20] (1993) studied the enamel loss and time requirements, when orthodontic bracket removal was done using conventional and ultra sonic debonding technique. Enamel clean up after deboning was done using high speed 12 fluted carbide finishing bur and further polishing with finer soflex abrasive discs, debonding plier and subsequent clean up by ultrasonic clean up and by ultra sonic clean up alone. Enamel loss was highest in the group where tungsten carbide and subsequent polishing using soflex disc was used. Bracket removal using debonding pliers and subsequent enamel cleanup using ultrasonic cleanup caused the least enamel damage.

K Zarinnia [21] (1995) evaluated the effects of different debonding techniques on the enamel surface. Two heavy filled composite resins, Concise and Achieve, were used for bracket bonding. Adhesive residuals were removed using fine polishing diamond point, no169L carbide bur at high speed, stainless steel finishing bur at low speed, coarse ,medium and fine sand paper discs, 12 fluted tungsten carbide bur at high speed, soflex disc(medium, fine, super fine) and shofu wheels. 12 fluted Tungsten carbide bur was found to be most efficient in adhesive resin removal. Finishing using medium, fine and super fine disc with air cooling and final finishing with rubber cup and zircate paste is needed for satisfactory restoration of the enamel surfaces.

Philip M Campbell [22] (1995) studied the enamel roughness after orthodontic bracket debonding. 30 fluted tungsten carbide bur, soflex abrasive disc, cross cut bur and band slitting pliers were used for adhesive removal. The teeth were polished using

points and cups, fine pumice, polishing paste and brown and green cups. All the methods are effective in resin removal but with considerable amount of enamel loss. 30 fluted tungsten carbide bur produced the least enamel loss and produced the finest result of all.

Bosch and Coops [23] (1995) evaluated the tooth colour and the properties which effect the tooth colour. It was found that the tooth colour is predominantly determined by the properties of dentin and enamel contributes through scattering at wave length in blue range.

Hong and Lew [24] (1995) did a quantitative and qualitative assessment of enamel surface following fine composite removal methods after bracket debonding. Ormco band removing plier, komet slow speed tungsten carbide bur, high speed ultrafine diamond bur, high speed tungsten carbide bur, high speed white stone finishing bur were used for adhesive removal. Ultra- fine diamond bur left the minimal adhesive remnant behind where as white stone finishing bur leave composite remnants on the entire bracket base area. Least surface roughness was caused by jet high speed tungsten carbide bur followed by white stone finishing bur, ormco band removing plier. Koet slow speed tungsten carbide bur and lastly ultra-fine diamond bur. Multistep finishing is advocated for satisfactory final results.

Inokoshy et al [25] (1996) studied the opacity and colour changes of tooth coloured restorative material. Chemically cured composite, light cured composites and resin modified Glass Ionomer Cements were compared after accelerated testing. Light cured composites showed the least colour change. The colour change of chemically cured composite took place only after four weeks whereas resin modified Glass Ionomer Cement showed an abrupt decrease of opacity at the initial stage accompanying darkening of the material.

Hubertus Van Waes et al [26] (1997) assessed the enamel loss caused by bonding and debonding of orthodontic brackets, 3 dimensionally. The adhesives were removed after debonding with a tungsten carbide bur at 20000 rpm without water cooling. He found that the residual self -curing composite on the tooth surface is removed efficiently with minimal enamel damage, as less as 7.4 micrometer of enamel loss.

S. C. Smith et al [27] (1999) evaluated the surface effects of enamel after orthodontic bonding resin residue removal by Carbon dioxide laser. The 2 W/ 100 ms of pulse duration was found to be optimal for the removal of orthodontic bonding resin. Higher laser power increases the enamel damage. There was a risk assessed for the pulpal damage due to the heat produced by the laser irradiation.

S J Hodges et al [28] (2000) discussed on undeliable enamel staining following fixed appliance therapy. The already compromised enamel surfaces exhibit greater staining susceptibility following orthodontic treatment. Localized or generalized developmental anomalies of the enamel was found to be a risk factor for undeliable enamel staining after fixed appliance treatment.

Ralf J Radlanski [29] (2000) studied a new carbide finishing bur for adhesive removal after debonding. The new bur had a slightly tapered shape with rounded tip and eight twisted blade. The wedge angle of the blade has been enlarged to 130 to 135 degree reducing the cutting efficiency into the enamel while maintaining the efficiency in residue removal. The new finishing bur was found to be less aggressive in residual resin removal.

Eliades et al [30] (2001) did a comparison of enamel colour changes associated with orthodontic bonding using two different adhesives. Brackets were bonded using no mix (1 phase) adhesive resin and chemically cured resin modified Glass Ionomer Cement. Adhesive removal was done using sequential use 12 fluted and 30 fluted tungsten carbide bur at low speed. There found no difference in colour change between etching mediated and no etch mediated adhesive systems.

Theodore Eliades [31](2004) quantitatively assessed the roughness of enamel surface following debonding using eight bladed carbide bur and ultrafine diamond bur. The

results showed that there was no consistent roughness reducing effect with soflex disc. Resin removal with diamond bur is faster than carbide bur with more enamel damage and making smoother surface.

Theodore Eliades et al [8] (2004) assessed the colour stability of light cured and chemically cured adhesives subjected to photo ageing. The study showed that all adhesives exhibited colour change. In addition to exogenous discoloration from food dyes, mouth rinses and plaque, endogenous discoloration also attributes to the enamel colour changes. The adhesive removal using rotary instruments further contribute to the colour alteration of resin infiltrated enamel.

A. J. Ireland [32] (2005) determined the degree of enamel loss when two different adhesive system and four different methods of enamel clean up were used. The results showed that significant amount of enamel loss occurred following the usage of 37% orthophosphoric acid than poly acrylic acid conditioners. Sow speed tungsten carbide bur instigated least enamel loss and highest was found for ultrasonic scaler and high speed tungsten carbide bur.

Morten Fjeld et al [7] (2006) did a scanning electron microscopic evaluation of enamel surfaces exposed to three orthodontic bonding systems. The specimen where bonded with bracket system in three combinations. 35% phosphoric acid etching with

Transbond XT primer and adhesive, 10% polyacrylic acid conditioning with Fuji ortho LC. In the third group self-etching primer (Transbond Plus) and Transbond XT adhesive was used. Acid etching produced more roughened surface and induced more resin penetration. Self- etching primer produced less pronounced etching surfaces and fewer resin tags. Resin modified Glass Ionomer Cement produced chemical rather than mechanical bonding to the enamel and hence less irreversible enamel surface was produced.

Neslihan Eminkahyagil et al [33] (2006) studied the effects of different resin removal methods on the shear bond strength of rebounded brackets, condition of the enamel surface, time spend for resin removal and location of bond failure. The resin removal methods used were slow speed tungsten carbide bur, high speed tungsten carbide bur, soflex finishing disc and micro etcher. The study showed that soflex disc consumed much time than rest of the resin removal system and also failed to effectively remove the residual adhesive. High speed tungsten carbide bur caused the most damage to the enamel surface.

Amna Hassan Al Shamsi et al [34] (2007) 3 dimensionally assessed the residual adhesive and enamel loss on teeth after debondng of orthodontic brackets. The amount of tooth loss in clean up procedures were attributed to the tactile ability of the operator and the type of instrument used. Composite resin bonding was found to be a mechanical risk to the enamel during the debonding and finishing procedures.

Andreas Faltermier [35](2008) studied the discoloration of orthodontic adhesives caused by food dyes and ultraviolet light. Transbond XT, Enlight, Rely X Unicem, Meron plus AC were subjected to 72 hours of artificial aging under UV light and 72 hours of immersion in food dyes. After exposure to tested food dyes or ultraviolet light, Rely X Unicem (3M Espe) showed the least and resin reinforced GIC, Meron plus AC showed the greatest colour change. Orthodontic adhesives are subjected to both internal and external discoloration.

