MICROLEAKAGE OF RESIN MODIFIED GLASS IONOMER CEMENTS AT THE CEMENT-ENAMEL CEMENT-BAND INTERFACES

Dissertation submitted to

THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfilment for the degree of

MASTER OF DENTAL SURGERY

BRANCH – V

ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

APRIL - 2015

CERTIFICATE

This is to certify that the dissertation entitled **"Microleakage of Resin Modified Glass Ionomer cements at the Cement-Enamel Cement-Band Interfaces"** by **Dr. AKHI GOPI**, post graduate student (M.D.S), Orthodontics and Dentofacial Orthopedics (Branch – V), KSR Institute of Dental Science and Research, Thiruchengode, submitted to the Tamil Nadu Dr. M.G.R. Medical University in partial fulfilment for the M.D.S. degree examination (April 2015) is a bonafide research work carried out by him under my supervision and guidance.

THE PRINCIPAL
Prof. Dr. G.S. Kumar, M.D.S.,
KSR Institute of Dental Science and Research,
Thiruchengode – 637 215.

THE HEAD OF THE DEPARTMENT
Prof. Dr. K. P. Senthil Kumar, M.D.S.,
Professor and Head of the Department,
Dept. of Orthodontics and
Dentofacial Orthopaedics,
KSR Institute of Dental Science & Research,
Thiruchengode – 637 215.

THE GUIDE
Dr. K.P. Senthil Kumar M.D.S.,
Professor and Head of the Department
Dept. of Orthodontics and
Dentofacial Orthopaedics,
KSR Institute of Dental Science and Research,
Thiruchengode – 637 215.

THE CANDIDATE
Dr. Akhil Gopi,
III year PG student,
Dept. of Orthodontics and
Dentofacial Orthopaedics,
KSR Institute of Dental Science & Research,
Thiruchengode – 637 215.

Date :
Place : Thiruchengode.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

Enamel demineralization and the development of incipient carious lesion around the bands and brackets especially in the poor oral hygiene patients is one of the main issues in fixed appliance treatment[27]. Different studies have documented the prevalence of these lesions to be up to 95% after fixed appliance therapy[1, 54]. Enamel demineralization can occur when specific bacteria is retained on the enamel surface for prolonged time. This enamel demineralization can leads to the development of white spot lesions in a month time after the initiation of fixed appliance therapy[68, 69]. Preventing these lesions during treatment is an important concern for the orthodontist because these lesions are unhealthy, uneasthetic and potentially irreversible.

Because of the most posterior position in the mouth, the banded teeth are more difficult to clean, resulting in more plaque accumulation and food retention than the bonded teeth[69]. Posterior bands are highly susceptible for band loosening and fracture because this is the area where greatest tensile and shear forces from mastication occur. Loosening of bands results in effective plaque trap and the banded surface of the tooth cannot be cleaned which may prone the exposed enamel surface to cariogenic attack. In addition to the compromised oral hygiene; cement seal breakdown, inadequate band strength and cement solubility in oral fluids may contribute to enamel demineralization[67].

The overall management of white spot lesions has become a critical concern during orthodontic therapy which includes the prevention of demineralization and encourages the remineralization of existing lesions. Meticulous oral hygiene maintenance, fluoride rinses, and topical fluoride application is mandatory to reduce the demineralization. Unfortunately the efficacy of fluoride containing agents and patient compliance has become a potential barrier against these preventive measures and hence are not much reliable[1]. Therefore, the preventive measures which do not require patient compliance might be more effective in reducing or preventing the demineralization[13]. Application of fluoride varnish has been found to be effective in this situation. This can occur only if the cements adhere firmly to the tooth surface under bands. Hence ideal cement for band cementation should not only have fluoride releasing property but also have proper enamel adherence.

Many of the orthodontic cements have been introduced in order to reduce the demineralization of enamel under the orthodontic bands. One of the first cement was Zinc phosphate cement, used for luting purposes. 1n 1960s although fluoride was incorporated in it to impede the enamel decalcification, which might weaken its luting properties. High oral solubility, increased brittleness and low tensile strength have reduced its use as an efficient luting agent for band cementation.

Polycarboxylate cement was introduced in 1968 by Smith. Unlike zinc phosphate cement, it adheres chemically to the tooth structure by chelating with calcium ions in the enamel[73]. The polyacrylic acid which is the main ingredient of the cement forms ionic bonds with stainless steel band. Fluoride also incorporated into it to enhance the cariostatic properties. However the reduced tensile strength, high viscosity, relatively high oral solubility, short setting and working times retarded the use of polycarboxylate cement as an effective luting agent for orthodontic band cementation.

Glass ionomer cement was introduced in 1971 by Wilson and Kent and is available in powder-liquid and dual and single paste light curable forms. The most interesting property of GICs is the formation of complete seal against the microleakage. They have low oral solubility, adequate shelf life, high compressive strength, fluoride releasing property and an ability to form chemical bonds with enamel, dentin and metal[67]. They form a stronger bond with enamel than with the stainless steel band, henceforth bond failure was noticed more at the band cement interface both in vivo and in vitro[21, 55, 67]. This tends to leave a protective cement layer over the enamel surface, may helps to prevent or reduce the demineralization under loose bands. Long term fluoride release from glass ionomer cements have been well investigated which may contribute substantially to enamel remineralization. Even though, GIC have some unfavourable properties. They are brittle and are susceptible to attack by water during the setting phase resulting in a weaker bond.

Addition of resin components into the Glass ionomer composition has lead to the development of hybrid cements allowing snap set and rapid strength development[55]. They were RMGICs and Polyacid modified composites or compomers with different polymerization mechanism such as chemical, light or dual curing.

A further innovation in glass ionomer technology has occurred with the development of this Resin Modified Glass Ionomer Cements, combining the properties of glass ionomers as well as the additional strength afforded by its composite resin component. They have the added advantages of both conventional GIC and modified composite resin making it as excellent luting cement for orthodontic band cementation. Resin modified glass ionomer cements set not only by the acid base reactions of conventional GICs but also by the photo-chemical polymerization of typical of composite resins. Resin modified GICs have found to be higher fluoride-release profiles, less enamel demineralization, higher adhesive strength and caries control activity than conventional GIC[50]. Another problem encountered in conventional GIC is the inconsistency in the powder-liquid ratio of the cement lute. Mixes with low powder-liquid ratio are likely to have inferior bond strength and higher failure rates clinically[51]. To overcome this, recently dual cured RMGICs have marketed in two paste form which enhances the reproducibility and consistency of the mix[55].

Recently a polyacid modified composite resin was introduced as luting cement for orthodontic band cementation. Because of the absence of water in the formulation, acid base reaction cannot be taken place efficiently and hence they do not form ionic bond with enamel surface than conventional GIC. This result in tendency of bands to failure at the cement-enamel interface leading to microleakage and enamel demineralization although this has not been confirmed in the further invitro studies. They are not self adhesives like the conventional and hybrid glass ionomers and are activated by photo polymerization. Laboratory studies of conventional GIC, RMGICs and Compomers have shown that conventional GIC is associated with more microleakage and enamel demineralization at the cement enamel and cement band interface than the other two cements[57].

To date, no published studies have quantitatively compared the invitro differences in demineralization among the resin modified glass ionomer cements used for orthodontic band cementation. My present study is undertaken to compare the microleakage of four different brands of RMGIC at the cement-enamel and cement-band interface.

.

AIMS AND OBJECTIVES OF THE STUDY

AIMS AND OBJECTIVES OF THE STUDY

AIM:-

This in vitro study was designed to compare the microleakage patterns beneath the bands cemented with four different brands of Resin modified glass ionomer cements (GC Fuji Ortho Band paste pak, GC Fuji CEM, GC Fuji ORTHO LC, GC Fuji PLUS) in order to achieve minimal enamel demineralization during orthodontic treatment.

OBJECTIVES:-

1. To assess the microleakage patterns of four different Resin Modified Glass Ionomer band cements at the cement-enamel and cement-band interfaces.
2. To observe the buccal and lingual cement-enamel and cement-band interfaces using stereomicroscope.
3. To calculate and compare the depth of dye penetration among different band cements.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

John C Cameron et al[35] (1963) has done an investigation to determine and standardize a proper consistency of mixing dental cements used for cementing orthodontic bands and how does it affect the physical properties of the cements. 8 brands of dental cements were used in this study, 7 brands were of zinc phosphate type and one was of silicophosphate type. A single technique was used for manipulating all brands of zinc phosphate cement. The proper mixing consistency was determined with the help of a glass tube, glass plate and 1kg weight. The result of investigation showed that among the brands tested, silicophosphate cements had superior physical properties, when compared to others. In the mouth temperature, a substantial increase in the setting time had been noted in some cement without influencing the compressive strength.

Rich J.M et al[73] (1975) demonstrated a reliable method for testing the retention of orthodontic bands and to relate the retentive properties of zinc phosphate cement to carboxylate and red copper cement. Ten freshly extracted human premolar teeth were selected for the study. Each tooth was fitted with optimum sized bands and was cemented with zinc phosphate, carboxylate and red copper cement. The buttons were welded onto the facial and lingual surfaces of the bands for easy attachment to the removal apparatus. A tensile testing instrument was employed to test the force necessary for debanding. The result of the investigation showed that zinc phosphate have highest retentive value followed by red Cu and lastly by carboxylate cements.

Sadowsky P.L et al[77] (1976) have compared the tensile bond strength, solubility and disintegration of orthodontic cements used for band cementation. 60 freshly extracted human maxillary central incisor teeth were used for this study. They were divided into 4 groups of 15 teeth each. All the teeth were banded and were cemented with composite cement, carboxylate cement, silicophosphate cement and a zinc phosphate cement. Tensile bond strength of the enamel and cement and cement-stainless steel band were tested in an Instron testing machine and microleakage was evaluated by using a dye penetration method. The result of the investigation showed that the composite cement exhibited the highest tensile bond strength to both enamel and band material. They were also free of marginal leakage at the cement enamel interface and showed no solubility or disintegration under the experimental conditions indicating the highest efficiency of composite cement over the other tested cements.

Walter B Shepherd et al[93] (1978) has done an investigation to test the effects of cold temperature rinsing in the physical properties of zinc phosphate and silicophosphate cements and how does it affect the retentive properties of bands cemented with these cements. They have also studied the effects of mixing techniques and moisture contamination with respect to the zinc phosphate and silicophosphate cements. They have investigated two commercially available silicophosphate and three zinc phosphate cements. From the study they came to the conclusion that the powder liquid ratio necessary to achieve a standard consistency is increased when the temperature of the mixing slab decreases. Setting time was decreased in a simulated oral environment when both types of cements were mixed at reduced temperature. Slight to moderate increase in compressive and tensile strength were observed in zinc phosphate cements mixed at low temperatures while the silicophosphate cements were less affected. Moisture free mix resulted in higher compressive and tensile strength at reduced temperature and zinc phosphate cement mixed on a frozen slab significantly increased the band retention.

