EVALUATION OF TIME AND EFFICIENCY IN ADHESIVE REMNANT REMOVAL AFTER ORTHODONTIC DEBONDING USING AIROTOR ILLUMINATED WITH WHITE LIGHT AND UV LIGHT: AN *IN VITRO* STUDY.

By

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In partial fulfilment of the requirements of the degree of

MASTER OF DENTAL SURGERY

IN

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

Under the guidance of

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Kothamangalam

2020-2023

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled "***Evaluation of time and efficiency in adhesive remnant removal after orthodontic debonding using airotor illuminated with white light and UV light - an in vitro study.***" is a bonafide and genuine research work carried out by me under the guidance of ***Dr. Binnoy Kurian***, Professor & HOD, Department of Orthodontics& Dentofacial Orthopaedics, St. Gregorios dental college, Chelad, Kothamangalam.

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This is to certify that the dissertation entitled ***"Evaluation of time and efficiency in adhesive remnant removal after orthodontic debonding using airotor illuminated with white light and UV light - an in vitro study."*** is a bonafide research work done by ***Dr. Lisie P Mathew*** under the guidance of ***Dr. Binnoy Kurian***, Professor & HOD, Department of Orthodontics & Dentofacial Orthopaedics.

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ABSTRACT

Background and Objectives: After Fixed Orthodontic treatment, brackets are debonded and residual adhesive is removed, sometimes causing iatrogenic enamel damage. Currently, no technique enables complete removal of the composite remnants without damage to the enamel surface. The objective of this study was to compare the efficiency and effectiveness of White light and Ultraviolet light in the detection of fluorescent adhesive remnants during orthodontic debonding by comparing the post debonding adhesive remnant score and adhesive remnant removal time.

Methods: A pilot investigation was first done to evaluate time and efficiency of fluorescent adhesive removal with UV light and white light for inclusion in the main study. An in-vitro study was then conducted using 120 human extracted premolars divided into 4 groups (N=30) according to the brand of adhesive and type of light used during adhesive removal.

Adhesive removal was performed with teeth mounted to a mannequin head to simulate a clinical setup. White light illuminated airotor handpiece and UV light illuminated airotor handpiece were used during removal of residual composite depending on the assigned group. Time (in seconds) was recorded for the clean-up of each debonded tooth. An Optical Stereomicroscope was used to assess the sensitivity of UV light in adhesive detection.

Results: Groups with UV light detection feature had significantly lower amounts of adhesive remnants than groups with white light. Groups with UV light were also found to be lower in time taken to remove the remnant composite adhesive.

Interpretation and Conclusion: UV illuminated airotor handpiece is more efficient and quicker than white light illuminated airotor handpiece in the detection and removal of fluorescent adhesive during orthodontic debonding. Even though there are limitations, UV illuminated airotor is a practical tool to avoid enamel damage and reduce the time needed for adhesive remnant removal.

Key words: Orthodontic debonding, adhesive, airotor, handpiece.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

INTRODUCTION

INTRODUCTION

Increase in awareness on facial aesthetics and early detection of malocclusion have increased the demand for orthodontic treatment. The Orthodontist bonds the bracket on the tooth surface using composite adhesives during fixed orthodontic treatment. After active orthodontic treatment, brackets and adhesive must be mechanically removed from the teeth to restore the enamel surface as close to its pre-treatment condition as possible. Many studies have indicated undesirable outcomes such as the persistence of adhesive remnants as well as enamel loss and roughness after adhesive removal[7].

Brackets are bonded to enamel surface by adhesive composite resins. The etchant commonly used to condition the enamel surface is 37% phosphoric acid. Application of etchant to the tooth surface for 20 seconds results microporosities on the surface. It is followed by rinsing and air drying of the tooth. Primer is then applied to the etched tooth surface in thin layer. This primer layer penetrates the etched tooth surface and resin tags are formed in the enamel, by micromechanical bond. The bracket with adhesive is then placed on this prepared surface and light cured. The bracket is then bonded to the enamel surface of the tooth using light cured composite resins. After the completion of active orthodontic treatment, two procedures need to be done to restore enamel surfaces to its exact pre-treatment conditions. They are Orthodontic debonding followed by adhesive remnant removal.

Orthodontic Debonding: Debonding is done to remove Orthodontic attachments and all remaining adhesives from the tooth and to restore the surface to its pre-treatment condition as much as possible. The initial procedure of orthodontic debonding is the removal of the bracket from the tooth surface. Mechanical failure needs to be induced at one of three interfaces: 1) between adhesive and the bracket, 2) within the adhesive itself, or 3) between the adhesive and the enamel surface. Sinha et al advocate that the most desirable location of failure is the adhesive-enamel interface because this would allow for less residual resin to remove and therefore, less risk for the operator to damage the enamel during resin removal[8].

Adhesive remnant removal: The next procedure in orthodontic debonding is the removal of adhesive remnant. Complete removal of adhesive by the clinician is a challenging task. Modern adhesives are designed to improve dimensional stability and increase tensile strength. However, these same qualities result in increased wear resistance and the presence of the adhesive remnants on the teeth[2]. It is known that bacteria will readily colonize on surfaces of rough materials, such as these resins, resulting in increased plaque accumulation and white spot lesions[2,9]. When the distance from bonded bracket pad to the gingiva is less, the excess adhesive or flash, can act as a mechanical irritant to the gingiva, resulting in periodontal problems[9]. In addition, these adhesive remnants may discolour and affect the aesthetic appearance of the teeth overtime[4,49]. Another negative effect that may occur during resin removal is the damage to the enamel surface.

During orthodontic debonding, the primary aim of the orthodontist is to restore the tooth surface as close as possible to the pre-treatment condition. However, till date, no damage free adhesive removal technique has been described[54,45].Various studies have been completed to explore different methods with minimal risk to the enamel surface.

Janiszewska-Olszowska et al determined in their systematic review that Arkansas stones, green stones, diamond burs, steel burs, and lasers were unacceptable instruments for adhesive removal due to scratching, gouging, and other damage to enamel[30]. The tungsten carbide bur appears to be most popular and accepted, even being reported as the "established" method of resin removal[10]. Diamond burs have been found to be one of the most destructive methods, producing deep grooves in the enamel surface[30,7,2,10] .Nevertheless, diamond burs remain popular despite their negative effects on the enamel surface due to their high efficiency, and reduced chair side time[10,28].

Flash-free adhesives have also been marketed and studied with the goal to minimize the need for adhesive clean up[31]. This would be beneficial as adhesive removal can be completed faster and easier.

Fluorescent Adhesive Resins: Fluorescence property allows a substance to emit more visible light than it receives. Teeth naturally fluoresce when exposed to light sources containing ultraviolet (UV) components and give the teeth an appearance of vitality and health. This autofluorescence of teeth is based on the presence of endogenous fluorophores residing in the enamel and dentine[33].

Europium, ytterbium, cerium, and terbium are examples of rare earth oxides included in the organic matrix or filler components of composite resins to produce the fluorescence[20,24].

Composite resins are practically impossible to detect completely under traditional clinical inspection procedures, such as tactile sense and conventional white lighting[40]. Fortunately, the fluorescence properties added to composite resins can also aid in the identification of restorative materials in contact with teeth[20,24,27,34].

UV assisted Composite resin Detection: Many studies have evaluated UV LED flashlights as an adjunct aid in detection of composite restorations in standard dental examinations as well as in forensic identification in post-mortem odontograms[20,27,40,44].Bush et al sought to determine the optimal wavelength of fluorescence excitation and emission maxima for 14 composite resin brands[44] . Results from the study indicated that the optimal excitation wavelength was 385- 395 nm, while 460 nm was determined to be the mean emission maxima. UV illumination was determined to be a valuable adjunctive aid when complete removal of resin is warranted[44].UV light illumination assists more efficient detection of fluorescent composite allowing quicker and accurate removal of adhesive.

The aim of this study is to compare and evaluate the efficiency of adhesive remnant removal using UV light illuminated and White light illuminated airotor handpiece, during orthodontic debonding.

AIMS & OBJECTIVES

AIMS AND OBJECTIVES

Aims

Aim of the study is to compare the efficiency and effectiveness of White light and UV light illuminated airotor, in the detection of adhesive remnants and its removal during orthodontic debonding by comparing the post debonding adhesive remnant score and the time needed for adhesive removal.

Objectives:

1. Precise removal of composite adhesives without damaging enamel.
2. Decreasing chair side time for composite adhesive removal.

BACKGROUND &

REVIEW OF LITERATURE

BACKGROUND OF THE STUDY

Bracket bonding is the first and foremost step during fixed orthodontic treatment. The orthodontist fixes the bracket on the tooth using composite adhesives. After completing active orthodontic treatment, brackets are debonded and residual adhesive is removed, often causing iatrogenic enamel damage. Efforts should be made to design tools and methods for the complete removal of adhesive remnants, minimizing enamel loss and achieving a smooth surface with minimal chair side time. Currently, no technique allows removal of the composite remnants without causing any damage to the enamel surface. The underlying reasons are acid etching resulting in resin infiltration into the enamel, and the hardness of the enamel (about 5 in the Mohs scale)being lower than that of the abrasive materials used (quartz, aluminium, carbon steel, zirconium oxide 7, and tungsten carbide 8)[30].

Efforts are to be made, to minimize the loss of the enamel layer, as it is the hardest protective layer and rich in fluoride[30]. Ultraviolet (UV) fluorescent chemicals have been added to orthodontic adhesives, allowing UV light to be used as an aid to adhesive remnant removal. Fluorescence allows a substance to emit more visible light than it receives. Multiple studies have evaluated UV light as an adjunct in the detection of composite restorations in standard dental examinations[59].

This study is done to compare and evaluate the efficiency of adhesive remnant removal using UV light and White light illuminated airotor handpiece during orthodontic debonding, with the objectives of precise removal of composite adhesives without enamel damage and to decrease chair side time for orthodontic debonding.

REVIEW OF LITERATURE

Michael G.Buonocore (1955)[35] developed a simple method to increase the adhesion of acrylic filling materials to the enamel surfaces. A phosphoric acid and a phosphomolybdate oxalic acid treatment have been employed so as to alter the enamel surfaces chemically. The phosphoric acid treatment gave better results and is simpler to use.

Brown CR (1978)[36] According to this study the techniques required in the removal of highly filled composite adhesives at the end of orthodontic treatment on an average cause more loss of enamel than removal of an unfilled polymethylmethacrylate adhesive. The amount of enamel lost during the removal of either adhesive may be of clinical significance because of the removal of a major part of the protective fluoride-rich layer of enamel. The use of zirconium silicate on a rotating bristle brush may cause considerable abrasion of enamel.

Rosenthal F. S. et-al (1986)[37] studied and explained the effect of prescription eyewear on ocular exposure to ultraviolet radiation. Epidemiological studies` and experimental animal studies have suggested that ultraviolet radiation (UVR) from sunlight may cause cataracts and possibly retinal disease. One factor influencing exposure to UVR is the use of prescription eyewear (spectacles and contact lenses). Spectacle lenses provide an attenuation of UVR which may vary greatly with the composition, size, and shape of the lens as well as the part of the ultraviolet spectrum that is being considered. UVR covers a range of wavelengths from 100 to 400 nm which is often broken down into three regions: UVA (315-400 nm), UVB (280-315 nm), and UVC (100-280 nm). Both UVA and UVB are found in sunlight and have been implicated as potential hazards to the eye. UVC emitted by the sun is completely absorbed by ozone in the upper atmosphere and does not reach the earth's surface. In the study they examined the UVA and UVB attenuation of a sample of spectacles and contact lenses in use, and investigated the dependence of this attenuation on various factors.