Avijith Banerjee et al [36] (2008) did an invitro investigation of the effectiveness of Bioactive glass abrasion (BGA) in the selective removal of orthodontic resin adhesive. Metal brackets were attached using non-self- etch resin adhesive system. The residual adhesive was removed using a slow speed 8 bladed tungsten carbide bur (TCB), Aluminium Oxide abrasive (AIA) and BGA. BGA air abrasion was found to be superior in adhesive removal and produced clinically smooth surface finish than Aluminium Oxide Abrasive or Tungsten Carbide Bur gold standard resin removal systems.

Goksu Trakyali et al [37] (2009) evaluated the enamel colour alteration of 5 different orthodontic bonding adhesives after photo ageing. The adhesive removal was done using a high speed tungsten carbide finishing bur and polishing using stain buster bur. The study showed that there is a colour change before and after orthodontic treatment procedure but those induced by photo aging was not observed clinically.

Polishing with tungsten carbide bur increased the light reflection hence maintained clinically acceptable colour to the teeth.

Arezoo Jahanbin et al [38] (2009) studied the effects of adhesive types on enamel discolouration around orthodontic brackets. The brackets were attached to the teeth using chemically cured composite resin without primer and with primer and orthodontic no- mix adhesive resin. Remnants of the resin removed using 12 and 30 fluted tungsten carbide bur at slow speed. The method of application or type of adhesive was found to be having effect on change in enamel colour. The colour change was attributed to the stain uptake by resin tags.

Caory Ulusoy [39] (2009) compared the finishing and polishing system for residual resin removal after debonding. He used 12 fluted tapered tungsten carbide bur in brush stroke with a high speed hand piece, 30 fluted tungsten carbide bur, aluminium oxide abrasive disc (coarse, medium, super fine) with a low speed hand piece, super snap rainbow system (coarse, medium, fine, super fine), diamond coated PoGo micro polisher point, silicon carbide impregnated optshine brush and a combination of brushes and burs. 12 and 30 fluted tungsten carbide bur were fast and efficient in resin removal with scar formation on the enamel. Super snap disc were found to be causing less enamel damage than soflex disc, one step PoGo micropolisher restored the enamel to as smooth as prebonding but found to be most time consuming.

Shinya Horiuchi et al [6] (2009) evaluated the debonding force and enamel surface after bonding with self- etching and phosphoric acid etching orthodontic adhesives in simulated clinical condition. Transbond plus, Beauty ortho bond (Self-etch), Transbond XT, Super Bond orthodontic (conventional etch) were used for bonding the bracket. Bond strength of self-etching primer exhibited lower bond strength than that of acid etched bracket bondings but were optimal for clinical usage. Enamel surface morphology studies showed that self- etching adhesive system were an effective means of eliminating enamel damage and/ or decalcification during orthodontic treatment.

Bjorn Oogard et al [40](2010) did a research on the enamel surface and bonding in Orthodontics. The bonding system using self-etching primers in combination with composite adhesive or resin modified glass ionomer cement induced less adverse effect tot eh enamel surface and were easier for further cleaning up procedures. This ascertained less chance of leaving behind residual bonding material on the enamel surface.

Bayram Corekci [41] (2010) evaluated the effects of staining solutions on the discolouration of orthodontic adhesives. Orthodontic composites will discolour from staining from beverages during the life time. The content of the inorganic filler of composite, monomer type, degree of polymerization and many other actors affect the composite discolouration.

Andreas Karamouzos [42] (2010) carried out a prospective clinical trial assess the tooth colour after orthodontic treatment. Chemically cured and light cured resins were used for bracket bonding and adhesives were removed using carbide bur. There was a significant amount of colour change following the usage of different adhesives in orthodontics. Chemically cured resins were found to be causing more colour change than light cured resin.

Sevinc Karan [43] (2010) assessed the enamel surface roughness after debonding using AFM 9 Atomic Force Microscopy. Light bond adhesive was used for bonding the brackets. 8 bladed tungsten carbide bur and a fiber reinforced bur (stain buster bur) was used for adhesive removal. Tungsten carbide bur showed greater enamel irregularities when compared with stain buster bur; but tungsten carbide bur was faster in adhesive removal.

Rodrigo De Marchi [44] (2011) compared effectiveness of two resin removing methods after bracket debonding. Optimize discs (TDV) and one gloss discs (shofu) were evaluated. Results showed that both the methods when used at low speed, were effective in removing adhesive remnants in one single step. Optimize disc produced smoother enamel surfaces than the one gloss.

Sacha Ryf [45] (2011) evaluated the enamel loss and adhesive remnants following bracket removal and clean up. Clean up was carried out with carbide bur, carbide but with Brownie and Greenie silicone polishers, carbide bur and Renew polishers, carbide bur and Astropol polishers, carbide bur, Brownie, Greenie and PoGo polishers. Clean up using carbide bur alone produced rough surfaces with lot of enamel loss. Least volume loss was reported with the usage of silicone dioxide and diamond particles. Adequate clean up without enamel loss is difficult to achieve.

Hyun Jin Joo et al [46] (2011) studied the influence of orthodontic adhesives and clean up procedures on the stain susceptibility of enamel after debonding. Two types and four brands of adhesive systems were investigated. Tansbond XT, Orthosolo, Transbond Plus, Prompt L- Pop were the adhesives used and resin removal was done using 12 fluted tungsten carbide bur and polishing using a rubber cup with pumice slurry. Self-Etching Primers showed smaller amount of residual adhesive than conventional adhesives but had greater stain susceptibility.

Sara Ekhlassi et al [47](2011) did a comparative study to assess the bond strength of different colour changing adhesives when used with a self- etching primer. Colour changing adhesives used were Transbond plus, Grengloo and conventional Transbond XT. There found to be having a significant difference in the mean shear bond strength between the three groups. Transbond Plus exhibited the highest mean

bond strength after one week. Thought the bond strength was significantly different for each adhesive systems, it was satisfactory for clinical usage.

Karine Macieski et al [48] (2011) evaluated the efficiency of three resin removal systems by means of scanning electron microscopy. Gross and medium Soflex discs, carbide burs in low speed and carbide bur at high speed were used for resin removal. Soflex disc fine and ultra-fine discs were used for polishing in the soflex resin removal group and rubber tis with polishing paste was used in the other groups for polishing. The least damage to enamel surface was caused by carbide bur in low speed along with enamel polishing using rubber tips and polishing paste.

Dennis Baumann et al [49] (2011) studied the influence of dental loupes on the quality if adhesive removal in orthodontic debonding. It was found that there was significant advantage for debonding with dental loupes. There was less enamel damage and composite residue when the procedure was done using dental loupes.

Abbas R Zaher et al [50] (2012) tested the association between enamel colour alteration and resin tag depth. All the adhesive system used caused clinically perceivable colour change after debonding and finishing and all the values exceeded the clinical colour detection threshold of ΔE 3.7 units. Significant moderate correlation was found between colour change and resin tag length. Shorter resin tag

length produce less change in enamel colour following clean up and polishing. Self - etch primers produced less resin penetration and hence formed less iatrogenic enamel discolouration.

Christina Theodora Proteasa et al [51] (2012) described the risks and complications associated with orthodontic treatment. Colour alteration after fixed appliance therapy has been pointed out as a main complication of the orthodontic treatment. The colour changes has been attributed to a multifactorial etiology. The presence of developmental deformations, white spot lesions, technique and material used in the fixed appliance therapy etc. was pointed out as possible factors in altering the enamel colour.

N J Cochrane et al [52] (2012) studied the effects of different orthodontic adhesive removal techniques on sound, demineralized and demineralized enamel. Adhesive removal was done using slow 16 fluted tungsten carbide bur, 12 fluted tungsten carbide at high speed, and Aluminium oxide polishing disc in slow speed without coolant and ultra-sonic scaler. Demineralized teeth showed greater enamel loss on adhesive removal and Aluminum oxide disc was found to be the best among the adhesive removal techniques used, causing least enamel damage. In the sound enamel, most damage on adhesive removal was caused by Ultra sonic scaler. 12 fluted Tungsten carbide bur was causing enamel damage next to ultra- sonic scaler followed by 16 fluted tungsten carbide bur and Aluminium oxide discs.