Mizrahi E et al[66] (1979) has done a survey to evaluate the rate of band failure after the bands were luted with different cements. This survey involved a total of 5949 bands cemented onto the teeth of 293 patients. Four groups were investigated. In group I and II, unitek preformed stainless steel bands were luted with polycarboxylate and durelon cements respectively. In group III and IV rocky mountain stainless steel bands luted with Ormco gold and Ames crown and bridge cement. The result of the survey showed that band failure rates increases in the order of group 2, group I and group 4 and the highest in group 3. The reduced band failure rate of group 2 may be because of the type of cements and bands used.

Bapna M.S et al[4] (1980) done an investigation to formulate an ideal consistency of mix for band cementation and to compare the physical properties of the epoxy resin cements, zinc phosphate and zinc polycarboxylate cements. The cements were mixed according to the ADA specification NO.8 and a precision universal penetrometer was employed for measuring setting time. The solubility, disintegration and compressive strength were measured according to the ADA specification NO.8. Compressive strength was determined on an Instron universal testing machine. The result of the investigation indicated that the setting times for resin and zinc polycarboxylate cements were about the same but less than that for zinc phosphate cement. The properties of percent solubility and compressive strength were significantly superior for resin cements.

Ira L. Shannon et al [1980][33] evaluated the effectiveness of incorporating NaF and SnF_2 into $ZnPo_4$ cement in reducing the solubility and increasing the micro hardness of human enamel. 70 extracted human premolars were collected and sectioned mesio distally to provide buccal and lingual halves. One half of the tooth was employed as control side and was treated with $ZnPo_4$ cement and the other side with test preparation. Atomic absorption spectrometry and micro hardness test were performed and they came to the conclusion that addition to SnF_2 into $ZnPO_4$ cement is more effective than NaF in view of reducing the enamel solubility and increasing the micro hardness of human enamel.

Sadowsky P.L et al[78] [1981] was undertaken a study to determine the amount of fluoride uptake by the enamel from the three cements used for band cementation and its effect on prevention of enamel demineralization. For the study, 30 maxillary central incisor teeth were collected and divided into three groups of 10 teeth each. The teeth were bonded and cemented with one of the three cements in each groups. The cements used are zinc phosphate, zinc phosphate containing 5% SnF_2 and silicophosphate cement. The teeth were suspended in synthetic saliva for 21 days. Three successive biopsies were taken from the enamel surface and the analysis of fluoride uptake was carried out electrometrically. The result of the investigation showed that the enamel beneath the silicophosphate exhibited the greatest fluoride uptake and therefore more resistant to enamel demineralization.

Mizrahi E et al[61] [1983] has done a cross sectional study to compare the prevalence and severity of enamel opacities before and after orthodontic treatment. The sample consisted of 796 patients divided into 2 groups. Group 1 had 527 pre-treatment patients and group 2 had 269 patients who had completed treatment. The result of this study indicated that the fixed appliance therapy contributed to the development of enamel demineralization and increases the severity of enamel opacities.

Stephen Norris D et al[85] (1986) has done an investigation to compare the retentive bond strength of orthodontic bands cemented with zinc phosphate, zinc polycarboxylate and glass ionomer cements. The site of cement failure was also evaluated. 180 freshly extracted human molar teeth were selected and were divided into 3 groups of 60 teeth each. Optimally sized bands were selected for each tooth. Lingual button were spot welded on both the buccal and lingual surfaces of molar band. Teeth in group I, group II and group III were cemented with zinc phosphate, zinc polycarboxylate and GIC respectively. With the help of an Instron machine, the force required to initially fracture the cement bond was evaluated. Both GIC and zinc polycarboxylate cement exhibited more band retention than zinc phosphate cement. More bands cemented with GIC failed at the cement band interface, leaving the cement adhered to the teeth which may offer protection against decalcification under loose bands.

Ogaard B et al[69] (1988) has evaluated the development of enamel lesion associated with fixed orthodontic therapy. 5 patients in the age group of 11-13 years, with the premolars scheduled for therapeutic extraction were chosen for the study. The bands were designed in such a way that 2 metal posts were welded to the inner surface of its buccal part and were cemented to the premolars with polycarboxylate cement. The patients wore the test appliances for 4 weeks in the absence of any fluoride supplementation. Both micro radiographic and SEM examination showed the softening of the enamel surface after 4 weeks indicating the rapid progression of enamel demineralization as a result of plaque harbors around the brackets and ill fitting bands.

Mark L Underwood[47] et al [1989] examined the clinical durability and caries prevention potential of a fluoride exchanging resin when it is used as an orthodontic bracket bonding adhesive. For evaluating the clinical durability, orthodontic brackets were bonded to alternate teeth with ER and the remaining teeth with concise orthodontic resin in 10 patients who were scheduled for first premolar extraction. The bracketed teeth were extracted after 60 days and were assessed for the presence of any lesion development. The result of the study demonstrated that the fluoride exchanging resin has a significant effect in the reduction of early enamel demineralization.

Rezk-Lega F et al[72] [1991] has investigated the in vivo cariostatic effects of 2 GICs Ketac-Cem and Aqua-Cem underneath the loose bands. A group of five patients intended for PM extraction were participated in this investigation. Specially designed stainless steel bands with two metal posts welded on to the inner surface to secure a space between the buccal tooth surface and the bands were us ed. Each pair of premolars was cemented sequentially with Ketac-Cem or Aqua-cem. A group of five patients with bands cemented with non-fluoride cement was taken as the control. After a period of 4 weeks, the mineral content of the tooth was assessed by micro radiography. The study concludes by saying that fluoride released from Glass Ionomer cements substantially reduces the demineralization of enamel while it doesn't give complete protection under loose bands.

Kevin James Donly et al[38] [1995] has done a study to evaluate the demineralization potential of glass ionomer cement adjacent to orthodontic bands. An acid protective varnish was applied in forty extracted permanent molars except an area of enamel approximately 2×6mm in the buccal surface. With an acidic gel, artificial caries lesions were created in the exposed enamel surface. Half the lesion in each tooth is coated with an acid protective varnish which act as the control site. Tooth was banded with GIC or $ZnPo_4$ cement with the gingival margin of the band is at the site of artificial caries lesion. The teeth were then sectioned and assessed for enamel demineralization. The study showed a significant reduction in the development of enamel caries under bands cemented with GIC than those cemented with $ZnPO_4$.

Elizabeth cho et al[17] [1995] has assessed the moisture susceptibility of resin modified and conventional glass ionomer cements and also investigated the effect of barrier coatings and different setting environments in the properties of the cements. The study showed that RMGIC are less sensitive to moisture than conventional GLC. Dry storage environment and fluoride sealant coatings significantly increased the strength of resin modified glass ionomer cement specimens.

David P Wood et al[12] (1996) has done a study to measure and compare the force required to deband the stainless steel molar bands when they were luted with zinc phosphate , polycarboxylate and GIC and to evaluate whether sandblasting the inner surface of the band increases the band retention. For the study they have used 30 extracted mandibular 3rd molars and were banded. The inside surface of the bands were sandblasted and were luted with zinc phosphate, polycarboxylate and GIC. With the help of an Instron testing machine, the force required to debanding was measured. The result of the investigation showed that GIC demonstrated the highest force to deband in both the non sandblasted and sandblasted orthodontic bands, and the force required to deband using zinc phosphate, polycarboxylate and GIC was approximately doubled following sandblasting.

Sevil Akkaya et al[81] (1996) has done a study to evaluate the amount of fluoride uptake by enamel after the bands were luted with GIC and zinc phosphate cement. The study was conducted on 21 children who were assigned for fixed appliance therapy and first premolar extraction and the subjects were randomly divided into 3 groups of 7 samples each. In the first experimental group, the teeth were topically fluoridated with 2% NaF, before orthodontic band cementation with Zinc phosphate cement. In the 2nd experimental group, the bands were cemented with GIC and the third experimental group is treated as controls without any dental procedures. After the three months of time, the first premolars were extracted followed by careful band removal. The enamel fluoride concentrations at three successive etch depths were determined by fluor ion electrode whereas the calcium concentrations were determined with an atomic absorption spectrophotometer. The result of the investigation showed that enamel fluoride concentrations were highly increased in both cementation groups as compared to the control group and no statistically significant differences were observed on both cementation groups.

Fricker J P et al[21] [1997] investigated the durability of retention of orthodontic bands cemented with resin modified light activated adhesives; Fuji II LC and Band-Lok with a chemical cured second generation glass ionomer cement Ketac-Cem. Fifty consecutive full banding cases cemented with the above mentioned cements were evaluated over a period of 12 months for loose bands. The results showed insignificant difference in the failure rates of Fuji II LC, Band-Lok and Ketac-Cem for the cementation of orthodontic molar bands. Bands cemented with Fuji II LC and Ketac-Cem were failed mostly at the cement band interfaces and Band-Lok at the cement-enamel interface which suggested the greater protection against enamel demineralization in bands cemented with Fuji II LC and Ketac-Cem.

Kan K.C et al[36] [1997] has done a study to compare the cytotoxicity and fluoride releasing ability of two resin modified glass ionomers [vitrimer tricure glass ionomer system and Fuji II LC], a conventional glass ionomer cement and a composite resin. Cytotoxicity was tested by means of 3T3 mouse fibroblasts. In this investigation they found that fluoride release and the cytotoxic effects of two tested resin modified glass ionomer cements differ among themselves. The characteristics of vitrimer tricure glass ionomer are more closely resembles to conventional glass ionomer cement while Fuji II LC had a similar findings to resin composite.

Millett D.T et al[55] (1998) compared the tensile bond strength, mode of band failure and the mean survival time of bands cemented with a dual cured cement (Band-lok) and a conventional GIC (ketac-cem). 80 sound extracted 3rd molars teeth were collected and were divided into 40 teeth of 2 groups and the teeth were banded. In one group, bands were cemented with band-lok and in other group with Ketac-Cem cements. 30 teeth from each group were evaluated for band retention using a Nene M3000 testing machine. 10 banded teeth from each group were used to assess the survival time following application of mechanical stress in a ball mill. The result of the investigation showed that mean tensile bond strength and mean survival time was significantly higher for bands cemented with dual cured cement. They observed an increased band failure rate at the cement band interface of those cemented with conventional GIC. This study emphasized the superior characteristic of dual -cured cements over conventional GIC for band cementation.