Krell KV (1993)[38] Did a study to examine the effects of ultrasonic orthodontic bracket removal and clean up and compare them with conventional debonding and cleaning of the enamel surfaces with burs and polishing disks. The amount of enamel loss and time for bracket removal and clean-up were also addressed. The total time for bracket removal and enamel clean-up for each group was recorded in seconds. They concluded the study with following results.1. Enamel loss as a result of orthodontic bracket removal is minimized by first debonding the bracket with the bracket removal pliers followed by ultrasonic removal of the residual composite. 2. The tooth surface was not adversely affected in a significant manner when either the combined pliers debonding and ultrasonic clean-up technique or the total ultrasonic debonding and clean-up technique was used. 3. Debonding orthodontic brackets first with bracket removal pliers, followed with the ultrasonic removal of the residual composite for clean-up required significantly less time than the other two techniques.

39.25. **Campbell PM et-al (1995)**[39] conducted a study about enamel surfaces after orthodontic bracket debonding. They studied enamel surfaces of extracted teeth clinically and with a scanning electron microscope following debonding of orthodontic attachments and subsequent polishing. Excess orthodontic resin was removed with tungsten carbide burs and abrasive discs. Several combinations of polishing agents were evaluated. The no. 30 fluted tungsten carbide bur appeared to be the most efficient method of removing highly filled resin, and it produced the least amount of scarring. A polishing sequence was developed which used resin points and cups followed by a water slurry of fine pumice and brown and green cups. This procedure was tested clinically and appeared to return the enamel to an acceptable condition which is fast, efficient, and comfortable for the patient.

Tani K et-al (2003)[40] evaluated the discrimination between Composite Resin and Teeth using Fluorescence Properties. The differentiation of composite resin from teeth using fluorescence emission was investigated as basic research for the visual detection of resin filled teeth in mass dental health examinations. Fluorescence spectra were taken from extracted human maxillary central incisors and 12 types of light-cured composite resins with a maximum of 15 shades via excitation using light with wavelengths of 400-500 nm. The fluorescence intensity ratio of resin to tooth was lowest around 500 nm for all the resins. The fluorescent images were taken based on spectroscopic results, which confirmed discrimination between the resin part and the tooth in the resin filled tooth.

Al Shamsi AH et-al (2007)[41] conducted a study on three-dimensional measurement of residual adhesive and enamel loss on teeth after debonding of orthodontic brackets: The study was done to evaluate 3-dimensionally the changes on tooth surfaces after debonding orthodontic brackets and after removing residual adhesive and finishing. Sixty premolars were randomly divided into 2 groups, and brackets were bonded according to the manufacturers' instructions. Two types of orthodontic adhesives were used: resin-modified glass ionomer cement (group 1) and resin-coated adhesive precoated brackets (group 2). The brackets were debonded on a testing machine at a cross-head speed of 1 mm per minute. The study concluded that adhesive thickness and enamel loss due to orthodontic procedures can successfully be measured in vitro by using 3-dimensional laser scanning technology.

Andreas Faltermeier et-al (2007) [42] did a study to investigate the colour stability of adhesives during ultraviolet irradiation and exposure to food colourants. There are internal and external causes for the discolouration of orthodontic adhesives. External discolouration can be caused by food dyes and coloured mouth rinses. The reason for internal discolouration can be found in ultraviolet irradiation and thermal energy. Ultraviolet light can induce physico-chemical reactions in the polymer, which cause irreversible colour changes. The study concluded that the orthodontic adhesives are discoloured by food dyes and UV light.

Ulusoy C (2009)[43] Comparative study was done on finishing and polishing systems for residual resin removal after debonding. The study was done to evaluate (1) the effectiveness of one-step polishers on the surface morphology of enamel using scanning electron microscope (SEM) and compare their effects with conventional systems for residual adhesive removal; and (2) the time spent to remove resin remnants. The brackets were debonded and residual adhesive was removed using different systems. Results showed 30-blade tungsten carbide burs were the least time consuming procedure. The study concluded that the effect of one-step and multi-step polishing systems on residual resin removal from the enamel was dependent on the characteristics of the instrument in each system. 12- and 30-fluted T'CB at high speed and water coolant proved to be fast and efficient in residual resin removal, but the resultant enamel surface with enamel scars needs to be finished by other polishing techniques. Following the use of TCB and multi-step disc systems for residual resin removal, scratching of enamel is inevitable. Super Snap discs were less aggressive than Sof-Lex discs in removing residual bonding resin and resulted in apparently better surface finish causing less damage to the enamel. One-step PoGo micro polishers resulted in enamel surfaces nearly as smooth as the intact enamel, but found to be the most time consuming method. The results of this research indicated that one-step polishing systems should be used after cleaning the resin remnants on enamel with TCB to avoid extending the chair time.

Bush MA et-al (2010)[44] conducted an in vitro study on using ultraviolet LED illumination for composite resin removal. This study explores a technique that utilizes a UV LED to cause composite resin to fluoresce. A UV/visible light spectrofluorometer was used to measure fluorescence excitation and emission maxima of 14 composite resin brands. Control samples of dentin and enamel were measured in a similar manner. Subsequently, each brand of composite resin was placed in extracted teeth and relative fluorescence was assessed. The composite resins were then removed and each tooth was inspected using UV light to detect remaining resin. This study revealed three types of resin: highly fluorescent, moderately fluorescent, and weakly fluorescent. In each instance, the UV light revealed the presence of resin after all resin was believed to have been removed. Based on the results of this study, it was concluded that the use of UV illumination can be a useful technique for determining whether composite resin has been removed completely.

Pont, H. B. et-al (2010)[45]Loss of surface enamel after bracket debonding: An in-vivo and ex-vivo evaluation was done. The study concluded that iatrogenic damage to the enamel surface after bracket debonding was inevitable. Whether elemental loss from enamel has clinical significance is yet to be determined in a long-term clinical follow-up of the studied patient population.

Karan S, Kircell1 BH et-al (2010)[46] conducted a study on enamel surface roughness after debonding.The study was conducted on crowns of 20 premolars that were embedded in acrylic blocks, and the buccal surfaces were subjected to atomic force microscopy (AFM), with measurement of initial roughness values. The brackets were bonded with a light-cured adhesive and were debonded with a debonding plier. In half of sample, adhesive remnants were removed with a tungsten carbide bur, whereas a fibre-reinforced composite bur was used in the other half. The second AFM measurements were made after resin removal. Duration of removal procedures was also recorded. The study concluded that, composite bur used for resin removal creates smoother surfaces after orthodontic bonding; however, the process takes longer than it does when the tungsten carbide bur is used.

Namura Y.et-al (2010)[47] evaluated the usefulness of orthodontic adhesive-containing fluorescent dye. Orthodontic adhesive is often left on the tooth surface when a multibracket appliance is debonded, and it is difficult to remove because its colour is like that of the tooth. If the adhesive changed colour during debonding, residual adhesive could be more easily removed. The study evaluated the usefulness of adhesive mixed with a small amount of fluorescent dye for clinical orthodontics. Sixty-four metal brackets were bonded to flattened bovine enamel surfaces using adhesives with three concentrations (0.001, 0.002, and 0.003 per cent) of fluorescent dye, and the shear bond strength (SBS) and adhesive remnant index (ARI) scores for each adhesive were determined. Colour penetrating through the transparent bracket was measured using a colour analyser. The SBS of the adhesive with 0.003 per cent fluorescent dye was significantly lower than that of the control (Transbond). In ARI tests, significantly more of the adhesive with 0.003 per cent dye was left on the tooth surface after 24 hours compared with the other adhesives. Regarding colour penetration, the adhesive with 0.003 per cent dye was five times more visible than to others. SBS and fluorescence intensity of the adhesives were not affected by thermal cycling. The study revealed that an adhesive containing less than 0.002 per cent fluorescent dye provides both sufficient bond strength for orthodontic brackets and sufficient fluorescent colour for easy visualization without aesthetic impairment.

Turkkahraman H et-al (2010)[48] did an in vitro evaluation of shear bond strengths of colour change adhesives. This study was done to test whether the shear bond strengths (SBS) of three commercially available colour change adhesives (CCAs), Transbond Plus Colour Change Adhesive, Gréengloo, and Blugloo, are different and to compare their bond strengths with a traditional light cure adhesive, Light Bond. Forty-eight human permanent premolar teeth extracted for orthodontic reasons and without any caries or visible defects were used in this study. The study concluded with the result that the three CCAs can be safely used in orthodontic practice since they yielded acceptable bond strengths. A higher incidence of ARI scores 4 and 5 revealed that bond failures in all test groups were mainly at the adhesive interface.

Joo HJ et-al (2011) [49] studied about the influence of orthodontic adhesives and clean-up procedures on the stain susceptibility of enamel after debonding. The study to determine the influence of the type of orthodontic adhesive system, such as conventional acid-etching (CE) and self-etching primers (SEPs), on the stain susceptibility of enamel surface after debonding. Effects of clean-up procedures on the enamel surface were also determined. Conclusion of the study was that SEP material showed a smaller amount of residual adhesive resin after debonding than CE material.SEP material showed higher stain susceptibility than CE material when only the finishing procedure was performed, which might have resulted from a greater amount of residual adhesive resin not detectable by the naked eye in SEP material. Additional polishing resulted in similar staining susceptibility in SEP material compared with CE material.SEP would show less stain susceptibility if the residual adhesive resin layer were removed by a polishing step.

Ryf et-al (2012)[50] conducted a study on enamel loss and adhesive remnants following bracket removal and various clean-up procedures in vitro. Brackets were bonded to 75 extracted human molars and removed after a storage period of 100 hours. The adhesive remnant index (ARI) was evaluated. The clean-up was carried out with five different procedures: 1. carbide bur; 2. carbide bur and Brownie and Greenie silicone polishers; 3. carbide bur and Astropol polishers; 4. carbide bur and Renew polishers; and 5.carbide bur, Brownie, Greenie and PoGo polishers. The study concluded that there were no significant differences in volumetric changes after polishing between the different clean-up methods. However, sufficient clean-up without enamel loss was difficult to achieve.

Hamba Y. et-al (2013)[51] conducted a study on preparation and properties of fluorescent orthodontic adhesives containing Y203:Eu3 particles. Orthodontic adhesives are typically colourless and transparent for aesthetic purposes. The utilization of fluorescence is one of the most effective solutions to make the adhesives visible for safe and complete removal after orthodontic treatments. Eu3+ ions were doped into yttrium oxides (Y203) using a homogeneous precipitation method. The crystals synthesized in this study exhibited submicron sizes and a very narrow size distribution. The X-ray diffraction (XRD) patterns agreed well with the known diffraction patterns of Y203, and indicated an absence of any other crystalline substances. Therefore, it was determined that the crystals synthesized in this study were in fact Y203:Eu3+. The spectra of the poly (methyl methacrylate) (PMMA) adhesives containing Y203:Eu3+ particles exhibited characteristic excitation and emission peaks corresponding to the 4f-4f transitions of Eu3+, despite the photoluminescence intensity being relatively low. The yielding loads of the Y203:Eu3+ particles contained in the PMMA specimens did not deteriorate by a significant amount. They concluded that it is feasible to add the Eu3+-doped Y20O3 crystalline particles into orthodontic adhesives.