Lilian Maria Brisque Pignatta et al [53] (2012) evaluated the enamel surface after bracket debonding and polishing. Transbond XT etch and rinse system was used for bracket bonding. For the bracket debonding, a straight debonding plier and Lift off instrument were used. Adhesive residue removal was done using long adhesive removing plier, 12 fluted tungsten carbide bur at high speed were used. All the protocols for adhesive removing were found to be causing enamel irregularities. Bracket debonding using straight debonding plier and resin removal using tungsten carbide bur at high speed with ample water cooling and final pumice polishing with a rubber cup was found to be the most efficient protocol for least enamel damage and smoothest post orthodontic enamel surface.

Cui Ye et al [54] (2013) compared the enamel discolouration associated with bonding using three different orthodontic adhesives and four different clean up procedures. The colour change was found greatest in tungsten carbide group and lowest was found when tungsten carbide along with PoGo polisher and tungsten carbide and soflex disc were used in combination. The resin modified glass ionomer cement showed the lowest colour difference and chemically cured resin groups showed the highest colour change among all the adhesives tested.

Emad F Al Maaitah et al [55] (2013) evaluated the effects of fixed orthodontic appliances bonded with different etching techniques on tooth colour as a prospective

clinical study. Self-etching primer and conventional etching was used. Adhesive remnants were removed using 12 fluted tungsten carbide bur on slow speed hand piece. The study showed that there was no statistical significance on tooth colour difference was caused by etching technique, tooth type and their interaction. Men and adolescent had more color change than girls and adults.

Farzaneh Ahrari et al [56] (2013) studied the different enamel roughness after debonding of orthodontic brackets and various clean up techniques. Transbond XT was the bracket adhesive used. For adhesive removal low speed Tungsten carbide bur, high speed tungsten carbide bur, diamond bur and Er: YAG laser were used. Tungsten carbide bur at slow speed was found to be the safest of all the adhesive removal systems used. Adhesive removal using Tungsten carbide bur at high speed produced rough enamel surface which was not visible clinically. Diamond bur and Er: YAG laser was found to be causing surface irregularity. It was found that gross irregularities formed during adhesive removal was not removed after final pumicing.

Mateus Rodrigues et al [57] (2014) evaluated different methods of resin removal after orthodontic debonding through a literature review. Rotary instruments were found to be effective in removing the residual adhesive without causing excessive damage to tooth structure. Diamond burs caused major enamel wear whereas tungsten carbide bur was effective in resin removal without enamel damage.

Bayram Corekci [58] (2014) tested the effects of contemporary orthodontic composites on tooth colour following short term fixed orthodontic treatment. The adhesives used were Grengloo, Light Bond, Kurasper F and Tranbond XT. The adhesives were removed first using high speed carbide bur and then slow speed carbide bur and finally enamel was polished using soflex finishing discs. All adhesive materials showed the same colour alteration on enamel and there were no significant difference for colour change between the groups.

Yasemen Boncuk et al [59] (2014) assessed the effects of different orthodontic adhesives and resin removal technique on enamel colour alteration. Etch and rinse adhesive system, self- etch adhesive system and a resin modified GIC were used for bracket bonding and colour evaluation was made before and after photo aging and a second photo aging. Resin removal was done using 12 bladed tungsten carbide bur and stain buster composite bur. Highest colour change was observed in etch and rinse adhesive system along with tungsten carbide bur group.

Joanna Janiszewska- Olszowska et al [60] (2014) did a systematic review on the effects of orthodontic debonding and adhesive removal on the enamel. The summary of the review shows that Arkansas stone, green stone, steel burs, diamond burs and lasers should not be used for adhesive removal. Tungsten carbide bur is faster and

effective in adhesive removal than soflex discs. Finishing procedure is best done with multistep soflex disc and pumice slurry for achieving a smoother enamel surface.

Elcio Mario Faria et al [61] (2015) evaluated the surface roughness and morphology of enamel with a surface roughness tester and scanning electron microscopy after the bracket adhesive and removal procedures. Aluminium oxide discs and carbide burs were used for finishing and polishing. Enamel surface roughness was more when tungsten carbide bur was used for polishing.

Quishuo Chen et al [62] (2015) evaluated the influence of orthodontic treatment with fixed appliance on enamel in a systematic review. Both adhesive system and resin removal technique contribute to enamel colour change. Chemically cured resin found to be causing more colour change than light cured composites. Enamel polishing systems like stain buster was advocated for effective removal of residual adhesive. Tungsten carbide bur was recommended for safe cleaning of resin modified GIC.

Shahin Bayani et al [63] (2015) studied the shear bond strength of orthodontic colour changing adhesive with different light curing times. Grengloo and Transbond plus colour changing adhesives were compared with light curing time of 20 seconds and 40 seconds. Shear bond strength was found to be higher in Grengloo than Transbond

Plus. Though the shear bond strength was reduced when the curing time was reduced with decreasing time for curing, the attained strength was sufficient for clinical usage.

Joanna Janiszewska- Olszowska et al [64] (2016) determined the effects of orthodontic debonding and residual adhesive removal on three dimensional micro roughness using confocal laser microscopy. A chemical cured orthodontic adhesive was used for bonding brackets. For adhesive residue removal, 12- fluted tungsten carbide bur, one step finisher and polisher and adhesive residue remover were used. There were different degrees of enamel roughness caused when different methods of adhesive removal was used. Smoothest surface was achieved when adhesive residue remover was used and roughest surface was obtained when tungsten carbide bur was used.

Shabnam Ajami et al [65] (2016) evaluated the effects of nanohydroxyapatite serum on the enamel roughness and tooth colour stability after orthodontic debonding procedure. Residue adhesive was removed using 12 fluted tungsten carbide bur followed by PoGo finisher for polishing. Final polishing was done using rubber cup and pumice slurry. Enamel colour change was noted even after aggressive residue removal. Nanohydroxyapatite crystals couldn't restore enamel condition.

Raquel Osorio et al [66] (2016) assessed the enamel surface morphology after bracket debonding. Highly filled resin composite was used for the bracket bonding. The filler in the adhesive consisted of inorganic micro particles. 12 fluted tungsten carbide bur, Arkansas stone both inn high and slow speed, soflex disc in slow speed, Enhance composite finishing disc in low speed, Enhance composite finishing disc and polishing cups in low speed with Prisma gloss polishing paste and ultra-fine polishing paste were used for adhesive removal. Smoothest surface was obtained when Enhance system with gloss polishing paste was used. Second smoothest surface was obtained using Soflex Aluminium oxide disc.

Mauricio Barbieri Mezomo et al [67] (2017) evaluated the temperature rise in the pulp chamber with different techniques of adhesive removal. High speed tungsten carbide bur with water cooling, without water cooling, low speed carbide burs, low speed aluminium oxide discs, low speed fiber glass bur were used for adhesive removal. Lowest pulp chamber temperature rise was caused by tungsten carbide bur with water cooling whereas the fiber glass bur evoked the highest temperature rise. Low speed Aluminium oxide disc was also fund to be increasing the pulp chamber temperature.

Xioa- Chuan Fan [68] (2017) evaluated the effects of various debonding and adhesive clearance method on the enamel surface. Brackets were debonded using debonding pliers and enamel chisel and clean-up was done using diamond bur and one gloss, super snap disc and one gloss polisher. Debonding pliers were found to be safer than

enamel chisels for bracket removal. One gloss polisher was found to be more efficient in polishing the surface after debonding but took more time.

Akshaya Pandian [69] (2017) assessed the enamel colour changes following orthodontic treatment through a literature search. Self- etching primers were found to be producing less enamel colour change than the conventional etch and rinse system. Resin modified Glass Ionomer Cement produced least colour change when compared to light cured and chemically cured adhesives. Complete adhesive removal through polishing significantly reduced the colour change of enamel post orthodontically.

Maria Francesca Sfondrini et al [70] (2017) conducted an epidemiological survey of different clinical techniques of orthodontic bracket debonding and enamel polishing. A series of instruments were found to be in use for adhesive removal and following polishing. Low speed tungsten carbide bur followed by high speed tungsten carbide bur was found to be the most commonly used adhesive removal technique. Rubber cup followed by abrasive discs were the mostly preferred enamel polishing method.