Leonard Gorelick et al[43] (1982) investigated the frequency of occurrence of white spot formation after full term orthodontic treatment. He has divided the samples into 3 groups. A control group of 50 children who were examined prior to the placement of brackets or bands, a bonded group comprises of 121 patients and a banded group of 71 children in whom 280 maxillary incisors were banded. The incidence of white spot formation is evaluated in the banded specimen by means of kodachrome slides which had been taken before and after treatment. The result of the investigation showed that 3.6% of the teeth had white spot formation in the control group and 10% after treatment and 50 % of patients experienced an increase in white spots. No significant differences were observed between the frequency of white spots in maxillary incisors that were banded or bonded and the incidence of white spot formation were independent of the longevity of banding.

Mizrahi E et al[63] (1998) has carried out a study to determine the prevalence and severity of enamel opacities occurring on different tooth surfaces as well as the distribution of these lesions in individual teeth following orthodontic treatment. The study comprised a total of 796 patients who were divided into 2 groups. In group I, 527 patients were examined prior to the multibanded fixed appliance treatment and in group II, 269 patients were examined after completion of multibanded orthodontic treatment. The result of the study showed that following orthodontic treatment, a statistically significant increase in the prevalence of enamel opacities were observed in the vestibular and lingual surface of the dentition. The cervical and middle third of the crown showed significantly greater opacities following orthodontic treatment. With regards to the individual teeth, the highest prevalence and severity of enamel opacities were observed in the maxillary and mandibular molars followed by maxillary lateral incisors and mandibular lateral incisors and canines.

O'Reilly M.M et al[68] (1998) has evaluated the amount and extent of demineralization occurred around the bonded orthodontic appliances after 1 month in the mouth and the ability of fluoride products to inhibit or reverse the demineralization. 20 orthodontic patients scheduled for premolar extraction were randomly divided into 4 groups -1 control and 3 test groups. The premolars were bracketed using an acid etch composite system. Patients in the control group were brushed once daily with the sodium fluoride dentifrice in addition to the daily use of mouth rinse. Patients were instructed to rinse daily with 0.05%NaF in test group I and topical application of 1.23% APF gel once in a week in a test group 2. In group III brushing daily with NaF dentifrice, mouth rinsing with 0.05% NaF, and once weekly topical application of a 1.23% APF gel is recommended. After 1 month, premolars were extracted and mineral profiles were determined. The control group was demonstrated upto 15% demineralization to a depth of

50µm, and the test group showed a rehardening and/or inhibition of demineralization. Test group II showed a hard outer layer. The study demonstrated the rapid development of enamel demineralization in a fixed appliance therapy and the ability of fluoride products to inhibit or reverse the demineralization.

Millet D.T et al[52] (1999) has done a study to compare the decalcification of enamel surface at pretreatment, at the time of bracket removal and at 12 month review when brackets were banded with a GIC or a resin adhesive. In this half mouth study, 240 brackets were bonded in 40 patients, half with GIC and half with resin adhesive. The enamel decalcification rate at the bonded site was assessed by a standard photographic technique and a modified DDE index. The result of the investigation showed that during the treatment period, the mean rate of decalcification was increased and in post treatment, decalcification appears to be less severe and no statistically significant difference were observed in decalcification rate between the adhesives used for bonding.

Aggarwal M et al[1] (2000) has evaluated the shear-peel band strength of 5 orthodontic cements used for banding as well as the effect of saliva contamination on the retention properties of bands. They have used zinc phosphate cement, two RMGIC's and two polyacid modified composite resin cements for their study. 280 extracted human molar teeth were collected and were divided into 7 groups of 40 teeth each. All the teeth were banded and cemented with each of the cements. For testing the effect of saliva contamination in band retention properties, the molar teeth were contaminated with saliva before band cementation in group VI and in group VII, sandblasting was performed before band cementation. The shear - peel band strength was assessed with the help of an Instron machine. The result of the investigation showed that RMGIC's and PMCR, exhibited highest shear-peel band strength compared to ZnPO4 cement. Lower band strength was noted in saliva contaminated PMCR cement group, indicating the importance of moisture control during band cementation.

Millet D.T et al[58] (2001) compared the time to first failure of permanent molar bands cemented with either Band–Lok or Aquacem. Patient's sex, age, severity of malocclusion and treatment mechanics was also assessed in relation to band failure. 219 bands cemented with Band–Lok in 108 patients and for 395 bands cemented with aqua-cem in 183 patients were analyzed. The result of the investigation showed no statistically significant difference in time to first failure of bands irrespective of the type of cement used for cementation. The use of head gear significantly reduced the band survival rate in both tested groups.

Gillgrass T.J[25] et al [2001] has compared the time of first band failure, position of band failure and change in white spot lesions during fixed appliance therapy of bands cemented to molars with a modified composite [Band-Lok] or a chemically cured GIC, [Ketac-Cem]. 140 band pairs were cemented in 98 patients with Band-Lok or Ketac-Cem. He has found out no significance differences between the pattern of band failure and changes in enamel opacities among the tested groups. However the band failure was predominantly at the cement-enamel interface for Band-Lok and at the cement-band interface for Ketac-Cem.

Linda Wang et al[44] [2001] investigated the anticariogenic behaviour of RMGIC insitu/ex vivo with simplified etch and rinse adhesive systems. For the study, bovine enamel blocks were obtained and a cavity was prepared in the centre of each block with 1.5mm diameter and depth. According to the surface treatment the enamel blocks were randomly divided into three groups. The groups include group VP (control) , Vitremer + its own primer, group VPB (Vitremer + primer and bond). Each volunteer was asked to wear an acrylic palatal appliance with two blocks of each group, so each appliance includes six blocks. After a period of 15days, the blocks were removed from the devices and demineralization was assessed by a microhardness analysis. The result of the investigation showed that none of the treatment groups are completely devoid of enamel demineralization. The study concluded that the tested resin modified glass ionomer cements with etch-and-rinse dentin bonding agents are not superior to conventional RMGICs in prevention of enamel decalcification

Foley Timothy et al[20] (2002) evaluated the degree of enamel demineralization of banding with 3 different orthodontic cements. 120 non carious fully erupted human 3rd molars were selected for banding and randomly divided into 4 groups: Zinc phosphate cement, Zn polycarboxylate cement, RMGIC and non banded control group. In each group, bands were cemented with respective cements and were stored in artificial saliva at 37ºC for 30 days. Tooth were sectioned and a dye penetration method was used for assessing the demineralization potential. The result of the study demonstrated that least dye penetration occurred along the bands cemented with RMGIC followed by Zn polycarboxylate and highest penetration occurred in $ZnPO_4$ and control groups. Hence the less depth of demineralization occurred in the RMGIC and Zn polycarboxylate group than did the $ZnPO_4$ and control groups.

Millett D.T et al[57] (2003) compared the shear peel bond strength and site of band failure of microetched orthodontic bands cemented with four different cements. They have used 2 RMGIC's (Fuji ortho l, 3M Multicure), a modified composite (ultra band lock) and Ketac-cem for band cementation. For measuring the shear peel bond strength, 80 extracted human third molars were collected and were divided into 4 groups of 20 teeth each and each group was cemented with one of the 4 cements. The specimens were stored in a humidator at 37ºC for 24 hrs and with Nene M 3000 testing machine; the shear debanding force was assessed. For assessing the survival time, 40 extracted 3rd molars were divided into 4 groups of 10 teeth each and were cemented with one of the 4 cements. The specimens were then subjected to mechanical stress in a ball mill. The result of the study showed that no statistically significant difference exist in the mean shear peel bond strength of micro etched molar bands cemented with any of the cements assessed where as the predominant site of band failure was seen at the cement enamel interface of bands those were cemented with Fuji ortho LC, Ultra Band Lok and Ketac Cem. Bands cemented with 3M multicure failed predominantly at the cement band interface. Bands cemented with either of the RMGIC's or modified composite have a greater survival time than for bands cemented with conventional GIC.

Warren J Cohen et al[94] [2003] compared the fluoride release and rerelease rates from three orthodontic bonding materials containing fluoride and one without fluoride. They have tested two polyacid modified composite resins – Pythin and Assure; Fuji Ortho LC, a resin modified GIC and Transbond XT, a non fluoride containing bonding adhesive. Ten standard specimens of each of the materials were fabricated and stored in deionized distilled water at 37ºC. In this study each of the 4 sample groups were subdivided into 5 samples of 2 groups. 5 samples from each group were exposed to 2% sodium fluoride gel. Fluoride release measure from both exposed and non exposed groups were taken after 18 months with the help of a fluoride ion specific combination electrode. The result of the investigation showed that Fujiortho LC has the highest fluoride releasing efficiency among the tested groups and Fuji Ortho LC, Assure and Python have sufficient long term fluoride release rates to reduce white spot formation.

Christophe Azevedo et al[9] (2004) has evaluated the effect of time on the flexural strength of a RMGIC and a composite adhesive system at 10min,1 hr and 7 days corresponding to the 3 stages of polymerization of Fuji ortho LC. Ten rectangular specimens of Fuji Ortho LC and concise were prepared in a metal mold and was stored at 100% humidity at 37ºC in an incubator. The test groups were divided into 6, group I to group VI, depends on the cement and the time at which the sample is fractured after initial setting. Flexural strength was measured using a universal testing machine. The result of their investigation showed that flexural strength was significantly higher in both the cement groups that were fractured after 7 days. But the flexural strength was higher in the concise than FujiorthoLC whatever the time of fracture.

Willams P.H et al[95] (2005) has done an investigation to compare the effectiveness of a conventional glass poly(alkenoate)cement and 2 polyacid modified composite resin cements used to cement orthodontic bands. In the invitro part of this study, 240 extracted human 3rd molar teeth were randomly divided into 4 groups of 60 teeth each. Each group consisted of 20 teeth of banding with conventional poly (alkenoate) cement, 20 teeth with polyacid modified resin composite (transband plus) and remaining teeth with additional polyacid modified resin composite (ultra band lok). The debanding force of all 3 groups was tested at 20 minutes, and 3, 6 and 12 months using an Instron universal testing machine. The result indicated that all 3 cements have shown an increased debanding force after 12 months. Of the 2 compomers, transband plus demonstrated the highest median force to deband at all 4 time intervals. In the invivo part of the study, molar bands were cemented with either intact or transbond plus in 30 patients. The results showed there to be no clinically significant difference in band failure rates between the 2 cements tested invivo. There are no significant changes between the invivo and invitro band failure rates.