Yasemen Boncuk et-al (2014)[52] conducted a study on effects of different orthodontic adhesives and resin removal techniques on enamel colour alteration. They investigated the colour alterations in enamel following the use of different orthodontic bonding resins and adhesive residue-removal burs. Metal brackets were bonded to extracted human premolars (n = 175) by using an etch-and- rinse adhesive system, a self-etch adhesive system (SEP), or a resin-modified glass ionomer cement (RMGIC). After 24 hours of photoaging, the brackets were removed and the adhesive residue on the tooth surfaces was cleaned with either a tungsten carbide bur or a Stain buster bur. Tooth colours were measured with a spectrophotometer at baseline, after adhesive removal, and after additional photoaging. The study concluded that orthodontic treatment alters the original colour of enamel, and both the adhesive system and the resin-removal methods are responsible for this change. When brackets are bonded with the etch-and-rinse system or the SEP, cleaning the adhesive residuals with Stain buster burs is recommended for minimal change. RMGIC can be safely cleaned with tungsten carbide burs.

Faria-Junior EM.et-al (2015)[53]conducted an in-vivo study to evaluate the surface roughness and morphology of enamel with a surface roughness tester and scanning electron microscopy after the removal of metal brackets and polishing. Ten orthodontic patients were selected for the study. At the conclusion of orthodontic treatment, their metal brackets were removed. For each patient, teeth on one side of the mouth were randomly chosen for finishing and polishing with aluminium oxide discs. Teeth on the other side were finished with multilaminate carbide burs. The study concluded that, aluminium oxide disc polishing system resulted in less enamel roughness than did the multilaminated carbide bur system.

Alexandre Antonio Ribeiro et- al (2017)[54] conducted a study about adhesive remnant removal and evaluated the application of UV light in an orthodontic setting. More adhesive was removed from enamel surface when the UV light was used to assist the procedure. The study concluded that UV illumination was a valuable adjunct when detection or complete removal of resin is warranted. The use of UVlight associated with a fluorescent adhesive allows more efficient adhesive removal compared with conventional lighting, without causing additional damage to enamel.

Cochrane NJ (2017)[55] conducted a quantitative analysis of enamel on debonded orthodontic brackets. Iatrogenic damage to the tooth surface in the form of enamel tear outs can occur during removal of fixed orthodontic appliances. The study aimed to assess debonded metal and ceramic brackets attached with a variety of bonding materials to determine how frequently this type of damage occurs. Eighty-one patients close to finishing fixed orthodontic treatment were recruited. They had metal brackets bonded with composite resin and a 2-step etch-and-bond technique or ceramic brackets bonded with composite resin and a 2-step etch-and- bond technique, and composite resin with a self-etching primer or resin- modified glass ionomer cement. The study concluded that enamel damage regularly occurred during the debonding process with the degree of damage being highly variable. Damage occurred more frequently when ceramic brackets were used (31.9%) compared with metal brackets (13.3%). Removal of ceramic brackets bonded with resin-modified glass 1onomer cement resulted in less damage compared with the resin bonding systems.

Fan XC et-al (2017)[56] studied about the effects of various debonding and adhesive clearance methods on enamel surface. The purpose of this study was to evaluate orthodontic debonding methods by comparing the surface roughness and enamel morphology of teeth after applying two different debonding methods and three different polishing techniques. Debonding pliers were safer than enamel chisels for removing brackets. Clean up with One-Gloss polisher provided enamel surfaces closest to the intact enamel, but took more time, and Super-Snap disks provided acceptable enamel surfaces and efficiencies. The diamond bur was not suitable for removing adhesive remnant.

Edmilson Nobumito Kaneshima et-al (2018)[57] assessed the use of UV light for removing adhesive remnant after debonding of orthodontic accessories and produced result similar to the non UV light removal technique on the enamel surface but in less clinical time . The study suggested that the proposal to remove AR with a UV light system is an interesting alternative that would make it easier to distinguish the difference between the adhesive material and the enamel surface, thus contributing to the preservation of dental structure, and representing a major advance in the orthodontic finishing step.

Claudino D et-al (2018)[58] did the enamel evaluation by scanning electron microscopy after debonding brackets and removal of adhesive remnants . The tested method showed that the best effectiveness for the removal of the adhesive remnants after bracket debonding was the use of a tungsten carbide multi-laminated high speed, followed by the use of a tungsten carbide multi-laminated, low-rotation drill. The use of fiberglass drill alone has proved to be in efficient for clinical use. The study concluded that all methods evaluated in the study proved to be inefficient for total removal of adhesive remnants from the enamel.

Connie Lai et-al (2019)[2 59] compared the efficiency of White light and UV light in adhesive remnant detection . To achieve complete and efficient removal of adhesive as well as produce minimal damage to enamel, dentists need to differentiate adhesive from enamel accurately and rapidly. The study concluded that the use of UV light resulted in less fluorescent adhesive resin remaining on tooth surfaces when compared with White light.

Paulo Henrique Rossato et-al (2020)[60] done a study to evaluate whether fluorescent agents alter the mechanical strength of adhesive. The study evaluated whether the addition of fluorescent agents influences the shear bond strength and clinical performance of a UV light-sensitive adhesive system. The study concluded that addition of fluorescent elements does not alter the in vitro and clinical mechanical strength of the orthodontic adhesives. Adhesive systems with fluorescent agents represent a viable alternative for orthodontic use.

RELEVANCE

RELEVANCE OF THE STUDY

Preservation of enamel to its original pre-treatment condition is of utmost importance in achieving the objectives of orthodontic treatment especially aesthetics and function. Procedures like acid etching during bonding, mechanical detachment of brackets and removal of adhesive remnant may results in irreversible enamel damage. Retained adhesive on tooth surface favours plaque accumulation and creates color variation over time leading to patient dissatisfaction, periodontal inflammation, and white spot lesions.

The greatest challenges with regard to orthodontic debonding is accurate remnant detection and removal without iatrogenic enamel damage like rough surfaces, vertical cracks, loss of the fluoride rich external surface within minimum working time.

Recently, ultraviolet (UV) fluorescent chemicals have been added to orthodontic adhesives, and UV light is used as an aid to detect adhesive remnant removal, during debonding. Many studies have suggested UV light as an adjunct in the detection of composite resins.

Focus of this study is the precise removal of composite adhesives without enamel damage and reduction of chair side time for orthodontic debonding. Adhesive removal method with UV illuminated airotor in this study, reduces the UV exposure too by focusing the UV light only to the working area during the process of adhesive removal by the clinician.

METHODOLOGY

METHODOLOGY

MATERIALS

1. 120 extracted human upper premolars teeth without any visible enamel defects.
2. Acid Etchant (37% phosphoric acid): 3M Scotchbond multipurpose
3. Metal orthodontic brackets: type premolar American Orthodontics
4. Adhesives
    a. Pad Lock Composite with Primer
    b. Opal Bond MV Composite with Primer

EQUIPMENTS:

1. Light Accessories
    a. 3M ESPE Elipar Deep Cure LED curing light(430-480nm)
    b. Light Meter
    c. Light Illumination for Airotor
        - Airotor with white light attachment
        - Airotor with UV light attachment
2. Protective eye wear
3. Bracket debonding pliers.
4. Optical Stereomicroscope (MagnUs)

STUDY SETTING:

1. Department of Orthodontics and Dentofacial Orthopaedics, St. Gregorios Dental College, Chelad, Kothamangalam.

2. Department of Nanotechnology, Amrita Institute of Medical Sciences and Research centre, Kochi.

SAMPLE SIZE DETERMINATION:

The present study, aims to compare the efficiency of UV light to white light among Pad Lock (P) and Opal Bond (O) adhesives in remnant composite removal during debonding. The samples were divided into four groups: P-W, P-UV, O-W and O-UV. At the base level pairwise comparisons were done . For example P-W was compared with P-UV or O-W was compared with O-UV. So the sample size can be calculated using the following formulae:

$$n=\frac{(Z_{\alpha/2}+Z_\beta)^2 \times 2 \times \sigma^2}{d^2}$$

Where,

n = Sample Size

α= Significance Level

1-β= Power of the test.

$Z_{\alpha/2}$= the critical value of the Normal Distribution at $\alpha/2$. (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96).

Z_β= the critical value of the Normal distribution at β (e.g. for a power of 80%, β is 0.2 and the critical value is 0.84).

σ^2= the population variance.

d = the difference you would like to detect or the effect size.

Here:

α= 5%

1-β= 0.8

$Z_{\alpha/2}$= 1.96

Z_β= 0.84.

σ^2= 0.9025

$d = 0.5$.

$n = ((1.96+0.84)^2 \times 2 \times 0.9025) / 0.5^2 = 57$ approximately.

30 samples are taken from each group to have enough samples for pairwise comparison which cumulate to a total of 60 samples considering pairwise comparison. So, if there are four groups, then taking 30 samples from each group will give a sample size n=120.

P-W	P-UV	O-W	O-UV
Sample ;30	**Sample ;30**	**Sample ;30**	**Sample ;30**

Inclusion Criteria:

1. Extracted human upper premolars with sound buccal enamel

2. Non carious tooth

3. Teeth without previous restoration

Exclusion Criteria:

1.Carious teeth

2.Teeth with enamel defects on buccal aspect

3.Teeth with altered morphology

Sampling procedure:

Specimens were subsequently assigned into 4 groups.

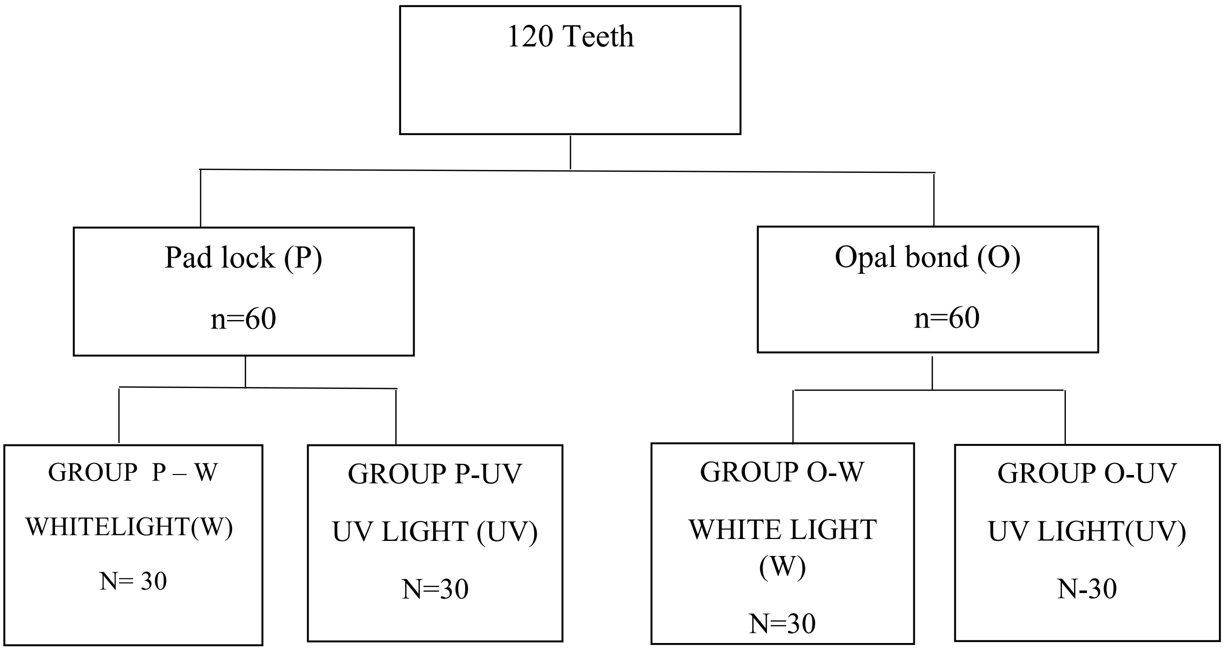
1.Group P-W (P-Pad Lock ,W-white light)

2.GroupO-W (O-Opal bond, W-white light)

3.Group P-UV (P-Pad Lock, UV-uv light)

4.Group O-UV (O-Opal bond UV- uvlight)

P-W and O-W groups used only the white light from the airotor. P-UV and O-UV groups used uv light of 395 nm wavelength from airotor.