MATERIALS AND METHODS

MATERIALS AND METHODS

The study was conducted on 150 extracted human premolars, from the patients for whom therapeutic extraction was indicated. The age of the patients, from whom the teeth were collected ranged between 15 to 25 years. The study was done after the ethical clearance from the institutional ethical committee (IEC/ VDCW/01/2015).

All the samples were divided into five groups with 30 teeth assigned to each group. The teeth included in the study were with sound enamel, non- carious, free of restorations, fractures, intrinsic stains, white spot lesions and any iatrogenic damage during extraction. All the teeth were immediately cleansed and stored in distilled water under room temperature until the experiments.

Specimen preparation

The teeth were imbedded in acrylic blocks of one inch length with crown above the acrylic (figure 1). The teeth were cleansed using ultrasonic scaling followed by polishing with rubber cup and pumice slurry (figure 2). The labial surface of the tooth around the FACC point was exposed through a window of 4 mm radius circle and the rest of the crown was covered in nail enamel. All the samples were marked with a number for identification.

Bonding procedure

The specimen were divided into 5 groups. Each group consisted of 30 teeth.

Group 1 served as control group in which no experiments were carried out. The enamel surfaces were left untreated and were subjected to colour assessment alone before and after two photo ageing cycles.

In group 2 and group 3 the teeth were bonded with metal brackets of 0.022 inch slots (Gemini, 3M Unitek, Monrovia) (figure 3), after etching with 37% orthophosphoric acid for 30 seconds and rinsed with air- water spray for 20 seconds and air dried for 10 seconds. The primer used was orthosolo (Ormco Corporation, Glendora) and brackets were bonded using Grengloo (Ormco corporation, Glendora) colour changing orthodontic adhesive, after removal of flash, using a LED light source (SS WHITE dental pvt. Ltd) for 10 seconds (figure 4).

In group 4 and group 5, the teeth were bonded with the metal brackets of 0.022 inch slot (Gemini, 3M Unitek) after etching with 37% orthophosphoric acid for 30 seconds and rinsed with air water spray for 20 seconds and air dried for 10 seconds. The primer used was Transbond XT (3M Unitek, Monrovia) and adhesive used was Transbond Plus (3M Unitek, Monrovia) colour changing adhesive and cured using LED light source (SS WHITE dental pvt. Ltd) for 10 seconds. (figure 5)

The specimens were stored in distilled water until photo ageing.

Colour assessment

The colour assessment was done for all the samples before the bonding procedure. Then the samples were subjected to first photo ageing. Immediately after debonding and resin removal, second colour assessment was done. The samples were then subjected

to second photo ageing and colour assessment was done again using hand held spectrophotometer (Vita easy shade advance 4.0) (figure 6). Before each measurement, the spectrophotometer was calibrated.

Colour evaluation was made in accordance with the CIE (Commission Internationale de l' Eclairage) L*a*b* colour system (lightness, red/green and blue/yellow).

For colour comparisons, the following formula was used

$$\Delta E_{2-1} = [(\Delta L)^2 + (\Delta a)^2 + (\Delta B)^2]^{1/2}$$

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

Whereas Δ E 1 is the colour difference between the values obtained at the start of treatment and after removal of adhesive and cleaning procedures. This difference obtained was the indication of colour change throughout orthodontic treatment.

ΔE2 is the colour difference from the beginning of the treatment and after second photo ageing values (baseline- ageing). Clinically it indicates the colour change that takes place during and one month after the orthodontic treatment.

ΔE3 is the colour difference between the values that obtained after the debonding, resin removal procedures and the second photo ageing values. Clinically it indicates the colour changing that occurs after the orthodontic treatment procedure.

Photo ageing procedure

The aim of photo ageing was to stimulate internal discoloration. The procedure induced ageing equivalent to exposure to sun radiation in India for a period of 30 days. For this purpose the specimen were placed in a photo ageing device (Q-Sun Xe- 1B) for a duration of 60 hours (figure 7, figure 8). The samples were exposed to ten hours of light cycle at 55 degree Celsius and 2 hours of dark cycle at 30 degree Celsius with intensity at 0.45 W/ m^2. The intensity control point was 340 nm UV sensor and lamps used were air cooled Xenon lamp. The total irradiance exposed on the sample was 81.4 Kj/ sq meters.

Debonding and resin removal

After the second photo ageing, the brackets were debonded using a straight debonding plier [53] (figure 9**)**. In group 2 and 4, the remaining adhesive was removed using 12 blade tungsten carbide bur (EMS Hg Ex 1, Golden remover) which was mounted on a water cooled, high speed contra angled hand piece (figure 10) and in group 3 and 5, coarse soflex disc (3M ESPE, USA) were used which was mounted on a slow speed contra angled micro motor (figure 11). The cleaning was performed under loupe magnification (2.5 x 420) for effective adhesive removal (figure 12). The efficiency of the resin removal was ascertained by viewing under stereomicroscope in 10 X magnification (figure 13).

LIST OF FIGURES

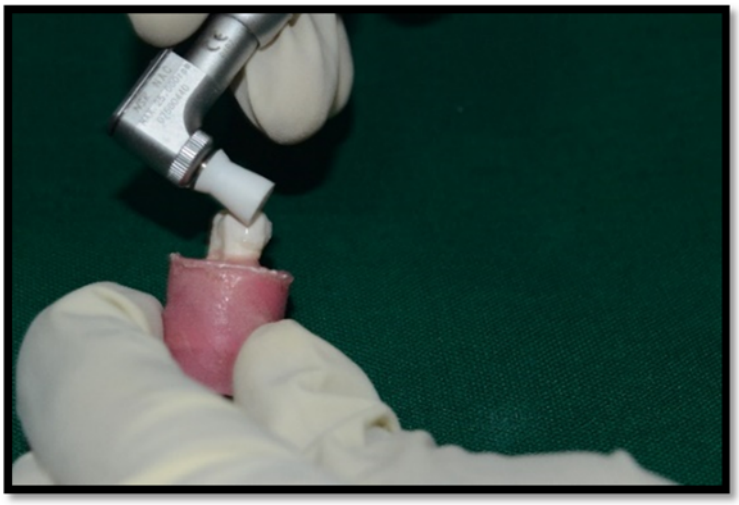


Figure 3: Orthodontic brackets used.

Figure 4: Grengloo orthodontic adhesive and Ortho Solo primer

Figure 5: Transbond Plus Orthodontic adhesive and Transbond XT primer

Figure 6: colour evaluation using spectrophotometer (Vita Easy Shade Advance 4.0)

Figure 7: Samples attached with brackets and fixed on to tray for photo ageing

Figure 8: Q-Sun Xe- 1B photo ageing apparatus with the tooth samples

Figure 9: Straight debonding plier for bracket removal

Figure 10: 12 fluted tungsten carbide bur for adhesive removal

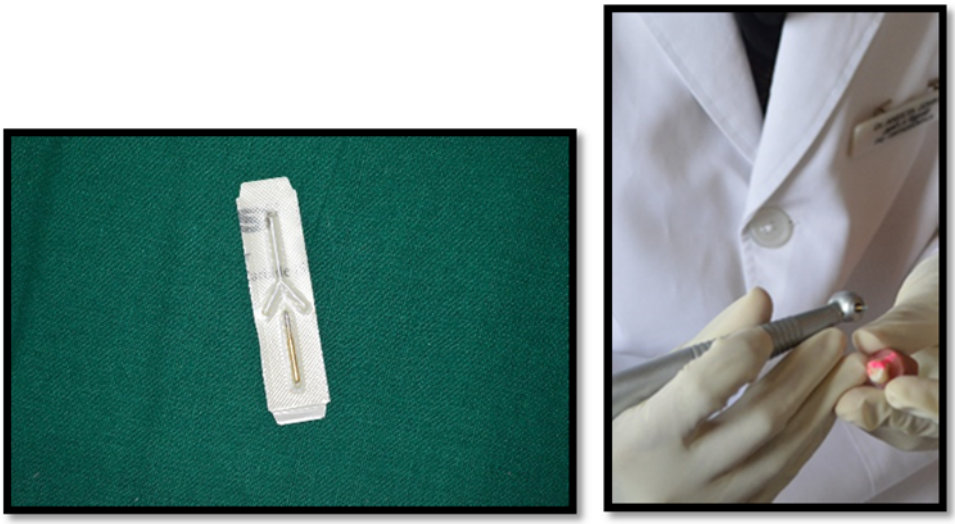


Figure 11: Coarse soflex aluminium disc for adhesive removal

Figure 12: Adhesive removal done using loupe magnification

Figure 13: Complete resin removal ensured under stereomicroscope

STATISTICAL ANALYSIS

STATISTICAL ANALYSIS

Shapiro Wilk and Levene test was used to check the distribution of variables and the homogeneity of the variances. Descriptive statistics were indicated as the median and interquartile range. One way ANOVA was used with Bonferroni correction to compare the effects of the adhesive systems and cleaning methods on ΔE1, ΔE2 and ΔE3 mean values. The differences between the three ΔE mean values among the cleaning methods and the adhesive system were evaluated using the ANOVA test with Bonferroni correction.