Sumie Yoneda et al[87] [2005] was evaluated the clinical performance of a paste-paste resin modified glass ionomer luting cement GC fuji Cem. A total of 290 restorations in 268 patients were luted with Fuji Cem after the enamel surfaces were pre etched with GC Fuji conditioner. After 21 months of follow up, no clinical failures were observed. Fuji Cem has shown promising results as an efficient luting agent.

Michael Behr et al[51] [2006] investigated the effect of variation from the recommended powder/ liquid ratio in the flexural strength modulus and three body wear of RMGICs. Two resin modified glass ionomer cements FujiPLUS and ProTec Cem were mixed using various powder- liquid ratios. The result showed a decrease in the flexural strength of both cements when the liquid content was increased while higher powder ratio doesn't have an effect. A higher liquid content also resulted in an incomplete setting reaction of both the cements.

Tracy Herion et al[92] (2007) compared the effect of GIC, RMGIC and compomer in luting porcelain molar denture teeth with respect to its mean shear peel bond strength, the amount of cement remaining in the teeth after debanding and the survival time of cemented bands subject to mechanical fatigue. For measuring shear peel bond strength, 60 porcelain denture teeth were grouped into 20 teeth of 3 groups and were banded with each of the 3 cements and the band strength was measured using a universal testing machine. 30 porcelain denture teeth (10 per cement group) were used to assess the survival time of the bands subjected to mechanical fatigue and the testing was done in a ball mill. The amount of cement remaining on the teeth surface after debanding was scored and a chi square test was used to compare groups. The result of their investigation showed that the shear peel strength of the 3 cements of luting porcelain denture teeth were insignificant but the band retention was greater in compomer and RMGIC group than with the conventional GIC when subject to mechanical fatigue.

Daniel John Rejman et al[10] (2008) was investigated the degree of a light cured resin modified GIC, light cured resin and a dual cured resin under molar bands. 15 orthodontic band strips were divided into 3 groups of 5 bands each. In each group 15 milligrams of each adhesive were applied to the base of each band and the band samples were firmly pressed against glass slide covered by a polystyrene strip and were light cured. The degree of cure was evaluated with micro-MIR FTIR spectroscopy. The result of the investigation showed that RMGIC (Fuji orthoLC) exhibited a significantly higher mean degree of cure under molar bands than that of eagle spectrum resin and variolink II dual cure, which didn't differ significantly.

Declan Millet et al[14] (2009) evaluated the effectiveness of adhesives used for band cementation in terms of their ability to retain the bands during treatment and vulnerability of it to cause tooth decay. The datas of the review were collected from electronic databases, conference proceedings and internet. Randomized and clinical control trials of adhesives used to fix orthodontic bands to molar teeth were chosen. 24 trials were found to be relevant for the study. Out of this only 5 randomized control trials met the inclusive criteria. Interventions assured the capability of $ZnPO_4$ cement, Glass ionomer cement, Polyacid modified composite resin, RMGIC and glass polyphosphate cement. The result showed that the evidence of the review was insufficient to make firm recommendations for the use of one band adhesives over the other as the inappropriateness of data analysis of the study and unfeasible meta analysis.

Sabri llhan Ramoglu et al[76] (2009) compared the amount of microleakage around the orthodontic brackets bonded with light cured RMGIC adhesive and conventional light cured adhesive system at the occlusal and gingival aspect of the brackets. 60 freshly extracted caries free maxillary premolar teeth were randomly divided into 15 teeth of 4 groups each. In group I and II, metal and ceramic brackets were bonded with RMGIC adhesive (GC Fuji ortho

LC) and in group III and IV, metal and ceramic brackets were bonded with conventional adhesive (transbond XT). 0.5% basic fuchsine solution was used for microleakage evaluation. The teeth were sectioned and the microleakage at the occlusal and gingival margins was determined by stereomicroscope. The result of the study showed that higher microleakage was observed on the gingival aspect of all 4 groups. But the higher microleakage score was seen in brackets bonded with RMGIC adhesive than those bonded with conventional adhesive irrespective of the type of brackets used.

Mervyn Y.H.Chin[50] et al (2009) evaluated the fluoride release profiles of 4 commercially available orthodontic adhesives and their effects in relation to enamel demineralization and caries development. For this study they have used 50 bovine enamel samples and were divided into 5 groups of 10 samples each. Brackets were bonded in all 4 groups of bovine enamel samples with each of the 4 adhesives (Ketac-cem, Fujiortho LC, light bond, tansbond XT) and one unbracketed group was treated as the reference group. For each adhesive, 5 specimens were taken as test samples and other 5 were served as controls. Each specimen was immersed alternatively in a dematerializing and remineralizing solution at 4 hrs and 20 hrs respectively. The test samples of each group were subjected to a fluoride mouth rinse for one minute each day. At regular intervals fluoride release was measured over 28 days and the mineral distribution of peribracket enamel after 28 days was quantified by transversal microradiographs. The result of the study showed that in the first 24 hrs higher fluoride release profile were observed among the groups bonded with ketac-cem and fujiortho LC, and light bond acid reached a constant level after 2 weeks. In both control and test groups, fuji ortho LC released significantly more fluoride and produce shallower lesions and less mineral loss than did other adhesives used. In contrast Transband XT and light bond offered few cariostatic effects to the enamel.

Sug –Joon Ahn et al[86] (2010) analyzed the difference in surface roughness and surface free energy characteristics of various orthodontic adhesives and evaluated the relationship of them with streptococcus mutans adhesion patterns. 7 light cured orthodontic adhesives were selected for the study (3 non fluoride composites, a fluoride releasing composite, a polyacid modified composite (compomer) and 2 RMGIC) were tested for SR and SFE by confocal laser screening microscopy and the sessile drop method. Each material was incubated with whole saliva. By incubating each material with tritium labeled cariogenic streptococci, adhesion assays were performed. The result of the study shows that surface free energy characteristics are significantly different among adhesives tested despite the more or less uniform surface roughness. RMGIC's showed higher SFE characteristics particularly dispersive, polar and acid characteristics than did composites and compomers. Because of its higher SFE characteristics st.mutans adhesion to RMGIC adhesives was higher than other groups.

Siddik Malkoc et al[82] (2010) evaluated the cytotoxicity of 3 different resin modified orthodontic band adhesives. They have used Biso Ortho Band Paste LC™, Multi-Cure Glass ionomer Band cement™, and Transbond Plus Light Band Adhesive™ for evaluating cytotoxicity. All cement specimens were prepared and the samples were extracted in 3ml basal medium eagle with 10% new born calf serum for 24 hours. The sample medium was incubated with L929 cells. Methyltetrazolium test was used to assess the mitochondrial activity. Their results showed that a reduction in the number of vital cell elements in the resin modified orthodontic band adhesive groups than the controls, indicating the increased cytotoxicity of the experimental group.

Klara Kim et al[39] (2010) compared the clinical parameters and sub gingival micro biota of patients receiving fixed orthodontic therapy of more than 6 months at the sites of teeth treated with orthodontic bands at or below the gingival margins or with brackets. 33 subjects with fixed appliance therapy were included in the study. They were all treated with the same type of prefabricated orthodontic bands and the adjacent 2nd premolars were banded with metal brackets. Microbial samples were collected from teeth treated with orthodontic bands at or below the gingival margins and supragingival position of teeth treated with brackets. The microbiota was assessed by the DNA-DNA checkboard hybridization method. The result of the study showed that higher incidence of bleeding on probing and probing pocket depth was observed in sites treated with orthodontic bands.

Tancan Uysal et al[90] [2010] has compared the effects of 3 light curing units on the microleakage scores of polyacid modified composite resin for band cementation at the cement-enamel and cement-band interface from the buccal and lingual sides at the occlusal and gingival margins. For the study he divided the freshly extracted mandibular third molar into 3 groups of 20 teeth each. Each tooth in the group was banded and cemented with PAMC and cured for 30 seconds with the QTH, for 20 seconds with the LED or for 6 seconds with the PAC. Microleakage was evaluated by a dye penetration method. The result of the study showed that the high intensity curing device PAC is associated with more microleakage than the LED and QTH at the cement-enamel interface.

Tancan Uysal et al[91] [2010] has compared the microleakage patterns of conventional GIC, RM-GIC and polyacid modified composite for band cementation at the cement-enamel and cement-band interface. Sixty caries free freshly extracted mandibular third molars were randomly divided into 3 groups of 20 teeth each. In all 3 groups Micro etched molar bands were cemented to enamel with one of the three cements: Ketac-cem, Multi-cure and transbond plus. Microleakage was evaluated by a dye penetration method. The study concludes by saying that conventional GIC is associated with more microleakage than the RM-GIC and Polyacid modified composite at both the cement-enamel and cement-band interfaces.

Hsiang Yu Cheng et al[31] (2011) compared the bond strengths of brackets bonded with Fuji Ortho LC (light cured RMGIC) and transbond (conventional light cured composite resin). 100 human premolars were randomly divided into 5 equal groups of 20 teeth each. The first 4 groups were treated with Fuji Ortho LC with or without 15% phosphoric acid etching treatment and with or without water contamination, preceding bracket bonding. The control group was treated with transbond composite resin under acid etching and without water contamination. The debonding strength was measured with an Instron machine. The result of the investigation showed that RMGIC is capable of achieving the same or greater bond strength as transbond, even if the enamel has not been acid etched or is not contaminated with water prior to bonding.

Marcel M.Farret et al[45] (2011) evaluated the effect of addition of chlorhexidine digluconate into 2 commercially available orthodontic band cements with respect to the mechanical and antibacterial properties. Ketac cem and Meron were used. These cements were mixed with their original composition as well as with 10 % and 18% CHD in the liquid to create a total of 6 groups The result of the investigation showed that addition of chlorhexidine digluconate into conventional GIC enhances the antibacterial properties for relatively longer periods of time without negatively alter the mechanical properties.

Rogerio et al[75] [2012] evaluated the cytotoxicity and the degree of monomer conversion of 4 different RMGIC's over different time periods - Fujiortho LC, Fujiorthoband, Ortho glass and Multicure glass ionomers were used. 3 control groups were included in the study- positive control, negative control, and cell control. The mouse L929 fibroblast cultivated in eagles minimum essential medium was used as a cell line for the study. 30 samples of each material were immersed in the culture for post cytotoxic evaluation and 15 samples were used to assess the degree of monomer conversion. The dye update technique was used to analyze the degree of cytotoxicity and the degree of monomer conversion was evaluated using infrared spectroscopy. The result of the study showed that there is decrease in cytotoxicity when the degree of monomer conversion increases. Among the 4 RMGIC's tested; only Fujiortho LC demonstrated biocompatibility over a 48 hour period.