PREPARATION OF THE SAMPLE

Collection and storage of specimens:

One hundred and twenty premolars without any visible enamel defects were collected. All teeth were visually inspected. All the teeth satisfied the inclusion criteria. Collected teeth were stored in 0 .1% thymol solution at 4 ^{O} C until the start of the study.

Preparation of the sample:

Ultrasonic scaling was performed on all the teeth and the buccal surface polished with pumice using a rubber cup in a low-speed handpiece for 10 seconds. The specimens were then rinsed and dried using an air-water syringe. The teeth were then mounted into a typodont (Fig 4).

The enamel was etched with 37% phosphoric acid for 30 seconds, rinsed with water for 20 seconds, and air dried for 5 seconds. Bonding primer was applied using a micro brush and cured . Premolar orthodontic brackets were bonded to the teeth, half the samples (60nos)using Pad Lock and the other half (60nos)using Opal Bond adhesive. The brackets were pressed firmly onto the enamel surface, excess adhesive was removed with an explorer, and the adhesive was light cured for 3 seconds each from occlusal, gingival, mesial, and distal aspects. The teeth were then stored in a humid chamber at 37.8 0C for 24 hours.

Brackets were then debonded by compressing and distorting the bracket using a bracket removing plier(Fig 5).

Adhesive removal:

The typodont was mounted to a mannequin to simulate patient head position as on a dental chair. Adhesive Remnant removal was carried out by the same Orthodontist with a minimum of 10 years clinical experience to avoid bias. Remnant removal was conducted with a 30-fluted, flame-shaped tungsten carbide bur in a high-speed airotor handpiece, with the operator using protective eye wear. A new bur was used after every 10 teeth. The handpiece was used with water spray.

Groups P-W and O-W used only the White light from the airotor, and groups P-UV And O-UV used the 395 nm wavelength UV light from airotor (Fig 6&7). Resin removal was carried out until the adhesive was visually determined to be completely removed and the time taken was recorded in seconds with a digital stop watch.

Stereomicroscopic Evaluation:

Photographs of the bonded surface of the teeth were taken under the stereomicroscope under white light. After assessing adhesive remnant under a stereomicroscope at 10x magnification, residual adhesive scoring was done using Adhesive Remnant Index.

TABLE 1

Modified Adhesive Remnant Index (ARI)

Score	**Definition**
0	No adhesive left on the tooth
1	1-25 percent of adhesive left on the tooth
2	26-50 percent of adhesive left on the tooth
3	51-75 percent of adhesive left on the tooth
4	76-99 percent of adhesive left on the tooth
5	All adhesive left on the tooth with distinct impression of bracket mesh