Sample mean may be calculated as

$$\overline{X} = x_1 + x_2 + \ldots\ldots\ldots\ldots + x_n = \sum_{i=1}^{n} xi/n$$

and S.D is $S = \sqrt{\dfrac{\sum_{i=1}^{n} (\bar{x}i - x)^{\wedge}2}{n-1}}$

The formula used for one- way ANOVA was

$$F = \frac{\left(\sum_{i=1}^{K} Ni\ (\bar{x}i - \bar{x})2\right) \Big/ (k-1)}{\left(\sum_{i=1}^{k} \Sigma(Ni-1)Si2\right) \Big/ (N-k)}$$

$$\text{Where } S_i^2 = \frac{\sum_{j=1}^{Ni} (x_{ij}-x1)^2}{N_i-1}$$

X_{ij} is the j^{th} observation in the i^{th} group, xi is the mean of observations in the i^{th} group and N_i is the number of observations in the i^{th} group. X is the overall mean of the entire observations.

$P<0.05$ was considered as the level of significance.

RESULTS

RESULTS

TABLE 1: Descriptive statistics indicating the median and interquartile range along with minimum and maximum ΔE values

Group	ΔE1(baseline- debonding)					ΔE2(baseline- aging)					ΔE3(debonding- aging)				
	Median	IR	Min	Max	N	Median	IR	Min	Max	N	Median	IR	Min	Max	N
Control	11.80	6.78	6.17	25.62	29 (96.6%)	13.25	5.22	5.27	27.72	30	6.97	3.46	3.74	15.56	23
Grengloo+tungsten carbide	15.91	8.67	5.47	29.23	30	15.04	6.31	5.83	31.35	30	8.75	5.77	3.78	18.93	28
Grengloosoflex	12.19	7.44	4.52	80.82	30	16.08	8.48	6.45	85.42	30	8.14	5.73	4.00	20.00	27
Transbond plus+ tungsten carbide	15.76	11.67	4.75	61.85	29	15.69	6.95	4.69	65.57	30	9.31	5.58	5.60	18.09	29
Transbond plus+ soflex disc	15.55	7.35	4.09	28.55	30	16.37	9.63	5.59	35.98	30	7.56	4.34	3.90	17.38	28

IR indicates interquartile range. Min, minimum; Max, maximum. N indicates the number of sample in each group above the clinical threshold value of ΔE 3.7. It shows a colour change of 96.6% samples in the ΔE1 of the control group.

TABLE 2- Comparison between the adhesive system and cleaning method with respect to the control in ΔE1

ΔE1 (Baseline-debonding)	Control (mean)	Grengloo (mean)	Transbond plus (mean)	P Value
Tungsten carbide	12.43	15.80	17.17	0.055
Soflex	12.43	15.17	15.19	0.398
P		0.851	0.383	

One way ANOVA was used to test the significance between the adhesives and the resin removal methods in respect to the control in baseline- debonding colour change. P value significant at <0.05.

In both the adhesive groups, there was no statistical colour change observed with tungsten carbide bur and soflex disc with a p value of 0.851 and 0.383 respectively. The colour change between the adhesives in each resin removal system was also found to be not significant with a p value 0.055 and 0.398 respectively. (Graph 1)

TABLE 3- Comparison between the adhesive system and cleaning method with respect to the control in ΔE2

ΔE2 (Baseline-Ageing)	Control (mean)	Grengloo (mean)	Transbond Plus (mean)	P value
Tungsten carbide	13.87	15.27	16.74	0.348
Soflex	13.87	18.03	17.61	0.171
P		0.321	0.711	

One way ANOVA was used to test the significance between the adhesives and the resin removal methods in respect to the control in baseline- Ageing colour change. P value significant at <0.05

In both the adhesive groups, there was no statistical colour change observed with tungsten carbide bur and soflex disc with p value of 0.321 and 0.711 respectively. The colour change between the adhesives in each resin removal system was also found to be not significant with p value of 0.348 and 0.171 respectively. (Graph 2)

TABLE 4- Comparison between the adhesive system and cleaning method with respect to the control in ΔE3

ΔE3 (Debonding-Aging)	Control	Grengloo (mean)	Transbond Plus (mean)	P value
Tungsten carbide	6.42[a]	9.27 [b]	9.79 [b]	0.002**
Soflex	6.42	8.18	8.15	0.136
P		0.331	0.102	

One way ANOVA with Bonferroni correction was used to test the significance between the adhesives and the tungsten carbide group with respect to the control in debonding- ageing colour change. ** The P value significant at <0.05.

In soflex group, one way ANOVA was used to compare the colour difference between the two adhesive groups with the control.

There was a statistical significance in colour change between the adhesive groups and control in tungsten carbide adhesive removal system with p value of 0.002. (Graph 3).

TABLE 5- Comparison between ΔE1, ΔE2 and ΔE3 with in the adhesive systems and cleaning methods.

	ΔE1 (Baseline-debonding) (mean)	**ΔE2** (baseline-ageing) (mean)	**ΔE3** (debonding-ageing) (mean)	**P value**
GRENGLOO				
Tungsten carbide	15.80[a]	15.27[a]	9.27[b]	< 0.001**
soflex	15.17[a]	18.03[a]	8.18[b]	0.004**
TRANSBOND PLUS				
Tungsten carbide	17.17[a]	16.74[a]	9.79[b]	0.003**
Soflex	15.19[a]	17.61[a]	8.15[b]	< 0.001**
CONTROL	12.43[a]	13.86[a]	6.42[b]	<0.001**

One way ANOVA with Bonferroni correction was done to test the significance between the adhesive removal systems in each adhesive group among ΔE1, ΔE2 and ΔE3.

** The difference between ΔE1, ΔE2 and ΔE3 is statistically significant ($p<0.05$).

In each row, same lower case alphabet denotes no significance.

The colour change was similar between ΔE1 and ΔE2 in all the experimental groups and both were significantly higher than ΔE3 values indicating there is a significant colour change after debonding. There is less colour change 30 days post debonding in all the groups.

The colour change was similar between ΔE1 and ΔE2 in the control group and both were significantly higher than ΔE3 values indicating there is a significant colour change after first photo ageing. There is less colour change after 30 days in the control group.