Enas T. Enan et al[18] (2013) has done an investigation to determine and compare the microleakage patterns of conventional GIC and GIC with different concentrations of nano-hydroxyapatite under orthodontic bands. The sample consists of 80 caries free premolar which was scheduled for therapeutic extractions. They were randomly divided into 4 groups of 20 teeth each. Each group was banded with conventional GIC, 5%, 10% and 15% of nanohydroxyapatite. Each tooth was sectioned and microleakage was evaluated by a dye penetration method at the cement enamel and cement band interface by a strong stereo microscope. Their results showed that conventional GIC has the highest scores of microleakage than bands those cemented with different concentrations of nano HA modified GIC regardless of the percentage used.

Erdem Hatunoglu[19] et al (2014) has evaluated the effect of adding ethanolic extracts of propolis to the conventional GIC used in orthodontic band cementation in terms of antibacterial and mechanical properties. The cement was divided into 4 groups: one using the original composition and three with 10%, 25% and 50% EEP added to the GIC liquid and then manipulated. 80 healthy extracted premolars were collected and were also divided into 4 groups of 20 teeth each. Perfectly fitting bands were chosen for the premolars and each group was cemented with one of the 4 cement composition is available. With the use of Instron testing machine shear peel bond strength was assessed and broth dilution method was used to determine the antibacterial capacity. The result of the investigation showed that addition of 25% and 50% EEP increases the antibacterial properties of conventional GIC. No significant differences were noted between the groups in terms of SPBS.

Danna Mota Moreria et al[11] (2014) evaluated the effect of adding Ag nanoparticles in opal band cement and its significance in relation to its biocompatibility and mechanical properties. The sample size constitutes 27 groups of Ag nano particle loaded opal band cement and 2 controls were formulated with varying concentrations of additional benzoyl peroxide and 22(p-Tolylimino) diethanol. The cements were poured into a mold between 2 glass slides and light curing was done on each side with VALOLED curing light for 40 sec, using an atomic absorption spectroscopy. Ag ion release was measured invitro for 4 months. Rockwell hardness and near infrared FTIR were carried out to determine the curing efficiency. 3 point bending was done to evaluate the modulus and ultimate tensile strength. The concentrations of st.mutans and lactobacillus acidophilus were tested invitro for 28 days by counting the colony forming units. His results showed that Ag ion release was evident upto 4 months in the Ag nanoparticle incorporated opal band group which had increased the invitro microbial effect without compromising the mechanical properties.

MATERIALS AND METHODS

MATERIALS AND METHODS

Sampling

80 freshly extracted mandibular first permanent molars were randomly selected from patients intended for extraction in the Department of Oral and Maxillofacial surgery, KSR Institute of dental science and Research, Tiruchengode as the samples for the study.

Sample grouping

The samples were divided into 4 groups such that, there are twenty samples in each group. The samples were grouped based on the 4 types of cements used for band cementation.

Group A: Teeth banded with GC Fuji Ortho Band paste pak (20 numbers)

Group B: Teeth banded with GC FujiCEM (20 numbers)

Group C: Teeth banded with GC Fuji Ortho LC (20 numbers)

Group D: Teeth banded with GC Fuji PLUS (20 numbers)

Inclusion Criteria

1. Freshly extracted Mandibular first permanent molars
2. Teeth should be of normal crown morphology
3. Teeth should be free from dental caries in all surface except the occlusal

Exclusion Criteria

1. Tooth with any clinical signs of enamel decalcification
2. Molars with dental caries involving any surface except the occlusal
3. Fractured or grossly decayed tooth

4. Tooth with developmental malformations or abnormal crown morphology

Materials used for the study

1. Sandblasted stainless steel molar bands without attachments [Libral Traders, Pvt.Ltd].
2. Four different brands of RMGICs for band cementation. They are listed in table 1

Table 1. Characteristics of each orthodontic band cement

Brand name	Manufacturer	Available form	Curing mechanism
GC Fuji Ortho Band paste pak	GC Corporation, Tokyo, Japan	Paste-paste	Chemically cured
GC FujiCEM	GC Corporation, Tokyo, Japan	Paste-paste	Chemically cured
GC Fuji ortho LC	GC Corporation, Tokyo, Japan	Powder-Liquid	Light cured
GC Fuji plus	GC Corporation, Tokyo, Japan	Powder-Liquid	Chemically cured

3. 0.5% chloramines solution was used as disinfectant
4. 10% formalin as a storage media.

5. 0.5% basic fuchsine dye to measure the depth of dye penetration.
6. Hard tissue microtome for tooth sectioning and
7. Stereomicroscope for valuation of dye penetration

METHODS

Immediately after the extraction, the molars were disinfected with 0.5% chloramine solution. The teeth were then stored in 10% formalin solution and were refrigerated. At the time of banding the teeth were cleaned with pumice slurry, washed in distilled water and dried thoroughly in a steam of air. Sandblasted preformed stainless steel orthodontic bands [Libral traders Pvt. Ltd] with sizes ranges from 35 to 38^+ without attachments were used. Band of correct size was selected and was properly contoured to the tooth surface. All bands were approximately seated at the middle third part of the crown. Then bands were tightly fitted to reduce the possibility of enamel dissolution.

The bands were cemented on teeth in each group using one of the following materials according to the manufacturers' instructions: GC Fuji Ortho Band paste pak, GC Fuji ortho LC, GC FujiCEM and GC Fuji PLUS.

Group A is cemented with GC Fuji Ortho Band paste pak which is available in a paste-paste presentation. The two pastes were mixed until it gets a homogenous mix and then applied directly to the internal surfaces of each band. The cement was allowed to set for 30 seconds. The excess cement was removed with a dry cotton roll.

Group B is cemented with GC Fuji Ortho LC. Initially enamel pretreatment is done with GC Fujiortho conditioner. After that the powder and liquid components are mixed and then applied to the fitting surface of the bands followed by light curing for 10 seconds.

Group C is cemented with GC Fuji CEM and is available in a two paste form. Enamel pre-treatment is done as in Group B. The cement was mixed thoroughly with lapping strokes for 10 seconds. The internal surface of the band was coated with sufficient cement and seated immediately. Excess cement was removed with a dry cotton roll.

Group D is cemented with GC FujiPLUS. Enamel pre-treatment is done as in group B and C. After that the powder and liquid components are mixed and then applied to the fitting surface of the bands.

24 hours before measuring the microleakage, all specimens were placed in distilled water. Teeth were rinsed and air dried with a chip blower to produce oil and water free surface. Each group was coated with different colours of two consecutive layers of nail polish up to 1mm from the band margins. To minimize the dehydration of the specimen, teeth were replaced in formalin solution immediately after nail polish was dried. The teeth were then placed in 0.5% basic fuchsine dye for 24 hrs. After removing from the solution, tooth was thoroughly rinsed in tap water. Superficial dye was removed with a brush and air dried. The samples were then embedded completely inside the self cure acrylic. After that the teeth were sectioned bucco-lingually into two equal halves using a hard tissue microtome [Leica SP1600].

The specimens were evaluated under stereomicroscope [Erma-Japan] 20X magnification to determine the depth of dye penetration at the cement-band and cement-enamel interfaces. Each section was scored from both buccal and lingual margins of the bands at the cement-band and cement-enamel interfaces. Microleakage was measured directly with the help of CMEIAS image analysis software [CMEIAS Ver.1.27 operating in UTHSCSA image tool Ver.1.27].

LIST OF FIGURES

Figure 1. Collected Samples

33

Figure 2. Preformed bands

Fig 3. Disinfectant

Fig 4. Storage media

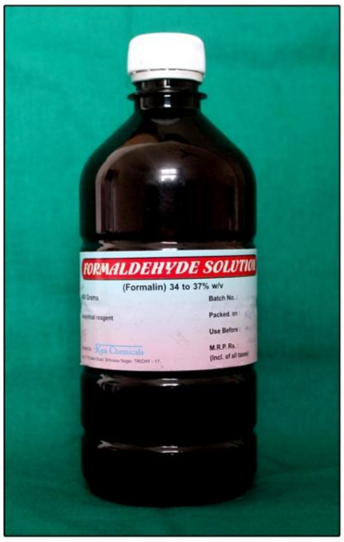
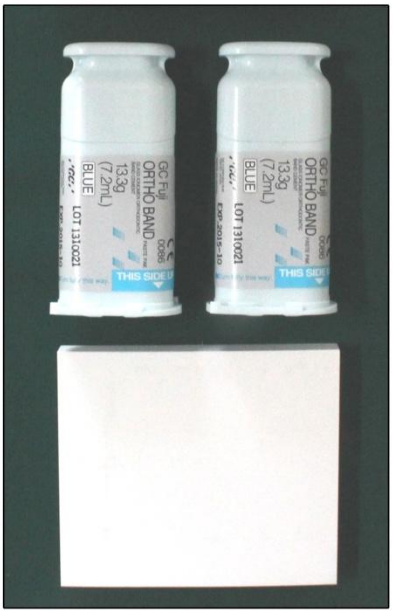