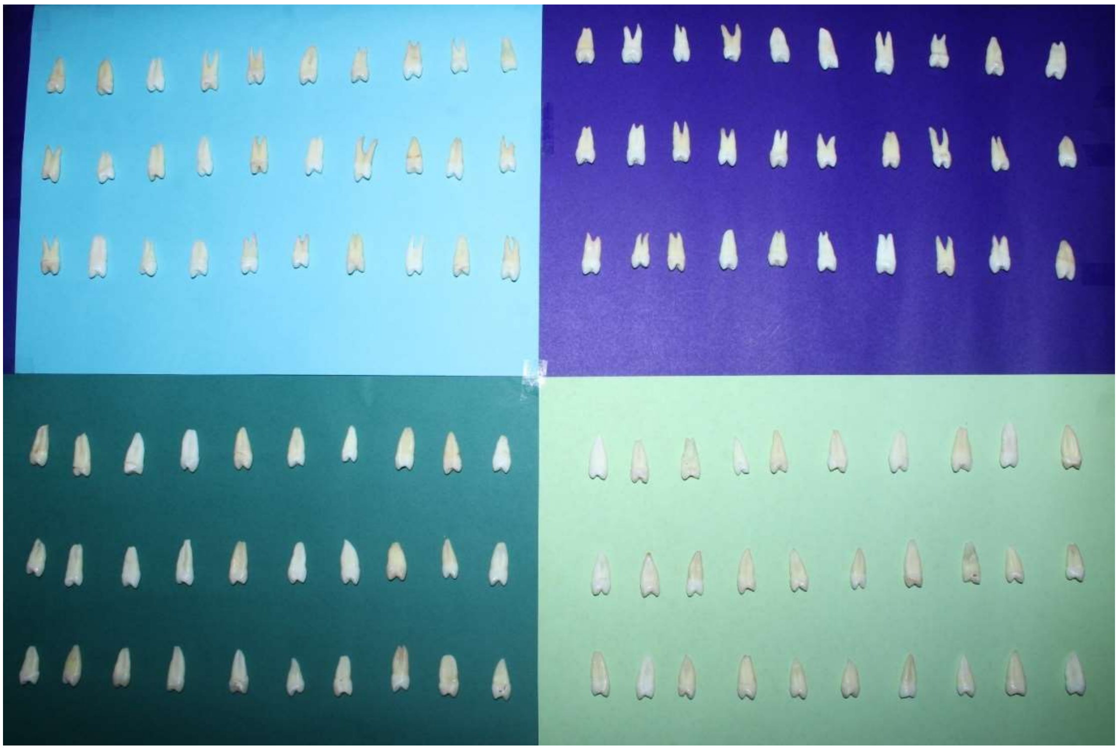


Fig 1. Samples satisfying inclusion criteria divided into four groups

Fig 2. Instruments and materials for bonding and debonding

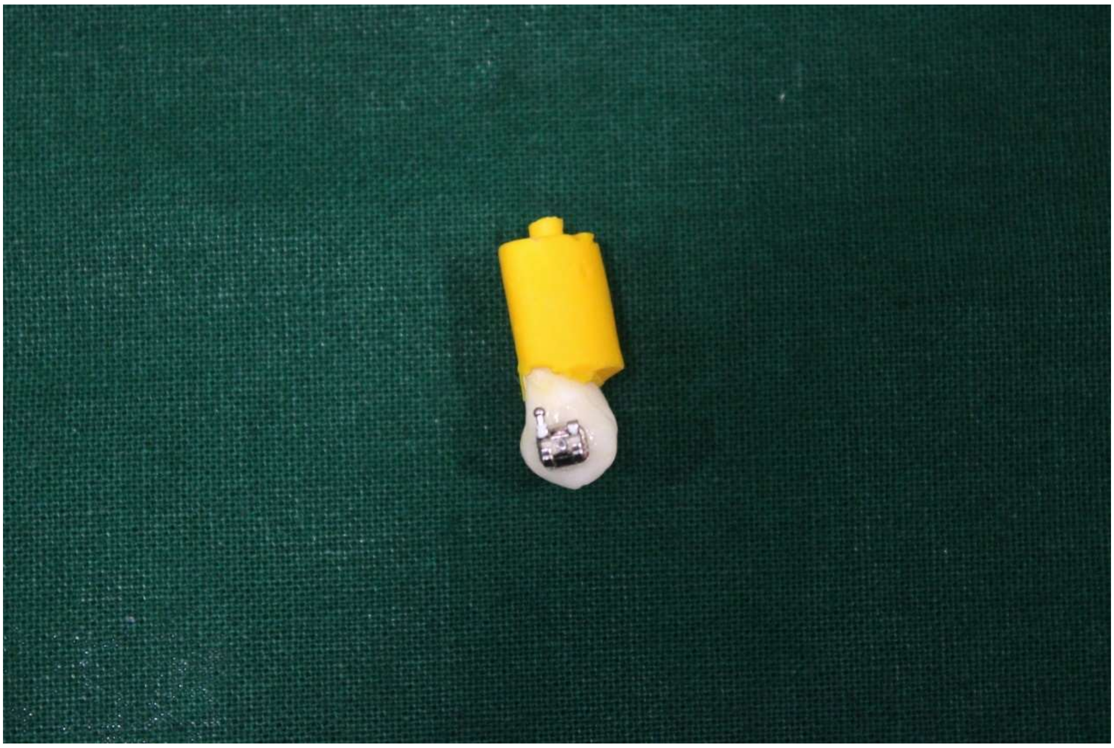


Fig 3. Prepared Sample

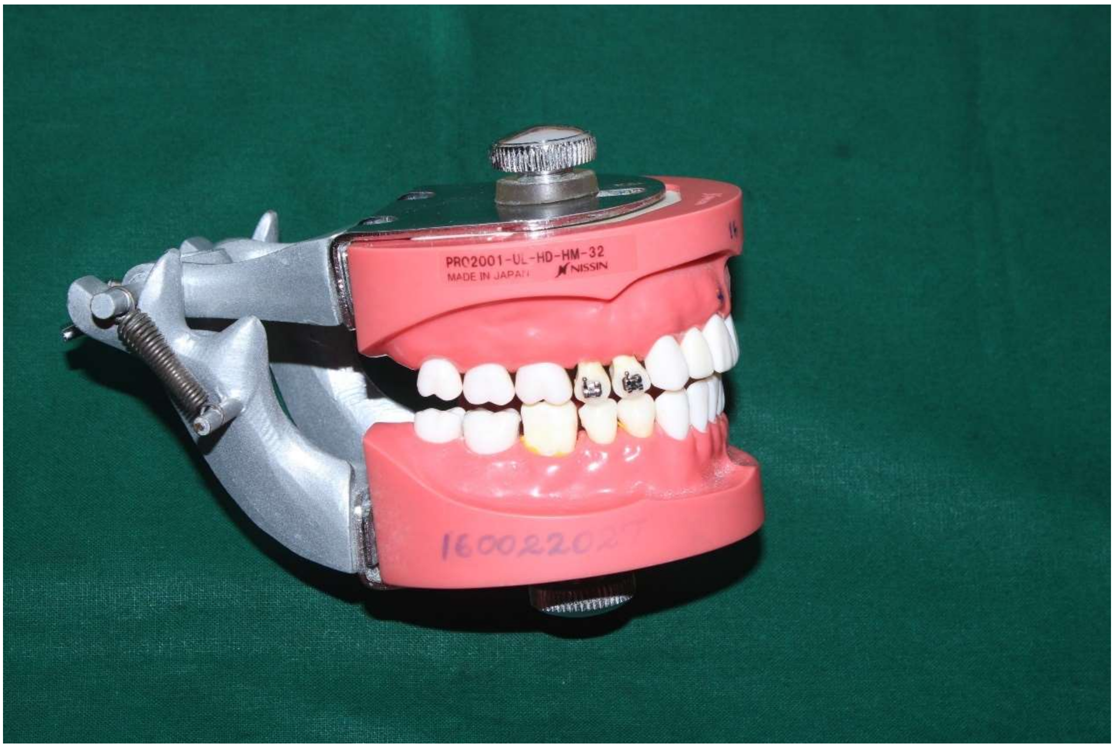


Fig 4. Sample mounted on typodont

Fig 5. Bracket Debonding using plier

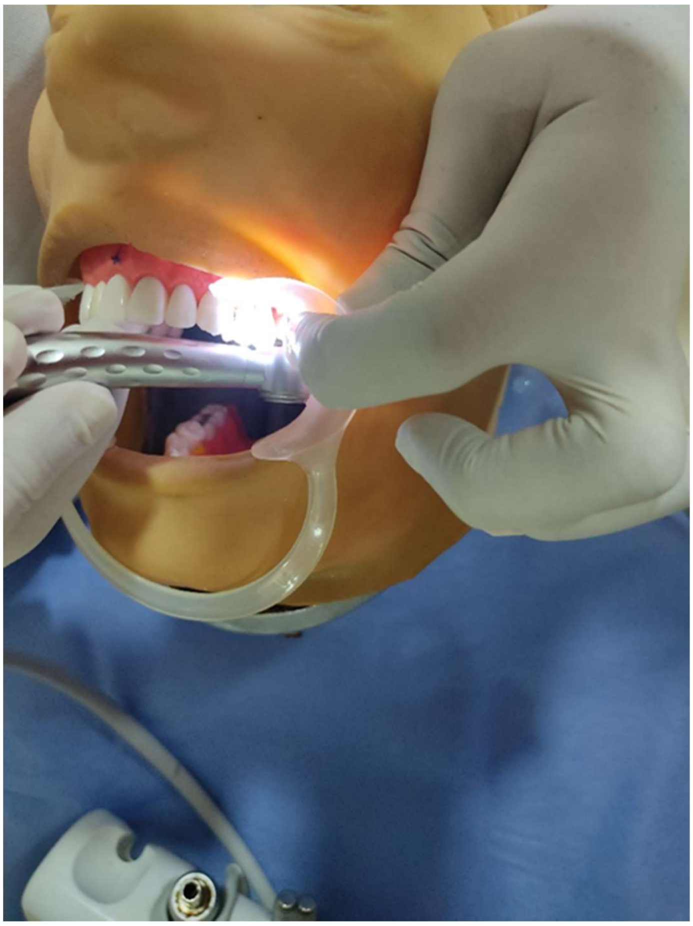


Fig 6. Adhesive remnant removal by white light illuminated airotor hand piece

Fig 7. Adhesive remnant removal by UV illuminated airotor hand piece

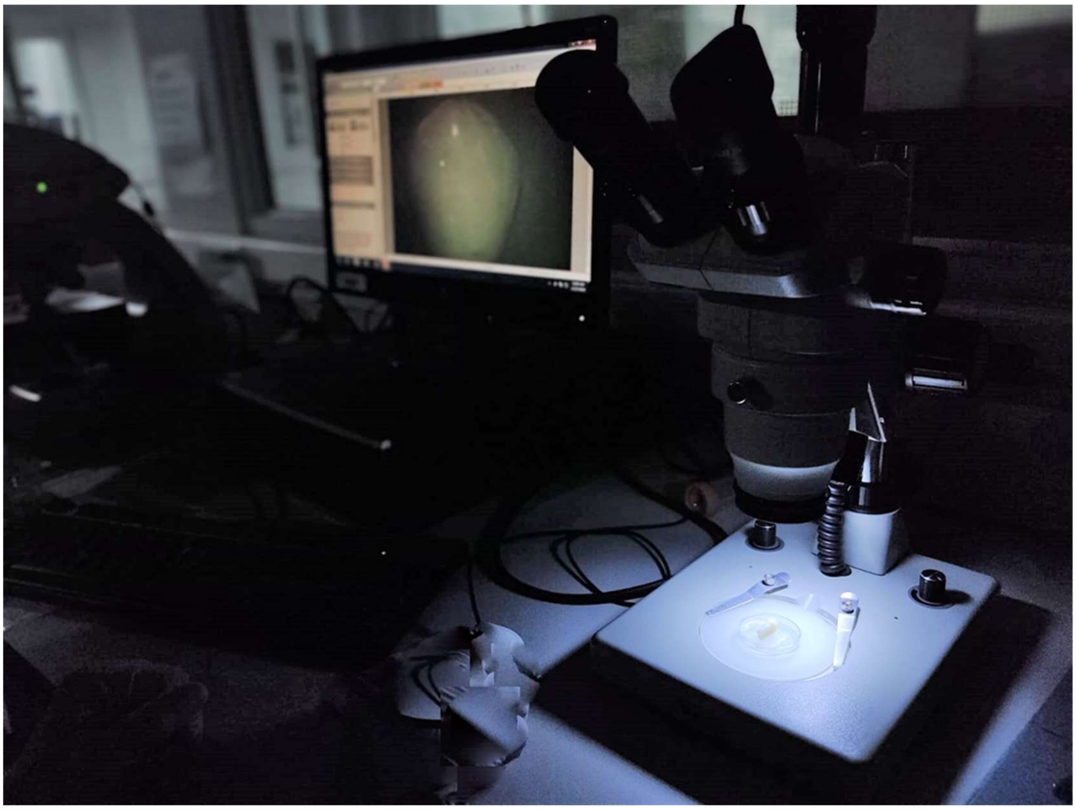


Fig 8. Visualizing the Adhesive Remnants using Optical stereomicroscope

Fig 9. Padlock after debonding Adhesive remnant before removal visualised on10 x magnification

Fig 10. Opal bond after debonding - Adhesive remnant before removal visualised on10x magnification

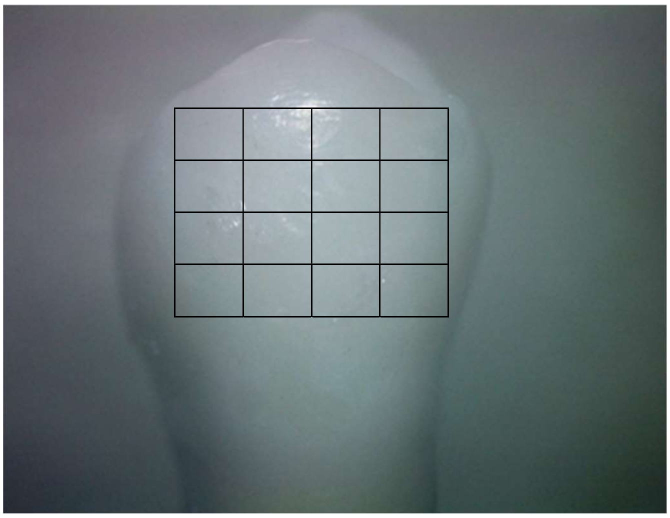


Fig 11. P-UV Adhesive remnant visualised on 10 x magnification

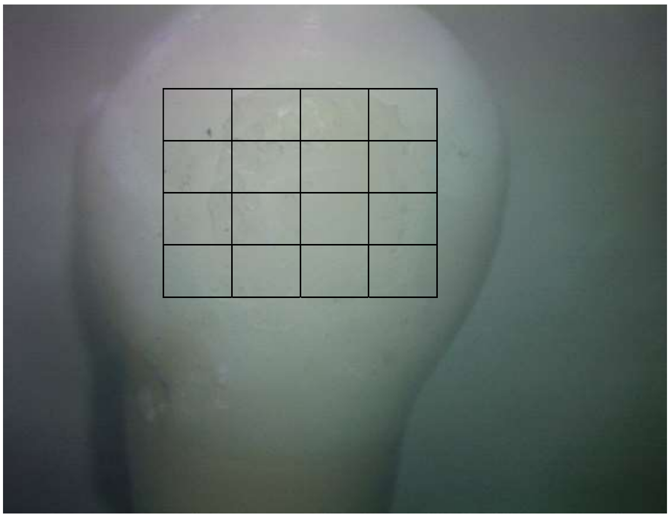


Fig 12. P-W Adhesive remnant visualised on 10 x magnification

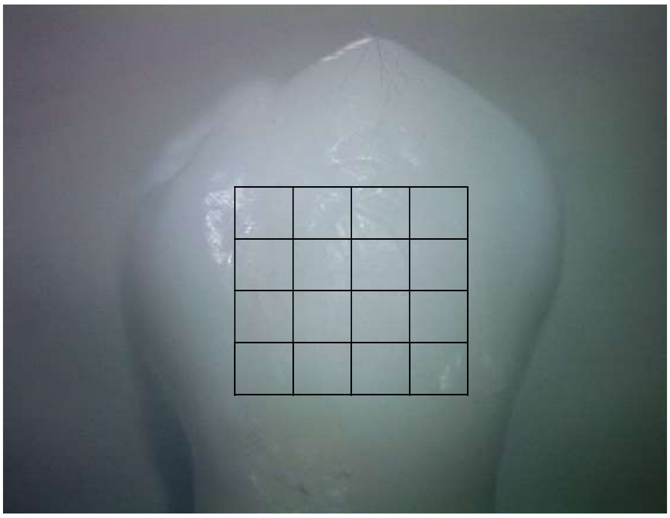


Fig 13. O-UV Adhesive remnant visualised on 10 x magnification

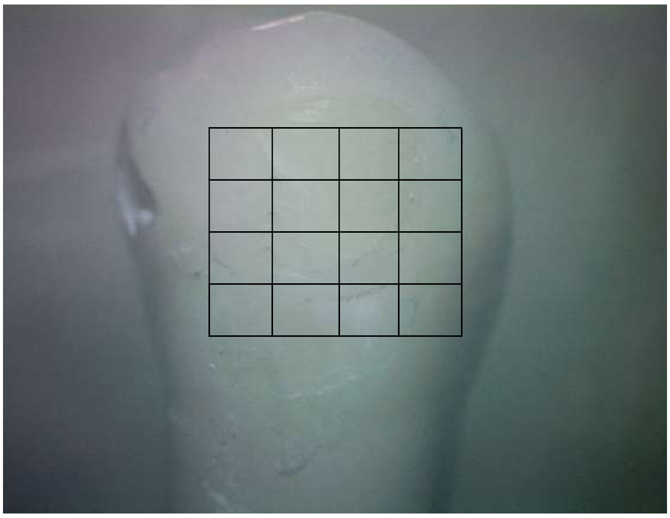


Fig 14. O-W Adhesive remnant visualised on 10 x magnification

RESULTS

RESULTS

The study involved the comparison of efficiency of adhesive remnant removal and time of removal among white light illuminated groups and UV light illuminated groups. The groups in which UV illuminated airotor handpiece is used had less adhesive remnant left on the tooth surface when compared to the groups which used white light illuminated airotor hand piece for remnant removal.

Statistical Analysis

The four study groups P-W, O-W, P-UV, P-W and variables time, Adhesive Remnant Index and light were statistically analysed.