TABLE 6- Cross comparison of ΔE1, ΔE2 and ΔE3 levels with respect to adhesive systems and cleaning methods

	Grengloo (mean)	Transbond Plus (mean)	P Value
ΔE1 (Baseline- debonding)			
Tungsten carbide	15.80	17.17	0.541
Soflex	15.17	15.19	0.994
P	0.851	0.383	
ΔE2 (Baseline-Ageing)			
Tungsten carbide	15.27	16.74	0.517
Sof lex	18.03	17.61	0.883
P	0.321	0.711	
ΔE3 (Debonding- Aging)			
Tungsten carbide	9.27	9.79	0.619
Soflex	8.18	8.15	0.974
P	0.331	0.102	

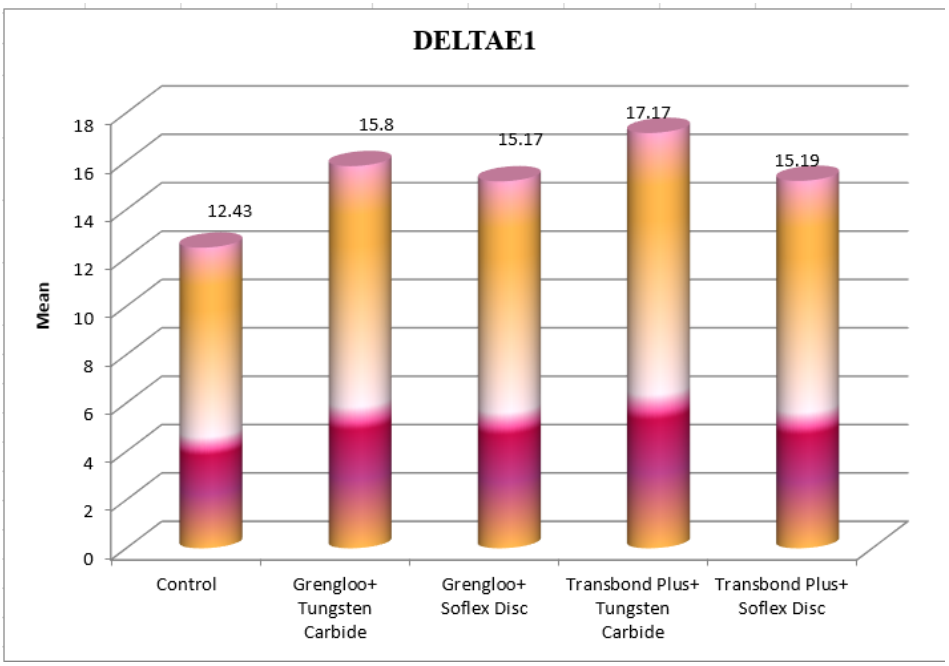
Comparisons between the adhesive systems and the resin removal methods have been done with one way ANOVA.

P value significant at <0.05. (Graph 4).

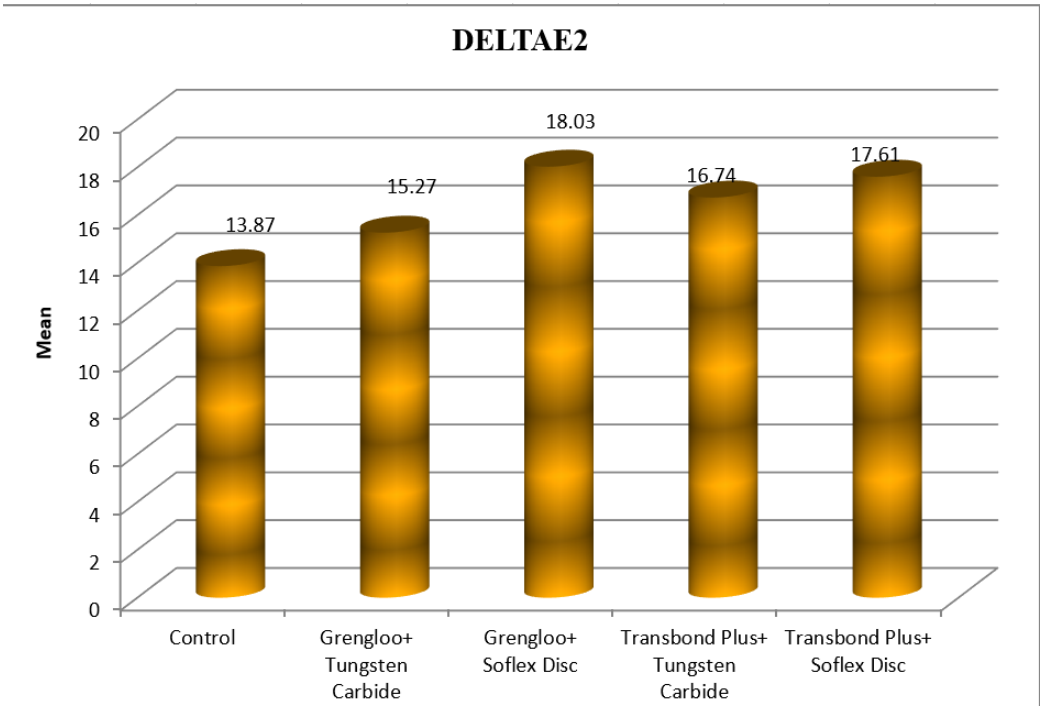
There was no statistically significant colour change between the adhesive systems and resin removal methods.