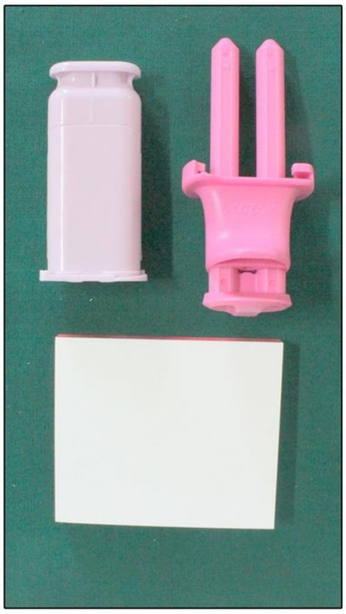
Fig 5. Dye

Figure 6. Cements used for the study

GC Fujji ORHOBAND



GC FujiCEM

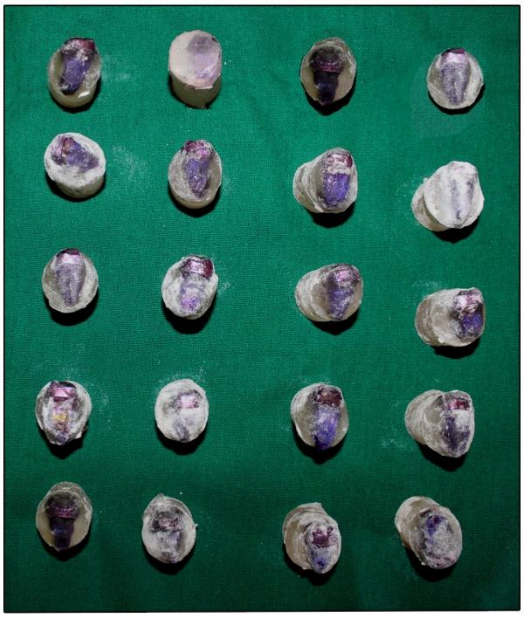


GC Fuji ORTHO LC

GC Fuji PLUS

Fig 9. Cemented Samples

Fig 10. Mounted Samples in Acrylic Resin



37

Figure 7. Hard Tissue Microtome

Figure 8. Stereo Microscope

36

STATISTICAL ANALYSIS

STATISTICAL ANALYSIS

The mean and standard deviation were estimated from the samples for each variable regarding depth of dye penetration in each group. Mean values were compared between groups and assessed by **Mann-Whitney U Test**. The formula used to assess the Mann-Whitney U Test is

$$\mathrm{U} = \mathrm{N1}\ \mathrm{N2}\,\frac{\mathrm{N1}(\mathrm{N1}\ +\ 1)}{2} -\ \mathrm{R1}$$

Where N1 = Sample size one

N2 = Sample size two

R1 = some of the ranks in sample 1

Mean values were compared between groups by **ANOVA** (Analysis of Variance) test and multiple comparisons were done by using Post Hoc Test.

The formula used for the ANOVA analysis

$$\text{ANOVA} = \frac{\mathrm{BMS}-\mathrm{WMS}}{\mathrm{BMS}+(\mathrm{n}-1)\mathrm{WMS}}$$

Where

BMS = Between subjects Mean Sum of squares

WMS = Within subjects mean sum of squares

n = Number of measurements

P value of less than 0.05 was considered to be statistically significant.

RESULTS

RESULTS

Calculated depth of dye penetration for each sample in each group

Table 2: Depth of dye penetration in group A [GC Fuji Ortho Band paste pak]

Samples	Buccal Surface (µm)		Lingual Surface (µm)	
	Cement-enamel	Cement-Band	Cement-enamel	Cement-Band
Sample 1	1.36	0.16	1.08	0.2
Sample 2	1.04	0.19	1.19	0.64
Sample 3	0.41	0	0.66	0.06
Sample 4	0.13	0.09	0.12	0.68
Sample 5	0.33	0.14	0.74	0.81
Sample 6	1.02	0	0	0
Sample 7	0.43	0.43	0.37	1.1
Sample 8	1	0.82	0.9	0.21
Sample 9	0.77	0.22	0.15	0
Sample 10	0	0.58	0.43	0.2
Sample 11	0.65	0.32	0.23	0.67
Sample 12	0.34	0.65	0.15	0.32
Sample 13	0.32	0.16	0.53	0.17
Sample 14	0.31	0.19	0.22	0.18
Sample 15	0.1	0.1	0.39	0.39
Sample 16	0.1	0.19	0	0.12
Sample 17	0.49	0.07	0.1	0.35
Sample 18	0.24	0.28	0.77	0.61
Sample 19	0.38	0.15	0.7	0.23
Sample 20	0.48	0.11	0.79	0.32

Table 3: Depth of dye penetration in group B [GC FujiCEM]

Samples	Buccal Surface (µm)		Lingual Surface (µm)	
	Cement-enamel	Cement-Band	Cement-enamel	Cement-Band
Sample 1	0.54	0.58	0.6	0.18
Sample 2	0.44	0.38	0.33	0.17
Sample 3	0.33	0.33	0.45	0.17
Sample 4	0.21	0.18	0.17	0.12
Sample 5	0	0	0.33	0.16
Sample 6	0.17	0.19	0.85	0.4
Sample7	0.15	0.3	0.46	0.19
Sample 8	0.08	0.2	0.15	0.3
Sample 9	0.76	0.06	0.33	0.59
Sample 10	0.34	0.24	0.54	0.23
Sample 11	0.25	0.11	0.51	0.27
Sample 12	0.24	0.22	0	0
Sample 13	0.29	0.23	0.18	0.18
Sample 14	0.16	0.16	0.28	0.11
Sample 15	0.21	0.16	0.27	0.25
Sample 16	0.3	0.12	0.11	0
Sample 17	0.17	0.06	0.34	0.7
Sample 18	0.46	0.35	0.68	0.44
Sample 19	0.4	0.27	0.54	0
Sample 20	0.34	0	0.32	0.43

Table 4: Depth of dye penetration in group C [GC Fuji Ortho LC]

Samples	Buccal Surface (μm)		Lingual Surface (μm)	
	Cement-enamel	Cement-Band	Cement-enamel	Cement-Band
Sample 1	0.75	0.2	0.8	0.11
Sample 2	0.44	0.28	0.24	0.24
Sample 3	0.84	0.84	0.2	0.18
Sample 4	0.87	0.35	0.05	0.05
Sample 5	0.3	0.25	0.38	0.41
Sample 6	0.25	0.51	0.3	0.32
Sample7	0.41	0.28	0	0
Sample 8	0.22	0.11	0.9	0.22
Sample 9	0.38	0.3	0	0
Sample 10	0.46	0.17	2.07	2.16
Sample 11	0.88	0.7	0.73	0.14
Sample 12	0.26	0.44	0.11	0.1
Sample 13	1.24	1.21	1.78	0.15
Sample 14	0.07	0.07	0.59	0.15
Sample 15	0.26	0.09	0.49	0.54
Sample 16	0.48	0.61	0.46	0.46
Sample 17	0.59	0.84	0.54	0.19
Sample 18	1.23	0.68	1.23	2
Sample 19	0.84	0.8	0.64	0.74
Sample 20	1.05	1.09	0.48	0.52

Table 5: Depth of dye penetration in group D [GC Fuji Plus]

Samples	Buccal (µm)		Lingual (µm)	
	Cement-enamel	Cement-Band	Cement-enamel	Cement-Band
Sample 1	1.11	0.3	0.27	0.17
Sample 2	1.42	1.24	1.09	1.14
Sample 3	0.45	0.53	0.99	0.41
Sample 4	0.13	0.11	0.71	0.13
Sample 5	0.81	0.93	0.2	0.18
Sample 6	0.38	0.07	0.18	0.15
Sample7	0.35	0.19	0.31	0.31
Sample 8	0.24	0.19	0.78	0.18
Sample 9	0.74	0.13	0.53	0.44
Sample 10	0.28	0.2	0.18	0.58
Sample 11	0.55	0.24	0.66	0.4
Sample 12	0.73	0.43	0.43	0.8
Sample 13	0.23	0.25	0.23	0.29
Sample 14	0.47	0.29	0.23	0.29
Sample 15	1.55	1.51	0.41	0.21
Sample 16	0.4	0.29	0.58	0.62
Sample 17	0.2	0.18	1.29	1.25
Sample 18	1.24	0.32	0.84	0.8
Sample 19	0.23	0.24	0.66	0.46
Sample 20	0.32	0.28	0.88	1.06

Descriptive statistical values and buccal and lingual microleakage comparisons between the cement-band and cement-enamel interfaces of individual groups by Mann-Whitney U Test are given from Table 6 to 10.

Table 6:- GC Fuji Ortho Band paste pak

Surfaces	N	Minimum	Maximum	Mean	Median	Std.Deviation	Sig.
Buccal CE	20	0.00	1.36	0.4950	0.3950	0.36792	0.935
Lingual CE	20	0.00	1.19	0.4760	0.4100	0.36104	
Buccal CB	20	0.00	0.82	0.2425	0.1750	0.21836	0.110
Lingual CB	20	0.00	1.1	0.363	0.275	0.2955	

The mean difference is significant at the 0.05 level

Table 6 depicts no statistically significant differences between the buccal and lingual microleakage scores of Fuji Ortho Band paste pak at both cement-enamel and cement-band interfaces.

Table 7:- GC FujiCEM

Surfaces	N	Mean	Median	Std.Deviation	Sig.
Buccal CE	20	0.2920	0.2700	0.17228	0.203
Lingual CE	20	0.372	0.330	0.2086	
Buccal CB	20	0.2070	0.1950	0.13963	0.665
Lingual CB	20	0.2445	0.1850	0.18780	

The mean difference is significant at the 0.05 level

Table 7 depicts no statistically significant differences between the buccal and lingual microleakage scores of GC FujiCEM at both cement-enamel and cement-band interfaces.

Table 8:- GC Fuji Ortho LC

Surfaces	N	Mean	Median	Std.Deviation	Signif.
Buccal CE	20	0.5910	0.4700	0.34865	0.626
Lingual CE	20	0.599	0.485	0.5544	
Buccal CB	20	0.491	0.395	0.3392	0.107
Lingual CB	20	0.4340	0.2050	0.59621	

The mean difference is significant at the 0.05 level

Table 8 depicts no statistically significant differences between the buccal and lingual microleakage scores of GC Fuji Ortho LC at both cement-enamel and cement-band interfaces.

Table 9:- GC Fuji Plus

Surfaces	N	Mean	Median	Std.Deviation	Sig.
Buccal CE	20	0.5915	0.4250	0.42807	0.968
Lingual CE	20	0.5725	0.5550	0.33172	
Buccal CB	20	0.396	0.265	0.3844	0.218
Lingual CB	20	0.4935	0.4050	0.34720	

The mean difference is significant at the 0.05 level

Table 9 depicts no statistically significant differences between the buccal and lingual microleakage scores of GC Fuji Plus at both cement-enamel and cement-band interfaces.

Comparisons of the buccal and lingual microleakage scores of individual samples showed no statistically significant differences at both cement-enamel and cement-band interfaces. Thus, the buccal and lingual microleakage scores for each sample were similar, and the microleakage values for each band cement and interface were achieved by calculating the mean of the buccal and lingual microleakage scores.

Descriptive statistics and the total microleakage scores between Cement-band and Cement-enamel interfaces of 4 Resin modified glass ionomer cements by ANOVA are given in Table 10.