Mean time for adhesive removal for all groups (P-UV, P-W, O-UV and O-W) is 22.34 sec and Std. Deviation 6.724. Maximum time taken for remnant removal is 41 second and minimum time taken for remnant removal is 12 second (TABLE 2). For Opal bond and Pad lock MV groups, mean time of remnant removal with UV light is less (16.53 sec) than that with white light(28.15sec). (TABLE 4)

Normality of the data on time is assessed by Kolmogorov-Smirnov and Shapiro-Wilk test. P value is .000 (< 0.05) no normality for time. (TABLE.5, GRAPH 1).

To test for significant difference in time taken for remnant removal based on four groups is assessed using Kruskal-Wallis Test. The P value is $< .05$. The null hypothesis is rejected. There is significant difference in the distribution of time across categories of group. The significance level is .050 (TABLE .6 and 7).

In order to find out which group shows significant difference in time taken for adhesive remnant removal Pairwise Comparisons of Groups is done. It is observed that there is no significant difference between P-UV and O-UV (P value .663) and O-W and PW (P value .289) and brand of composite resin is immaterial. But when comparison between UV group and white light group is done there is significant difference between PUV -OW groups, between PUV- PW groups, between (O-UV) - (O-W) and also between (O-UV) - (P-W) groups, with P value 0.000 (TABLE 7). More over test confirms that time taken for remnant removal is significantly lower for UV light pad lock and UV light opal bond group, when compared to white light pad lock and opal bond. Same can be observed in pair wise comparison graph.

Mann-Whitney U Test for Time is conducted to observe significance of difference by considering the distribution of time taken for remnant removal using white light and UV light.

Since P value is <.050 it is observed that time taken for remnant removal in UV light is significantly lower than that in white light (Table 8). Same can be observed in Graph 5a.

Adhesive remnant index Evaluation

For remnant removal when white light is used majority of samples has been observed with more than 50% adhesive left on tooth. In case UV light groups more than 50% samples is observed to be with less than 25% adhesive left on the tooth. This observed association can be confirmed using Chi-Square test. From Chi-Square analysis, Pearson Chi-Square value is 86.882 (df=4) and P value <.05. Therefore, it is concluded that UV light is associated with less adhesive left on the tooth and white light is associated with high adhesive left on the tooth (Table 10,13). Same can be observed in Graph 6. Groups of white light had more ARI index than that with groups of UV light. Among white light groups, half of the sample had 50-75 % adhesive left on tooth surface after removal. UV light groups had ARI value 0 and 1, no adhesive and 1-25% (respectively) adhesive left after remnant removal. P value < .05(TABLE .10,13)

When four groups and the adhesive remnant is considered, it is observed that majority of cases with UV opal bond and pad lock groups falls in low category of adhesive left on the tooth. But when Pad lock white and Opal bond white groups considered majority of cases falls in high category of adhesive left on the tooth. This inference is confirmed from summary Table 13.

Biplot generated using correspondence analysis presented in graph 7 confirms the fact that groups O-UV, P-UV is closely associated with low percentage of adhesive left on the tooth and groups P-W, O-W are closely associated with high remnants left on the tooth (Graph 7).

Statistics

Time (Seconds)

N	Valid	120
	Missing	0
Mean		22.34
Median		21.00
Std. Deviation		6.724
Minimum		12
Maximum		41

TABLE 2: Descriptive Statistics of Variable: Time (Seconds)

Report

Time (Seconds)

Group	Mean	N	Std. Deviation	Median	Minimum	Maximum
O-W - Opal Bond MV	27.03	30	3.528	28.00	20	36
O-UV - Opal Bond MV	16.77	30	2.402	17.00	12	22
P-W PADLOCK	-29.27	30	4.495	29.00	21	41
P-UV PADLOCK	-16.30	30	2.200	16.00	12	21
Total	22.34	120	6.724	21.00	12	41

TABLE 3: Descriptive Statistics of Variable Time based on Group.

Report

Time (Seconds)

Light	Mean	N	Std. Deviation	Median	Minimum	Maximum
White Light	28.15	60	4.161	28.00	20	41
UV Light	16.53	60	2.296	17.00	12	22
Total	22.34	120	6.724	21.00	12	41

TABLE 4: Descriptive Statistics of Variable Time based on Light.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Time (Seconds)	.149	120	.000	.937	120	.000

a. Lilliefors Significance Correction

TABLE 5: Test for Normality of Variable: Time (Seconds)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Time (Seconds) is the same across categories of Group.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

TABLE 6(a): Kruskal-Wallis Test for Time (Seconds) across Group

Total N	120
Test Statistic	89.751[a]
Degree Of Freedom	3
Asymptotic Sig.(2-sided test)	.000

a. The test statistic is adjusted for ties.

TABLE 6(b): Independent-Samples Kruskal-Wallis Test Summary

Pairwise Comparisons of Group

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
P-UV - PADLOCK-O-UV - Opal Bond MV	-3.900	8.958	.435	.663	1.000
P-UV - PADLOCK-O-W - Opal Bond MV	-56.767	8.958	6.337	.000	.000
P-UV - PADLOCK-P-W - PADLOCK	-66.267	8.958	7.398	.000	.000
O-UV - Opal Bond MV-O-W - Opal Bond MV	52.867	8.958	5.902	.000	.000
O-UV - Opal Bond MV-P-W - PADLOCK	-62.367	8.958	-6.962	.000	.000
O-W - Opal BondMV-P-W - PADLOCK	-9.500	8.958	-1.061	.289	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.

Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

TABLE 7: Pairwise Comparisons of Groups for difference in Time (seconds)

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Time (Seconds) is the same across categories of Light.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

TABLE 8: Hypothesis Test Summary

Total N	120
Mann-Whitney U	13.000
Wilcoxon W	1843.000
Test Statistic	13.000
Standard Error	190.024
Standardized Test Statistic	-9.404
Asymptotic Sig. (2-sided test)	.000

TABLE 9: Independent-Samples Mann-Whitney U Test Summary

Count

		Adhesive Remnant Index					
		No adhesive left on the tooth	1-25 percent of adhesive left on the tooth	26-50 percent of adhesive left on the tooth	51-75 percent of adhesive left on the tooth	76-99 percent of adhesive left on the tooth	Total
Light	White Light	0	2	10	30	18	60
	UV Light	21	26	12	1	0	60
Total		21	28	22	31	18	120

TABLE 10: Light *Adhesive Remnant Index Crosstabulation

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	86.882[a]	4	.000
Likelihood Ratio	112.794	4	.000
Linear-by-Linear Association	79.181	1	.000
N of Valid Cases	120		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.00.

TABLE 11: Chi-Square Test Summary for Testing Association between Light and Adhesive Remnant Index

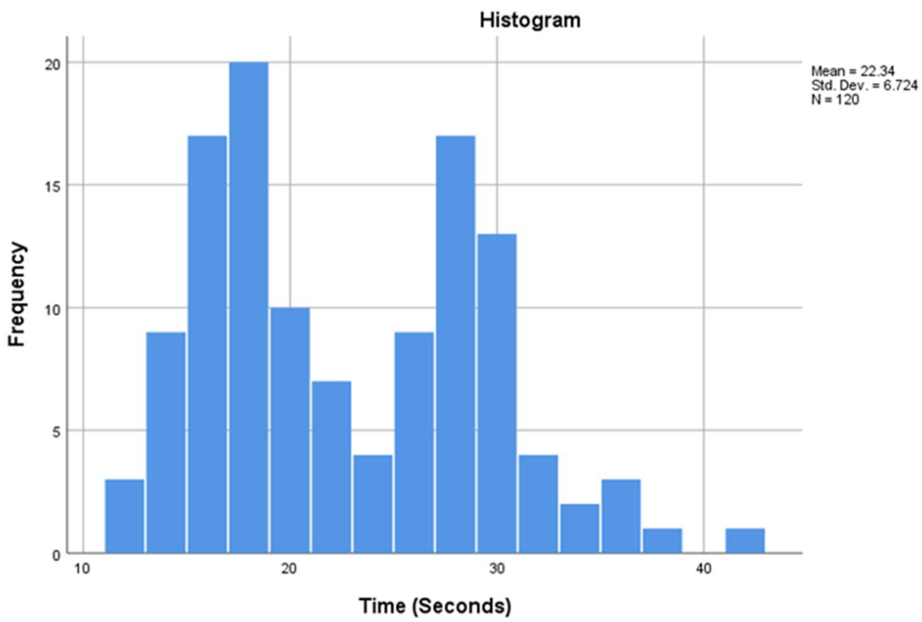
Group	Adhesive Remnant Index: 1-25 percent of adhesive left on the tooth	26-50 percent of adhesive left on the tooth	51-75 percent of adhesive left on the tooth	76-99 percent of adhesive left on the tooth	Active Margin
O-W - Opal Bond MV	1	4	16	9	30
O-UV - Opal Bond MV	13	7	1	0	21
P-W - PADLOCK	1	6	14	9	30
P-UV - PADLOCK	13	5	0	0	18
Active Margin	28	22	31	18	99

TABLE 12: Correspondence Table

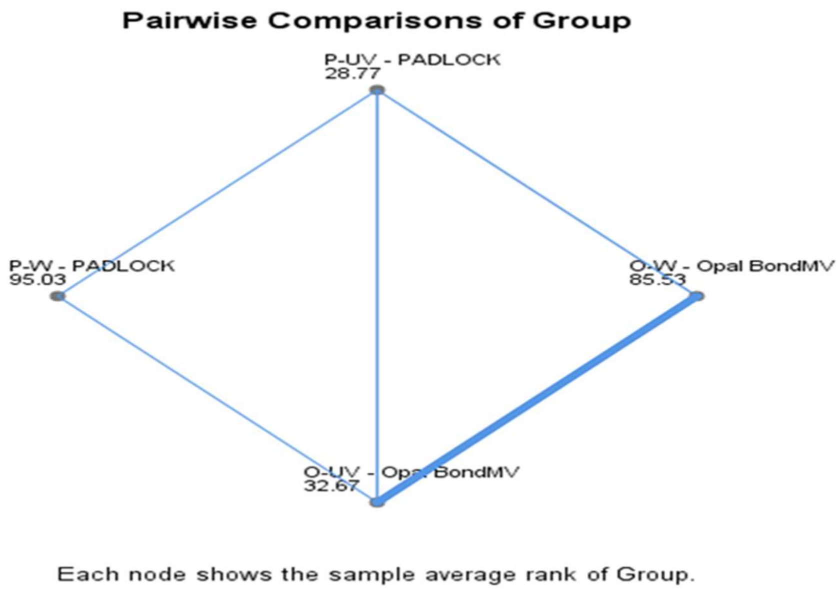
Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Correlation 2
1	.808	.653			.989	.989	.046	.068
2	.078	.006			.009	.998	.100	
3	.032	.001			.002	1.000		
Total		.661	65.404	.000[a]	1.000	1.000		

a. 9 degrees of freedom

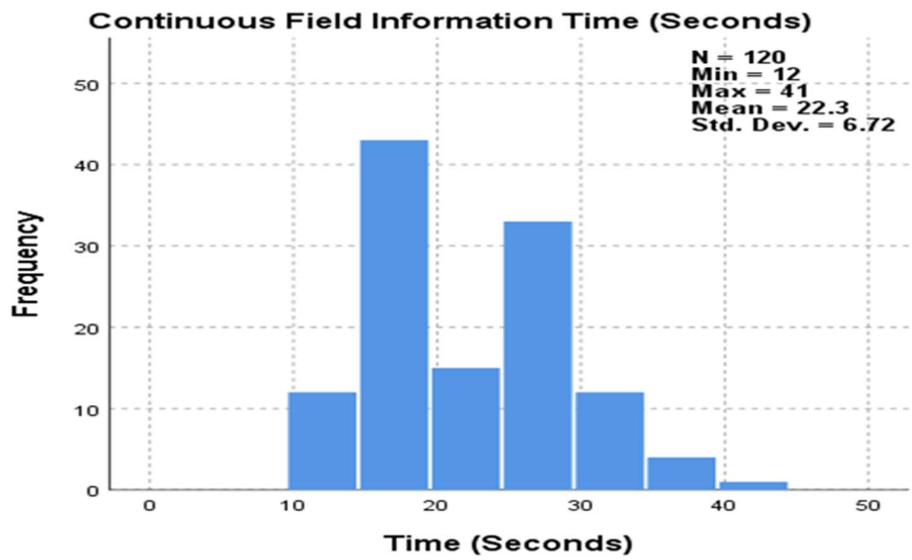
TABLE 13: Correspondence Analysis Summary