GRAPHS

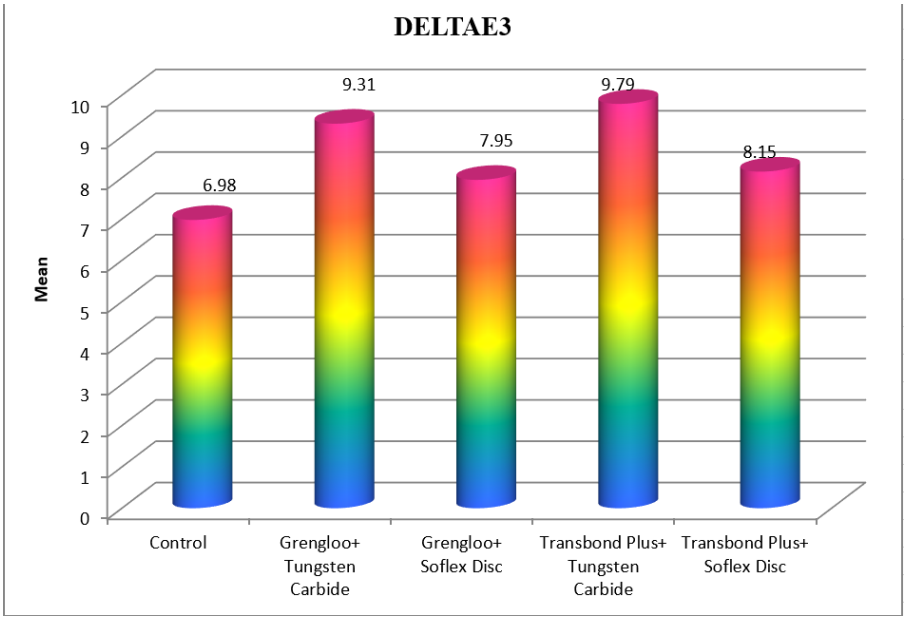
Graph 1



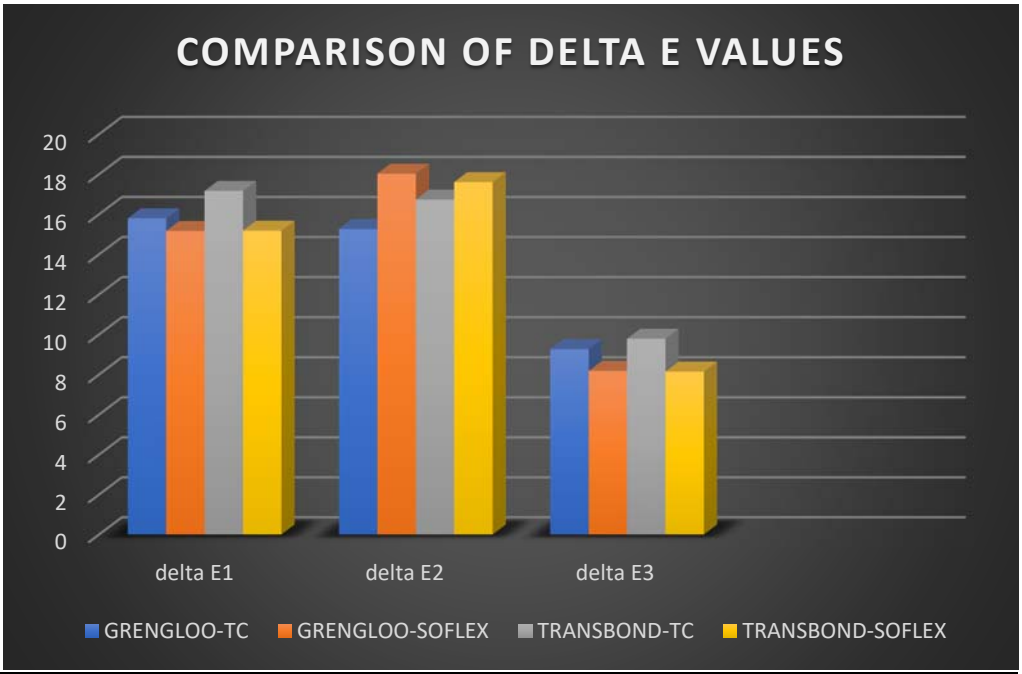
Graph 2



Graph 3



Graph 4



DISCUSSION

DISCUSSION

An attractive smile grants its owner the perception of being superior, intellectually and socially. Possessing an attractive smile also increases the facial attractiveness which is a key factor in influencing kinship opportunities, personality evaluations, performance, mating success and employment prospects. An aesthetically pleasing smile is determined by many factors like tooth position, size, shape, lips, gingival display, buccal corridor etc. Among the factors, tooth colour owns a prime status in determining the attractiveness of smile[3].

Colour is important for aesthetics of the teeth which results from volume scattering of light by enamel. Illuminating light follows highly irregular light paths through the tooth before it emerges at the surface of incidence and reaches the eyes of the observer [46].

Enamel is a highly mineralised connective tissue which consist of prism like structures called enamel rods made up of hydroxyapatite crystals. These prisms has a head called as core and tail called as periphery when seen in cross section [71]. For attaching a bracket on to the enamel surface, in conventional acid etching technique, a mechanical retention surface is created by the dissolution of prism peripheries. Based on the area of dissolution there are five types of etching pattern. Type 1 honey comb appearance formed by the preferential dissolution of prism cores, type 2, cobble stone appearance by the preferential dissolution of the peripheries, type 3 a mixture of type 1 and type 2 etching pattern, type 4 characterised by pitted surface [72] and type 5 identified as smooth surface[73.] The art of complete removal of resin tags is not yet perfected in the current scenario.

The enamel colour changes following orthodontic treatment are due to the colour intake by the resin tags, scratches and enamel irregularities formed during debonding and finishing procedures, type of orthodontic adhesives and their application[7,13,17, 24, 32,.]

Multiple light scattering inside the tooth determines the light paths. After clean up procedures, the refractive index of the enamel surface are changed which influence the diffusely reflected light[23]. According to Eliades et al, this phenomenon has influenced the colour parameters of tooth because the tooth surface after debonding and clean up was mainly composed of cut enamel prism infiltrated by resin tags, occupying the sites of enamel rods dissolved by acid etching. [30]

Andreas Karamouzos et al[35] and Andreas Faltermeier et al[42] stated that the colour of natural teeth after orthodontic treatment, changes in various ways of external and internal discolouration of remaining adhesive materials, permanent iatrogenic damage of enamel caused during bonding, debonding and polishing, dental and pulp alterations during the orthodontic treatment etc. Yasemen Boncuk et al [59] showed that orthodontic adhesives and resin removal systems are responsible for enamel colour alteration during and after orthodontic treatment. Abbas R Zaher [50] ascertains that an iatrogenic enamel colour change seems to be inevitable after orthodontic treatment.

Colour changing orthodontic adhesive, unlike the tooth colour orthodontic composites, makes it easier for the clinician to remove excess flash as well as complete removal of residual orthodontic adhesive after bracket debonding. This by itself is a favourable factor in reducing post orthodontic enamel colour change.

Transbond™ PLUS is one of the Colour Changing Adhesive which is a moisture tolerant light cure bonding system. It provides excellent bond strength with metal and ceramic brackets along with the special features of colour change with curing and fluoride release. Colour changing property of the adhesive allows better bracket positioning and flash clean-up. The colour change does not indicate curing of the adhesive. With the presence of ambient light, the pink colour fades away before the actual polymerisation of the composite. It is compatible with Transbond XT regular primer and Transbond Plus self-etching primer and Transbond Moisture Insensitive Primer system. It contains hydrophilic monomers. When used with regular Transbond XT primer, the adhesive doesnot exhibit moisture tolerance. The composition of Transbond Plus adhesive is similar to the Transbond XT with micro quartz and campheroquinone and an addition of colour element. Ekhlassi et al [47] compared the enamel bracket bond strength of different colour changing orthodontic adhesives and it was shown that the mean shear bond strength at one week of bonding, Tranbond plus showed the highest.

Grengloo colour change adhesive manufactured by Ormco, claims on-demand color contrast feature aiding in fast and accurate clean-up at bonding and debonding. As Grengloo warms to the temperature of the body, the colour disappears and remains clear throughout treatment. When debonding, simple introduction of a short blast of cool air or water lowers the bonding surface temperature and the adhesive turns green again for easy and thorough clean up. The adhesive was found to provide high level of impact resistance for reduced emergency visits as a result of bond failures caused by traumatic impacts. Formula includes a unique hybrid filler material that provides excellent handling characteristics, making clean up easy and virtually eliminating bracket drift. In study by

Hakkan Türkkahraman, the author preferred to use Grengloo and Blugloo in situations which needed higher shear bond strength. Study by Shahin Bayani [63] shows that the shear bond strength of Grengloo was higher than that of Transbond Plus.

The present study was done to evaluate the colour changing effect on the enamel by the two colour changing adhesives, Transbond Plus and Grengloo and also finding a combination of colour changing adhesives and resin removal technique which would impart least enamel colour change following orthodontic treatment.

Visual inspection of the colour variation is subjective and colour perception differs from person to person. The enamel colour change is mathematically calculated through the CIE L*a*b* system, as it is considered to be the standard color indicating system and it is quantified as ΔE. ΔE value less than 1 is not perceived by the human eye and a value greater than 3.7 is found to be unacceptable in the clinical conditions [37, 38, 46]. So in the present study, the clinical threshold value of ΔE was 3.7. Vita easy shade advance 4.0 was used for the colour quantification of enamel surfaces.

Caory Ulusoy [39] compared various resin removal methods including tungsten carbide bur and soflex and found that 12 fluted and 30 fluted high speed and water coolant system was the fastest and efficient in resin removal but resulted in lot of scar formation. There is difference in opinion regarding the speed and number of flutes employed in the tungsten carbide bur, in determining the efficiency. A J Ireland [32] observed that slow speed tungsten carbide bur caused the least enamel damage during the adhesive removal whereas ultra- sonic scaler and high speed tungsten carbide bur caused the maximum enamel scarring. Whereas Bjorn U Zachrisson [12] affirmed that plain cut or spiral fluted tungsten carbide bur at low speed produced the finest scratch pattern

and least enamel loss. Retief and Denys [15] has agreed on the efficiency of 12 bladed tungsten carbide bur at high speed in removing adhesive residue with in the least time period. According to Zarinnia et al [21], 12 fluted tungsten carbide at high speed when finished with medium, fine and ultra-fine soflex disc produced the most effective result. Hong and Lew [24] found that Jet high speed Tungsten carbide bur produced the least enamel roughness when compared with a series of adhesive removal systems.

Elcio Mario Faria et al [61] evaluated the enamel surface after adhesive removal using Aluminium oxide disc and carbide burs and found that enamel roughness was more when multi-laminated carbide bur was used. Raquel Osorio et al [66] evaluated the enamel surface morphology after bracket debonding and following adhesive removal using a variety of adhesive removal systems and found that soflex discs produced smoother surface than 12 bladed tungsten carbide bur. NJ Cochrane [52] observed a lesser degree of enamel damage by slow soflex than high speed tungsten carbide bur. Cui Ye et al found that tungsten carbide bur when used alone, caused the highest colour change and a finishing procedure with soflex disc can considerably reduce the color change. In the extant study 12 bladed tungsten carbide bur at high speed and soflex coarse aluminium oxide disc in slow speed micromotor is used for the adhesive residue removal.