Table 10:- ANOVA: ANALYSIS OF VARIANCE

Interface	Group	n	Median(µm)	Sig.
Cement-Enamel	GC FUJI ORTHO BAND PASTE PAK	20	0.9	**0.004***
	GC FUJI CEM	20	0.635	
	FUJI ORTHO LC	20	0.99	
	GC FUJIPLUS	20	1.09	
Cement-Band	GC FUJI ORTHO BAND PASTE PAK	20	0.46	**0.005***
	GC FUJI CEM	20	0.45	
	FUJI ORTHO LC	20	0.745	
	GC FUJIPLUS	20	0.845	

The mean difference is significant at the 0.05 level

Statistical comparisons showed significant differences exist among the band cements at the cement-band and cement-enamel interfaces.

Multiple comparisons of the total microleakage scores of 4 resin modified glass ionomer cements by Post Hoc Test are shown in table 11 and 12.

Table 11:- Total microleakage comparison [Post Hoc Test] at Cement-Enamel interface

Interfaces	Groups		Mean Difference	Std.Error	Sig.
Cement - Enamel	2	1	0.15350	0.08053	0.230
		3	0.26325*	0.08053	0.007*
		4	0.25000*	0.08053	0.012*
	1	3	0.10975	0.08053	0.525
		4	0.09650	0.08053	0.629
	3	4	0.01325	0.08053	0.998

The mean difference is significant at the 0.05 level

Table 12:- Total microleakage comparison [Post Hoc Test] at Cement-Band interface

Interfaces	Groups		Mean Difference	Std.Error	Sig.
Cement-Band	2	1	0.07700	0.07581	0.740
		3	0.26375*	0.07581	0.011
		4	0.21900*	0.07581	0.023
	1	3	0.15975	0.07581	0.155
		4	0.14200	0.07581	0.244
	3	4	0.01775	0.07581	0.995

The mean difference is significant at the 0.05 level

Multiple comparisons showed statistically significant differences between GC FujiCEM with GC Fuji Ortho LC and GC Fuji Plus. However no statistically significant differences between GC FujiCEM and GC Fuji Ortho Band paste pak. No statistically significant differences between GC Fuji Ortho LC with GC Fuji Plus and GC Fuji Ortho Band paste pak. No statistically significant differences were found between GC Fuji Ortho

Band paste pak and GC Fuji Plus. Among the four brands of resin modified glass ionomer cements evaluated, GC FujiCEM has the least microleakage scores between the cement-band (0.45µm) and cement-enamel (0.635µm) interfaces.

A bar chart showing the mean depth of dye penetration (µm) at Cement-Enamel [CE] and Cement-Band interfaces when compared between the groups are shown below.

Mean depth of dye penetration (µm) when compared between the groups

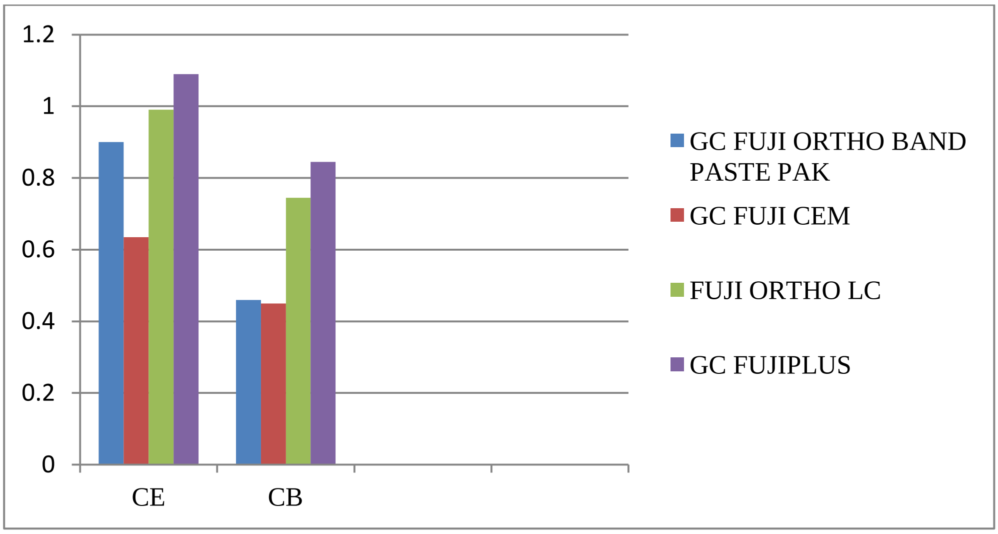
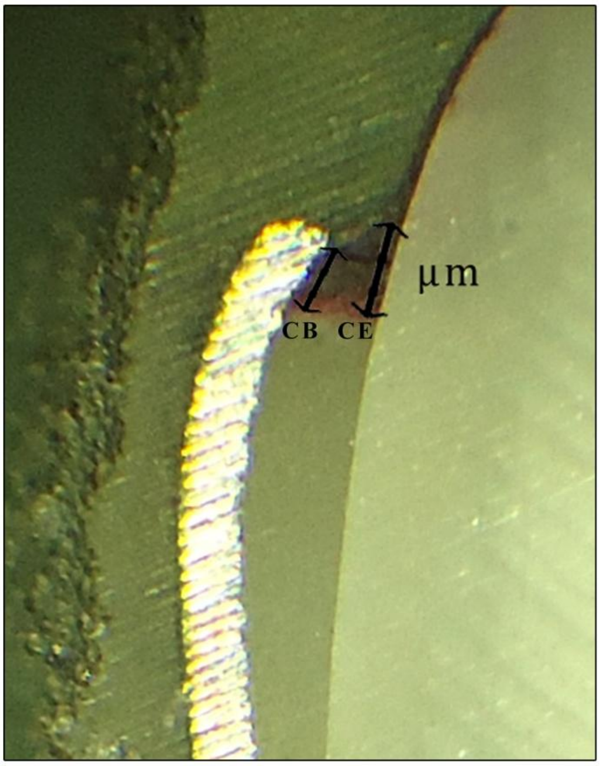


Figure 11. Sectioned sample

Fig 12. Depth of dye penetration



51

DISCUSSION

DISCUSSION

Even though the introduction of bonding has almost completely abolished the banding technique in orthodontics except molar band cementation, banding of anchor teeth remains admired due to the fact that bonded brackets are weaker than cemented bands as well as of the increased masticatory force levels in the posterior region.

The incidence of clinically noticeable areas of enamel demineralization, following the removal of orthodontic bands has become a serious but a potential problem to all orthodontists[61]. Although the areas around an orthodontic band are crucial, the areas under the band also need special attention. Prolonged retention of bacterial plaque on the enamel surface may leads to the development of white spot formation or enamel decalcification[24, 29]. This enamel demineralization underneath ill-fitting orthodontic bands may develop within 4 weeks-that is within one orthodontic appointment time[69]. Inadequate bonding strength of luting cements, breakdown of cement seal, solubility of cements in oral fluids and poor oral hygiene all contribute to the initiation of decalcification[26]. In accordance with Geiger et al [1988], who stated that the incidence and severity of white spot formation after fixed appliance therapy is related to treatment time; the lengthier the treatment, the more severe the complexity of white spot formation[24].

One of the most effective agents in caries prevention is the supplementation of fluoride regimes which inhibits the dental caries as well as encourages the remineralization of porous enamel and softened dentin. Henceforth administration of fluoride supplementation which doesn't require much patient co-operation is needed in orthodontic practice[67]. Fluoride releasing cements can be effective to reduce the demineralization under the bands. This can occur only if the cement adheres firmly to the tooth under the bands. Hence, ideal banding cement should not only have a fluoride releasing ability but should also have a good adherence to the enamel.

Zinc Phosphate and glass ionomer cements have been more comprehensively tested both in laboratory and clinical trials[62, 64]. Invitro investigations have shown that GIC have greater retentive capacity than other cements and this has been supported by a reduced failure rate in vivo[63].

So many studies have conducted so far to evaluate the cement which produces the least microleakage under the orthodontic bands. Jasmine Gorton et al has shown that Glass ionomer cements considerably decrease the enamel demineralization around the brackets when compared with composite resins[34]. Similar study by Kvam et al also shows less enamel demineralization under GIC than Zinc Phosphate cements[41]. According to Tancan Uysal, least microleakage is associated with RMGIC than with conventional GIC and modified composite[91]. However none of the studies have so far been evaluated the efficiency of different types of RMGIC both powder-liquid and paste forms in preventing microleakage under orthodontic bands. So my present study is intended to assess the microleakage patterns of 4 different brands of RMGICs at the cement-enamel and cement band interfaces.

To save the time and to ensure uniform banding, preformed stainless steel bands have been used in my study. When these bands have well fitted and well contoured, they have given better results than the custom made bands[83]. To make the tooth sectioning easier, bands with attachments are neglected and plain molar bands are preferred.

In the present study sandblasted microetched inner surface bands are used for molars. Previous studies have shown that sand blasting the inner surface of the bands significantly increased the band retention[30]. In sandblasting, a stream of aluminium oxide particles is sprayed under high pressure against the metal surfaces of the bands being cemented. For ensuring excellent bond strength, aluminium oxide with a particle size of 50µm has been used for the procedure[12]. Sandblasting process thinning this oxide layer and roughens the internal surface of the bands which provides more micro mechanical retention than unsandblasted bands[96]. Millett D T et al[56] (1995) and Mennemeyer et al[49] (1999) have reported a five to eight fold decrease in the mean failure rate of microetched bands in their study when compared with the untreated bands. Henceforth to ensure proper band retention, sandblasting was performed in all bands used in this study.

The extracted teeth were disinfected with 0.5% chloramines solution to prevent cross contamination. This is in accordance with the ISO standard 11405 which recommend the extracted teeth should be disinfected with 0.5% chloramine T (chlT) for up to 1 week and thereafter dipped in a storage media.

In a study by Jason Jonghyuk Lee et al [2007] 10% formalin solution is proved as the best storage media of bovine teeth that are to be used in dental bonding invitro studies. He noted sterilization and storage in other medias like saline and H_2O_2 has negatively affected the bond strength[42]. Studies by Kavita Sachdeva[37] at al [2012] also supporting the statement. She has found the best storage media for invitro dental bonding studies is the 10% formalin solution followed by saline solution, distilled water, 3% hydrogen peroxide, artificial saliva, and least by 70% ethanol. Hence 10% formalin solution is used in this study to store the freshly extracted molars.

Several techniques have been introduced to evaluate the microleakage around dental restorations. Dye penetration is the most common methodology in restorative dentistry[20] and also in orthodontics[2, 3, 90, 91] because it is a simple, reasonable, quantitative, and comparable method of evaluating the performance of the different techniques. This methodology involves exposing the samples to a dye solution and then viewing cross sections with a light microscope[71]. To evaluate the significance of leakage test, the size of oral bacteria must be taken into consideration. Because of the range of bacteria sizes, methylene blue and fuchsine dyes are the realistic agents to evaluate the sealing ability of the tested material[55]. Hence in my study, 0.5% basic fuchsine is used as dying agent.