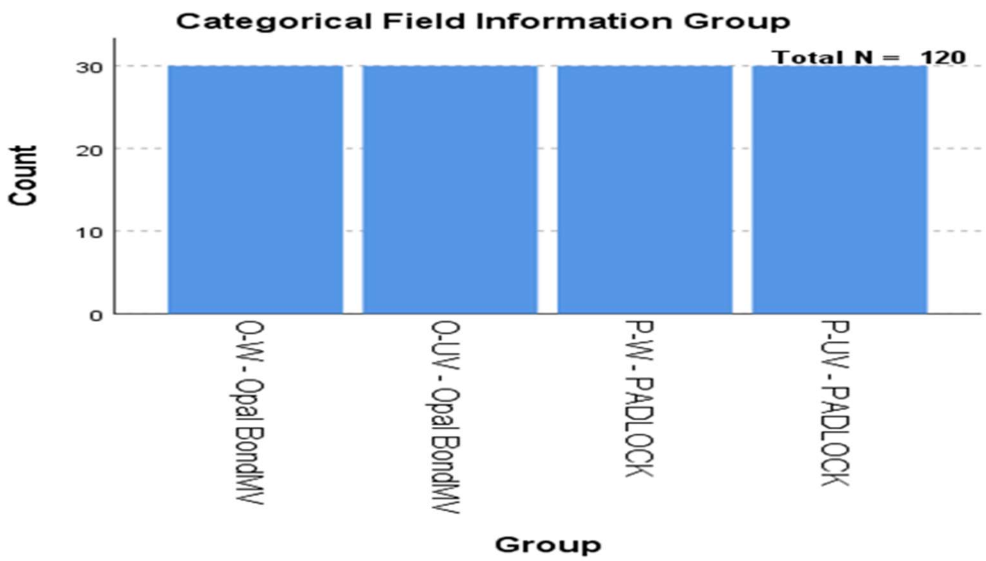
GRAPH 1: Histogram of Variable Time (Seconds)



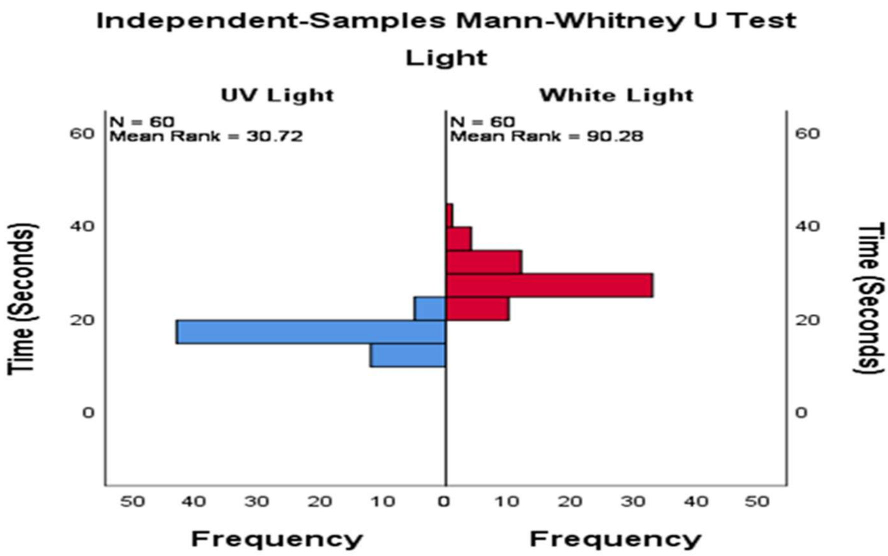
GRAPH 2: Pairwise Comparison of Group based on Time (Kruskall Wallis Test)



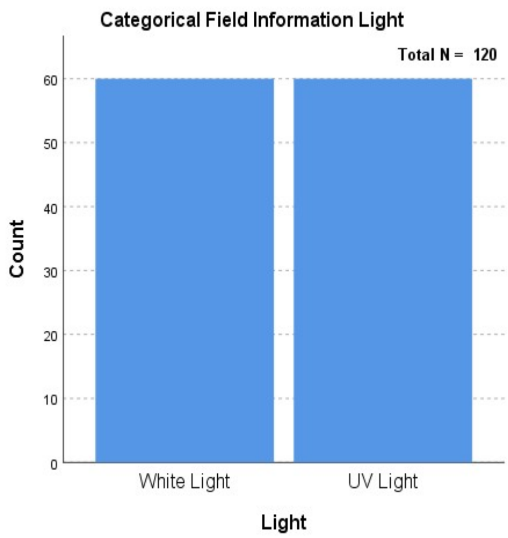
GRAPH 3: Continuous Field Information of Time (Seconds)



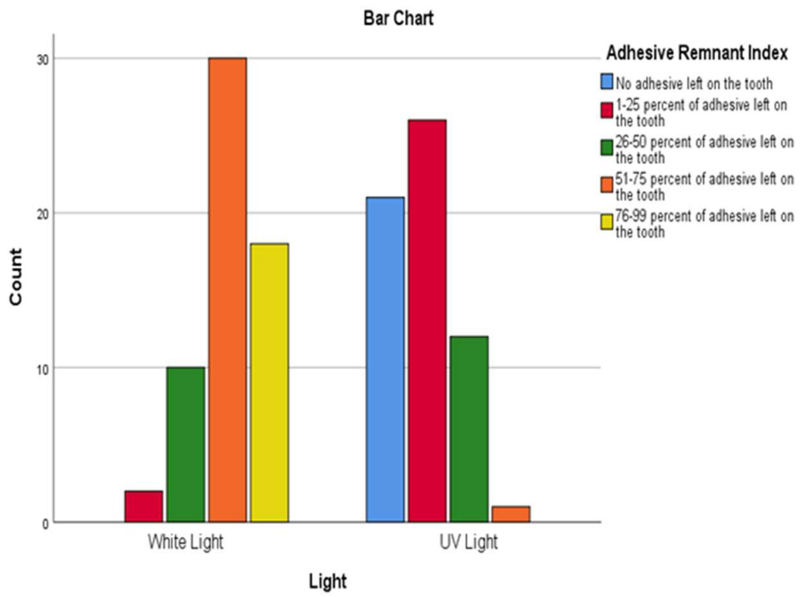
GRAPH 4: Categorical Field Information of Group



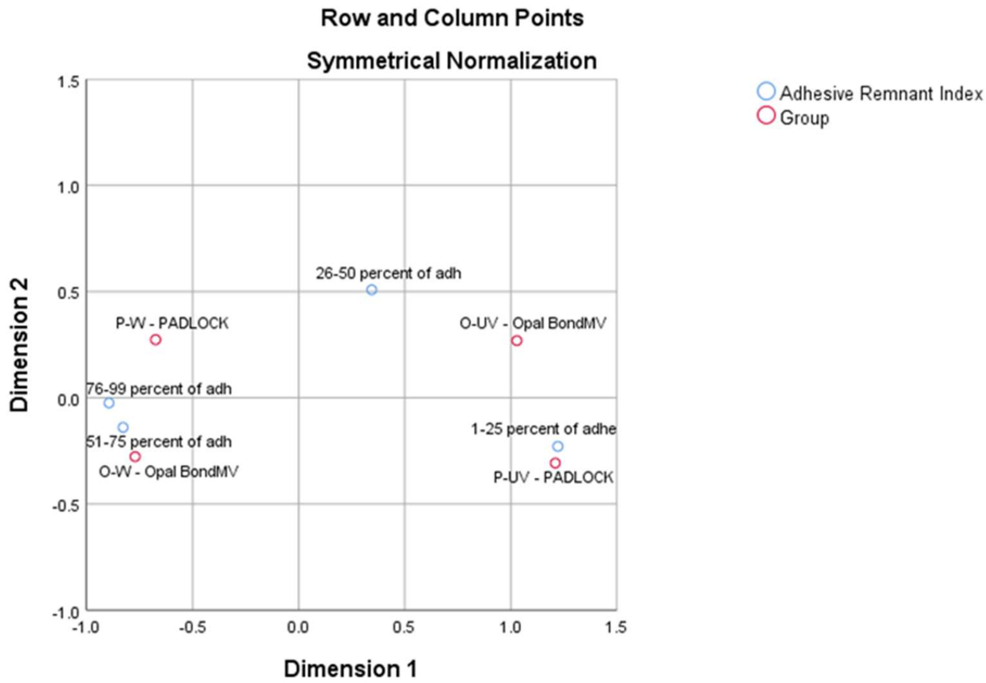
GRAPH 5(a): Graphical Visualization of Independent Samples Mann – Whitney U Test



GRAPH5 (b): Categorical Field Information of Light



GRAPH 6: Clustered Bar Chart of Adhesive Remnant Index based on Light



GRAPH 7: Biplot of Correspondence analysis regarding association between Adhesive Remnant Index and Group

DISCUSSION

DISCUSSION

Orthodontic treatment plays an important role in enhancing aesthetics, functions and self-esteem of a patient. The bonding of brackets to tooth surface is a temporary procedure. After the completion of active orthodontic treatment, the brackets are to be debonded and adhesives removed. The orthodontic attachments and remnant adhesives are removed during debonding to restore the enamel surface to its pre-treatment state. Some amount of adhesive remnants still remains on the teeth after remnant removal, though the surface may clinically seem to be clean[1]. When the color of the adhesive system is similar to the natural tooth color, a careful examination with a manual instrument, such as a dental explorer, should be performed after adhesive removal and polishing of tooth surfaces, in order to verify the color more accurately[47].Residual adhesive resin on the tooth surface after debonding results in enamel roughness that can cause discoloration of tooth, plaque accumulation and enamel defects. If there is loss of enamel surface during debonding and cleaning it may develop tooth sensitivity. The amount of enamel loss during bonding and debonding can be up to 150 micro meters as indicated in many studies[25].

Although the damage on the enamel surface during adhesive removal is unavoidable the damage can be reduced to a negligible level if proper technique is adopted. Many studies have investigated various adhesive removal techniques that may result in the least damage to the tooth structure. Many techniques have been proposed including slow speed multifluted tungsten carbide burs, high speed multifluted tungsten carbide bur, aluminium oxide discs, ultrafine high speed diamond finishing burs; ultrasonic scalers, hand scalers, band removing pliers, sandblasting, ceramiste wheels, specialized adhesive removal burs, and carbon dioxide lasers[50.]