According to Denis. F. Baumann [49], there were less enamel damage and composite residue when the procedure was done using dental loupes. Usage of loupes helped to effectively remove the remaining adhesive and hence could evaluate the efficiency of adhesive removal system more efficiently. Considering the facts, in the

present study the residual adhesives were removed under 2.5 x 420 magnification dental loupe to aid in the resin removal.

Stereomicroscope under 10 X magnification has enabled the investigator in ensuring the complete removal of orthodontic adhesives.

Colour change of the teeth can be due to internal discolouration or external discolouration. In the present study, for the homogeneity of the samples studied, all the teeth were subjected to internal discolouration through the process of accelerated artificial photo-ageing, avoiding factors that may cause any other type of discolouration. The efficacy of this method is confirmed by the presence of samples with a colour change above the threshold of ΔE 3.7, observed in 56% of the control specimens [59]. In the present study, the samples which showed a colour change above the clinical threshold of ΔE was found to be 96.6% in the control group confirming the effects of artificial accelerated ageing.

In the present study the extent of colour change was found to be more in the period after debonding (p value <0.05 in all the experimental groups). This result is corroborating the study results by Eliades et al [8] , Jahanbin et al [38] and Yasemen Boncuk et al [59].There was significant colour change after bracket removal and polishing, in all the groups, when compared with in themselves. There was significant colour change in the control group also after two cycles of photo-ageing.

When the adhesive system and resin removal method with respect to the ΔE1 and ΔE2 values were compared with the control, there was no statistically significant

difference among the adhesive system nor the resin removal techniques. When the adhesive system and resin removal method was compared with respect to the ΔE3, tungsten carbide group showed a significant colour change from the control in both the adhesive groups (p value = 0.002). This shows that there was a greater colour change in post orthodontic treatment period when tungsten carbide bur was used for resin removal. Tungsten carbide group exhibited higher colour change during the treatment period from bonding to debonding and also in between the debonding and after 30 days. The overall colour change was found to be more in tungsten carbide bur along with etch and rinse technique in the study by Yasemen Boncuck [59], when the earlier was compared with stain buster bur in combination with self -etch primer. The increased colour change in debonging- ageing colour evaluation of tungsten carbide group may be attributed to the increased roughness produced by the bur, causing a variation from the refractive index of the normal tooth. But when the overall colour change from the beginning to 30 days after orthodontic bracket debonding was evaluated, soflex group was showing slight increase. But there was no statistically significant difference.

Bayram Corekci et al [58] studied the effects of contemporary orthodontic composites on tooth colour following short term fixed orthodontic treatment, using regular light curing orthodontic adhesives along with Grengloo and found that all the orthodontic adhesives exhibited similar colour change post orthodontically and there were no significant difference between the adhesives. Eliades et al [8] and Jahanbin et al [38]stated that the type nor the method of application of the adhesive was affecting the enamel colour change after the bracket debonding. The complete adhesive removal without the enamel loss is not achievable with any type of residual adhesive removers

and hence results in irregular enamel surfaces, resulting in a notable colour change after bracket debonding, if not followed by through polishing and finishing procedures [21, 45, 22, 24, 39]. The present study was validating these studies. The colour change produced by different colour changing orthodontic adhesive and resin removal systems used in the current study was found to be insignificant when compared among themselves. Which means that the colour change exhibited by both the adhesives and resin removal systems in this study was similar.

Better evaluation of the bonding resins and resin removal systems on enamel colour can be done by carrying out the study in-vivo, where the tooth will be subjected to various staining elements which were not tested in the present study.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The study has been done

1. To assess the enamel colour change following the usage of two different colour changing orthodontic adhesives.
2. To find out a resin removal system which contribute to minimal enamel colour change when used along with different colour changing adhesives.
3. To find a better combination of an adhesive and a resin removal system which causes minimal enamel colour change post treatment.

150 extracted human premolars were divided into 5 groups, one control and 4 experimental groups in which orthodontic brackets were bonded using 2 colour changing orthodontic adhesives, Greengloo and Transbond Plus. After subjected to artificial ageing the brackets were debonded and resin removal was done using 2 types of adhesive removal system 12 fluted tungsten carbide bur and coarse Soflex disc. An episode of artificial ageing was carried out again. The colour changes were noted at the baseline, after debonding and after second photoageing.

The following observations were made

1. There was significant colour change in all the groups post photo ageing.
2. The colour change produced after removing the residual adhesive resin by both the resin removal system was found to be similar and not significant compared to the control group.
3. The colour change produced by different adhesive resins compared with the control after debonding and 30 days post debonding was not significant.

4. Tungsten carbide bur group was found to be producing a significant colour change compared with the control group when assessed 30 days after the bracket debonding.
5. There was no statistically significant colour change between the adhesive systems and resin removal methods. The colour change produced by both the colour changing adhesives were similar.

Clinical studies with different combinations of adhesives and newer resin removal systems might be done to bring about better clinical aesthetic enamel integrity post orthodontic treatment.

The study concluded that

1. There was insignificant amount of enamel colour change post orthodontically, when Grengloo and Transbond plus colour changing orthodontic adhesive were used.
2. Tungsten carbide and soflex resin removal systems has similar effect on enamel colour immediately after debonding.
3. Tungsten carbide bur group has shown to produce discolouration 30 days post treatment, when compared with the control.
4. Grengloo and Transbond plus colour changing adhesives along with soflex disc may be used for better aesthetics after orthodontic treatment with minimal enamel colour change.

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ANNEXURE

INSTITUTIONAL ETHICS COMMITTEE
VIVEKANANDHA DENTAL COLLEGE FOR WOMEN

SPONSORED BY : ANGAMMAL EDUCATIONAL TRUST

Ethics Committee Registration No. ECR/784/Inv/TN/2015 issued under Rule 122 DD of the Drugs & Cometics Rule 1945.

Dr. J. Baby John	Chair Person	Dr. (Capt.) S. Gokulanathan	Member Secretary
Mr. K. Jayaraman	Social Scientist	Mr. A. Thirumoorthy	Legal Consultant
Dr. R. Jagan Mohan	Clinician	Dr. N. Meenakshiammal	Medical Scientist
Dr. B.T. Suresh	Scientific Member	Dr. R. Natarajan	Scientific Member
Dr. Sachu Philip	Scientific Member	Mr. Kamaraj	Lay Person

No: VDCW/IEC/ 01 /2015

Date: 14.12.2015

TO WHOMSOEVER IT MAY CONCERN

Principal Investigator: Dr. Aneeta Johny

Title: An invitro study to compare the effects of different colour changing orthodontic adhesives and different resin removal techniques, on enamel colour.

Institutional ethics committee thank you for your submission for approval of above proposal .It has been taken for discussion in the meeting held on 04 .12.15.The committee approves the project and it has no objection on the study being carried out in Vivekanandha Dental College For Women.

You are requested to submit the final report on completion of project. Any case of adverse reaction should be informed to the institutional ethics committee and action will be taken thereafter.

CHAIRMAN
INSTITUTIONAL ETHICS COMMITTEE
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Test Certificate for Q-Sun Xe-1 B Exposure

No. QP: Q-Sun Xe-1 B (216A): 144

This is to certify that the 150 Nos. of Acrylic Mounted Tooth samples marked as 1 TO 150 given by M/s DR. ANEETA JOHNY, TAMIL NADU has been exposed in our Q-Sun Xe-1 B equipment Sl. No 01-2258-4-Xe1 for the duration of 60 hours as per the Customer Specified Day Light Filter standards. These samples were exposed to 10 hrs. of Light cycle @ 55 deg. C and 2 hrs. of Dark cycle @ 30 deg. with Intensity at 0.45 W/m^2. The intensity control point was 340 nm UV sensor and the lamps used were Air Cooled Xenon Lamp. The total irradiance exposed on the sample was 81.4 KJ/sq. mts.

This Exposure is Equivalent to 30 days of Ageing in India.

Test Conducted by: A. Lakshminarayan
Technical Group

25 July 2017

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Test Conducted by: A. Lakshminarayan
Technical Group

1 September 2017

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