Another factor to be considered is the chairside time required for remnant removal. Adhesive remnant removal is the most time consuming part in debonding procedure.

Very few studies have focused on techniques that may aid in the detection of the adhesive remnant. There are studies in which adhesive detection is done with UV Led light in clinical set up in vitro studies. Introduction of fluorescent adhesives and use of UV illumination for adhesive detection is in its initial stage of development.

Edmilson Nobumito Kaneshima et-al suggested that, for more efficient removal of orthodontic accessories, UV light may be used in association with multi-bladed burs at high speed until visualizing a thin layer of adhesive remnant, and then completing its removal with specific finishing and polishing tips at low speed. This method applied to clinical practice would allow fast, complete, and safe removal of adhesive remnant, while also preserving the enamel surface of the patient[57].

Alexandre Antonio Ribeiro et- al (2017) conducted a study about adhesive remnant removal and evaluated the application of UV light in an orthodontic setting. More adhesive was removed from enamel surface when the UV light was used to assist the procedure. The study concluded that UV illumination was a valuable adjunct when detection or complete removal of resin is warranted. The use of UV light associated with a fluorescent adhesive allows more efficient adhesive removal compared with conventional lighting, without causing additional damage to enamel[54].

Connie Lai et-al (2019)compared the efficiency of White light and UV light in adhesive remnant detection . To achieve complete and efficient removal of adhesive as well as produce minimal damage to enamel, dentists need to differentiate adhesive from enamel accurately and rapidly. The study concluded that the use of UV light resulted in less fluorescent adhesive resin remaining on tooth surfaces when compared with White light[59].

Although adhesive remnant may be clinically easier to visualize by UV light, it is worth emphasizing that care should be taken not to be overeager to remove it[39].

This study was conducted to compare and evaluate, the efficiency of adhesive remnant detection, removal and time of remnant removal using UV illuminated and white light illuminated airotor hand piece. The fluorescent composite used for the study was Opal bond MV and Pad lock. One hundred and twenty samples which satisfied the inclusion criteria was divided into P-W,O-W,P-UV,O-UV groups according to light and composite combination. The prepared samples were mounted on typodont. The enamel was etched with 37% phosphoric acid for 30 seconds, rinsed with water for 20 seconds, and air dried for 5 seconds. Bonding primer was applied using a micro brush and cured. Premolar orthodontic brackets were bonded to the teeth, half the samples (60nos) using Pad Lock and the other half (60 nos) using Opal Bond adhesive. The teeth were then stored in a humid chamber at 37.8°C for 24 hours.

Brackets were then debonded by compressing and distorting the bracket using a bracket removing plier (Fig 5).

Adhesive Removal:

The typodont was mounted to a mannequin to simulate patient head position as on a dental chair. Adhesive Remnant removal was carried out by the same Orthodontist with a minimum of 10 years clinical experience to avoid bias. Remnant removal was conducted with a 30-fluted, flame-shaped tungsten carbide bur in a high-speed airotor handpiece, with the operator using protective eye wear. A new bur was used after every 10 teeth. The handpiece was used with water spray.

Groups P-W and O-W used only the White light from the airotor, and groups P-UV And O-UV used the 395nm wavelength UV light from airotor (Fig 6&7). Resin removal was carried out until the adhesive was visually determined to be completely removed and the time taken was recorded in seconds with a digital stop watch.

Stereomicroscopic Evaluation:

Photographs of the bonded surface of the teeth were taken under the stereomicroscope under white light. After assessing adhesive remnant under a stereomicroscope at x 10 magnification, residual adhesive scoring was done using Adhesive Remnant Index.

Adhesive remnant detection and removal using UV light illuminated airotor resulted in cleaner enamel surface with relatively smaller amounts of adhesive remaining. This method using UV light is found to be an efficient method than using white light in the detection of both Pad Lock and Opal Bond MV. Both groups, P-UV and O-UV had least adhesive retained on tooth surface. These results are similar to that of Ribeiro et al study and Connie Lai et-al study who also found adhesive to be more effectively removed under UV light. Ribeiro et al study included only Opal Bond MV as the fluorescent adhesive and found median adhesive remnants of 0.80 mm^2 with white light and 0.25mm^2 with UV light. Connie Lai et-al study used UV LED flash light for UV illumination[59]. In this study adhesive remnant removal time was also evaluated in O-W,P-W,O-UV,P-UV groups. Faster adhesive remnant detection and lesser time for removal was expected from the groups using UV illumination. Both UV light groups were found to have lower mean times of remnant removal than both the white light groups.

In this study, using UV illumination, the airotor handpiece focusses the UV light directly to the remnant material that has to be illuminated, detected and removed. Thus, the scattering of UV light is restricted to the area of operation intra orally. This is a great advantage over the technique of using UV flash light for remnant detection.

Implications for Clinical Practice

For quicker and more efficient removal of adhesive remnant, UV illuminated airotor can be a better choice**.** This technique results comparatively intact enamel surface and less chair side time which is beneficial to the patient and the clinician.

LIMITATIONS OF THE STUDY

1. The contour and anatomy of tooth surface are different for each tooth in both arches. The time and efficiency of remnant removal may depend on the anatomy of tooth surface also. In this study only premolar tooth is included.
2. As the availability of extracted human premolars that satisfy the inclusion criteria is limited, a modified ARI was used to evaluate samples after bracket debonding and samples with 80- 99% of adhesive remaining on the tooth (ARI=4) were included .
3. Accessories like UV illuminated airotor handpiece was custom designed for this study. This required frequent monitoring for its functional efficiency.
4. Number of fluorescent composite groups used in the study were limited to 2 due to market availability.

CONCLUSION

CONCLUSION

This comparative study assessed the efficiency of UV light and white light in remnant detection. When UV light is used as an aid to adhesive remnant detection, the procedure becomes quicker and more efficient.

After debonding, the time of adhesive remnant removal and amount of adhesive remnant left on the tooth surface were assessed. UV light illuminated airotor technique and white light illuminated airotor technique for remnant removal were compared. Less adhesive was left on the tooth surface with minimum enamel damage after remnant removal in less time when UV illuminated airotor technique is used.

UV illuminated airotor technique in fluorescent adhesive remnant removal, is found to be superior in adhesive detection and remnant removal in less chair side time.

Airotor hand piece with UV illumination focussed the UV light to the remnant removal spot only during functioning of handpiece. Thus, the scattering of UV light is restricted to a great extent which makes this technique more superior than many other previous studies which used UV LED flash light for remnant detection.

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REFERENCES

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ANNEXURES

ANNEXURES

Annexure 1. Adhesive remnant removal Time and ARI Group O-W

Group O-W - Opal BondMV / White Light		
Sample	**Time (Seconds)**	**Adhesive Remnant Index**
1	36	3
2	31	2
3	33	2
4	28	3
5	30	1
6	28	2
7	26	3
8	21	3
9	26	2
10	28	2
11	20	3
12	28	1
13	28	2
14	29	3
15	20	3
16	27	2
17	29	1
18	27	3
19	28	2
20	26	3
21	28	3
22	26	1
23	30	2
24	29	3
25	28	3
26	22	2
27	26	3
28	23	2
29	24	3
30	26	3

Annexure 2. Adhesive remnant removal Time and ARI Group O-UV

Group O-UV - Opal BondMV / UV Light		
Sample	**Time (Seconds)**	**Adhesive Remnant Index**
1	20	1
2	19	0
3	21	1
4	16	1
5	18	2
6	22	2
7	17	1
8	16	1
9	19	0
10	16	1
11	18	2
12	18	1
13	15	0
14	17	0
15	16	1
16	17	1
17	13	2
18	16	2
19	14	3
20	16	2
21	12	2
22	12	0
23	17	0
24	19	0
25	17	1
26	18	1
27	16	0
28	18	1
29	17	1
30	13	0

Annexure 3. Adhesive remnant removal Time and ARI Group P-W

Group P-W - PADLOCK / White Light		
Sample	**Time (Seconds)**	**Adhesive Remnant Index**
1	38	3
2	41	2
3	36	2
4	34	1
5	26	2
6	31	3
7	26	3
8	28	2
9	30	3
10	32	2
11	36	1
12	28	3
13	29	3
14	30	2
15	22	3
16	24	3
17	29	3
18	30	2
19	26	3
20	28	3
21	32	2
22	30	1
23	29	2
24	21	3
25	27	2
26	28	1
27	28	3
28	29	3
29	27	2
30	23	3

Annexure 4. Adhesive remnant removal Time and ARI Group P-UV

Group P-UV - PADLOCK / UV Light		
Sample	**Time (Seconds)**	**Adhesive Remnant Index**
1	18	1
2	20	2
3	16	2
4	13	1
5	21	1
6	12	2
7	19	1
8	17	2
9	17	1
10	14	0
11	18	0
12	19	1
13	17	2
14	14	0
15	16	0
16	13	0
17	17	1
18	16	1
19	17	0
20	16	1
21	16	1
22	18	0
23	17	0
24	13	1
25	19	2
26	16	1
27	15	0
28	14	0
29	16	1
30	15	0

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UNDER THE MANAGEMENT OF MJSCE TRUST, PUTHENCRUZ
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SGDC/152/2021/4015 17/02/2021

ETHICAL CLEARANCE CERTIFICATE

To,

Dr. Lisie P Mathew
St. Gregorios Dental College
Chelad, Kothamangalam

Dear Dr. Lisie P Mathew

Subject: Ethics Committee Clearance-reg

Protocol : Evaluation of time and efficiency in adhesive remnant removal after orthodontic debonding using airotor illuminated with white light and UV light-An in vitro study.

At the Institutional Ethics Committee (IEC) held on 15th of January 2021, this study was examined and discussed. After consideration, the committee has decided to approve and grant clearance for the aforementioned study.

The members who attended the meeting at which the protocol was discussed were:

1) Dr .C.K.K Nair - Former BARC Scientist
2) Dr.Cinu Thomas A - Scientist, Vice Principal, Caritas College of Pharmacy
3) Dr. Lissy Jose – Former member of Women's welfare Association.
4) Adv. Jose Aranjani – Advocate.
5) Dr. Sauganth Paul – Reader, Department of Biochemistry, St. Gregorios Dental College.
6) Dr. Eapen Cherian – Secretary, Professor, St. Gregorios Dental College
7) Dr. Jain Mathew – Principal and Head of the Department, Department of Conservative Dentistry and Endodontics.
8) Dr. George Francis – Head of the Department, Department of Prosthodontics and Crown and Bridge.
9) Dr. Binoy Kurian – Head of the Department, Department of Orthodontics and Dentofacial Orthopaedics.

Dr. C.K.K Nair
Chairman Institutional Ethics Committee
St.Gregorios Dental College, Chelad.

Dr. Eapen Cherian
Secretary

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Dr. Lisie.P. Mathew

LIST OF ABBREVIATIONS

UV	Ultra Violet
ARI	Adhesive Remnant Index
P	Padlock
O	Opal bond MV
P-UV	Padlock- Ultra Violet
P-W	Padlock- White
O-UV	Opal bond- Ultra Violet
O-W	Opal bond- White
AFM	Atomic Force Microscopy
TCB	Tungsten Carbide Bur
SEP	Self- Etching Primer
UVR	Ultra Violet Radiation