In previous studies, the banded specimens are subjected to either thermocycling [1, 67] or a mechanical insult in ball mill[15, 56] to imitate the environmental conditions likely to be encountered clinically. Celiberti and Lussi et al[8] elucidated failure by polymerization shrinkage or various linear coefficients of thermal expansion from resin components and tooth hard substances. In restorative dentistry, thermal cycles are widely used to imitate temperature changes in the oral cavity, generating successive thermal stresses at the tooth-resin interface. Kubo et al[40] examined the microleakage of self-etching primers after undergoing thermal and flexural load cycling and concluded that the marginal integrity of self-etching primers did not go down even after thermal cycles (5000-10000 cycles) and flexural loads. Similarly, several researchers pointed out that more thermal cycles were not associated with increased microleakage of restorations[6]. Therefore, thermal cycling was not performed in this study.

In the literature, various failure sites for bands were reported.[38, 55, 85]Stephen Norris et al[85] evaluated that more bands cemented with GIC failed primarily at the cement-band interface, while most of the band failures occurs at the cement-enamel interfaces of ZnPO4 and Zn polycarboxylate cements. Similar results were also observed in a study by Kevin James Donly et al[38]. The conventional glass ionomer cements form a stronger ionic bond with enamel than the stainless steel bands because of the stronger acid base reaction, may be the possible reason of reduced microleakage formation at the cement-enamel interface[21]. Another study by D.T Millett[57] et al shown that band failures occur at the cement-enamel interfaces of Fuji Ortho LC [RMGIC] while band failures occur at both cement-enamel and cement-band interfaces of Multicure [RMGIC] and there is no significant differences in the bond strength values among the two RMGIC cements. Therefore from the microleakage point of view my evaluation was perfomed at both the cement-enamel and cement-band interfaces of RMGICs. Microleakage at the cement-band interface might be a reason for the band failure caused by adhesion degradation. However the cement-enamel interface is more critical because microleakage at this site is more vulnerable for the development of white spot lesions[3].

A study by Mizrahi et al[61] has shown that highest prevalence of enamel opacities were observed on the buccal and lingual surfaces of the banded molar teeth. Microleakage might not be the same on both sides of a banded tooth, although studies in restorative dentistry have alleged that assessment of 1 side represents the whole tooth. Because of the differences in the adhesive thickness between the band and enamel at the buccal and lingual surfaces, microleakage was evaluated from both the sides[63]. However according to the findings of my present study, no statistically significant differences were observed in the buccal and lingual microleakage scores of individual cements at the cement enamel and cement band interfaces. A similar study by Tancan Uysal et al[91] also found no statistically significant differences between the buccal and lingual marginal leakage scores of molar teeth banded with conventional GIC, RMGIC and a poly acid modified composite resin. Another study by Tancan Uysal[90] assessing the effect of high intensity curing lights under orthodontic bands also gives the similar result.

In the present study least microleakage was observed in bands cemented with GC FujiCEM which was supplied in a two paste form. FujiCEM consists of two pastes. Paste 1 is monomer-based, consisting of 70% fluoroalumino- silicate glass, 20% 2-hydroxyethyl methacrylate, and 10% dimethacrylate in weight. Paste 2 is water-based, consisting of 45% polyacrylic acid, 35% distilled water, and 20% silica. These distinctive compositions facilitate the development of paste-paste type RMGIC. In my study, statistically significant differences were observed between GC Fuji CEM with Fuji Ortho LC and GC Fuji plus which are in a powder liquid form. The least microleakage scores of FujiCEM are in agreement with the findings of Sumie Yoneda et al[87] who evaluated the effectiveness of 2 paste form FujiCEM over a period of 24 months. No failure rates were observed with Fuji Cem luted indirect restorations. Scanning electron microscopic examinations also showed absence of micro gap between the cement-enamel interfaces.

The reduced microleakage scores of FujiCEM in the present study may be because of the consistent mixing of two pastes which minimizes the disparity in mechanical properties of RMGICs caused by the incorporation of powder-liquid–type cements. This is supported by a similar study by Millett DT et al[59] who found that significant differences were observed in band failure rates (from 10 to 16%) by clinicians using GIC based on a powder liquid system.

Another study by D.T Millett[51] et al also emphasized the disadvantages of using a powder –liquid cement type for orthodontic banding which is in consistent with the present study. In this, the author compared the mean survival time and tensile strength of dual cured glass ionomer cement [Band Lok] in two paste form with a conventional GIC [Ketac Cem] in powder liquid form. He observed a highest tensile strength and a 4 times more survival rate of Band Lok than Ketac Cem.

Similar results were also observed in a study by D.T Millet et al[57]. In this study he has compared the two RMGICs [Fuji ortho LC in an encapsulated form; 3M Muticure in a separate powder-liquid form] with a modified composite (Ultra Band Lok – single paste form) and a conventional GIC (Ketac Cem in powder-liquid form). Among the four groups, Fuji Ortho LC which was in an encapsulated form has shown the highest mean survival rate of bands

Another study by Michael behr et al[51] is also supportive to the present study which has shown that statistically significant differences were found in the properties of 2 resin modified glass ionomer cements, Fuji Plus and Pro-TecCEM by varying the powder-liquid ratio. He stated that higher liquid content significantly reduced the flexural strength of both Fuji Plus and Protec Cem.

Dye penetration was correlated with the degree of enamel demineralization caused by acid incubation. More band failures and larger demineralization areas are likely with bands cemented with GC Fuji Plus, GC Fuji Ortho LC and GC Fuji Orthoband mix than with GC FujiCEM. Although all cements release fluoride into enamel, the results might be justified not only by the amount of fluoride release but also by the amount of fluoride release between cement and enamel. My findings suggest the use of FujiCEM as the most effective and reliable cement for orthodontic band cementation.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

This study has done to

1. To assess the microleakage patterns of four different band cements at the cement-enamel and cement-band interfaces.
2. To observe the buccal and lingual cement-enamel and cement-band interfaces using stereomicroscope.
3. To calculate and compare the depth of resin penetration among different band cements.

Eighty freshly extracted mandibular first permanent molars were divided into four groups of twenty teeth each. All teeth were banded and cemented with four different types of luting resin modified glass ionomer cements namely GC Fuji Ortho Band paste pak, GC FujiCEM, GC Fuji Ortho LC and GC Fuji Plus.

A dye penetration method was used to assess the depth of dye penetration. The teeth were sectioned bucco-lingually and the depth of dye penetration at the cement-enamel and cement-band interfaces was evaluated under a stereomicroscope.

The study concluded that

1. The buccal and lingual sides in all groups had similar microleakage scores for both cement-enamel and cement-band interfaces.
2. Bands cemented with GC FujiCEM had significantly lesser microleakage scores than GC Fuji Ortho LC and GC Fuji Plus but no statistically significant difference with GC Fuji Ortho Band paste pak.
3. Teeth banded with Fuji Ortho Band paste pak, Fuji Ortho LC, GC Fuji Plus had similar microleakage scores, with more leakage than the GC FujiCEM.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Aggarwal M, Foley TF, Rix D. A Comparison of shear- peel band strengths of 5 orthodontic cements. Angle Orthod 2000; 70: 308–316.;
2. Arhun N, Arman A, Cehreli SB, Arikan S, Karabulut E, Gulsahi K. Microleakage beneath ceramic and metal brackets bonded with a conventional and an antibacterial adhesive system. Angle Orthod 2006;76:1028-34
3. Arikan S, Arhun N, Arman A, Cehreli SB. Microleakage beneath ceramic and metal brackets photopolymerized with LED or conventional light curing units. Angle Orthod 2006;76:1035-40
4. Bapna M.S et al; Physical properties of ZnO base and resin cements; Angle Orthod 1980 January; 67-70
5. Basdra E.K, Dr.med.dent, Huber H, Komposch G ; Fluoride released from orthodontic bonding agents alters the enamel surface and inhibits enamel demineralization in vitro; Am J Orthod Dentofac Orthop 1996;109:466-72.
6. Bedran-de-Castro AK, Cardoso PE, Ambrosano GM, Pimenta LA. Thermal and mechanical load cycling on microleakage and shear bond strength to dentin. Oper Dent 2004;29:42-8
7. Cary Leizer, Martin Weinstein, Alan J. Borislow, and Leonard E. Braitman ; Efficacy of a filled-resin sealant in preventing decalcification during orthodontic treatment ; Am J Orthodontics and Dentofacial Orthopedics 2010;137:796-800.
8. Celiberti P, Lussi A. Use of a self-etching adhesive on previously etched intact enamel and its effect on sealant microleakage and tag formation. J Dent Res 2005;33:163-71
9. Christophe Azevedo ; Jean-Paul Forestier ; Bruno Tavernier ; Effect of time on the flexural strength of glass ionomer and composite orthodontic adhesives ; Angle Orthod 2004;75:114-118.

10. Daniel John Rejman, Theodore Eliades, Thomas G Bradley, George Eliades; Polymerization efficiency of glass ionomer and resin adhesives under molar bands; Angle Orthodontist 2008; Vol 78; No 3
11. Danna Mota Moreira, James Oei, Henry Ralph Rawls, Jeffrey Wagner, Lianrui Chu, Yiming Li, Wu Zhang, Kyumin Whang; A novel antimicrobial orthodontic band cement with in situ-generated silver nanoparticles; Angle Orthod 2014, Aug 6 [Online Publication]
12. David P Wood, Leonar W Johnson, The effect of sandblasting in the retention of orthodontic bands The Angle Orthodontist, 1996; 66(3);207-214
13. De Moura MS, de Melo Simplício AH, Cury JA. In-vivo effects of fluoridated antiplaque dentifrice and bonding mate-rial on enamel demineralization adjacent to orthodontic appliances. Am J Orthod Dentofacial Orthop 2006;130:357-63
14. Declan Millett; Nicola Mandall; Joy Hickman; Rye Mattick; Anne-Marie Glenny ; Adhesives for fixed orthodontic bands ; Angle Orthod 2009;79:193-199.
15. Durning P, Mccabe J F, Gordon P H, A laboratory investigation into cements used to retain orthodontic bands; British Journal of Orthodontics, 1994; 21: 27–32:
16. Ekaterini Paschos, Thomas Kleinschrodt, Tatiana Clementino-Luedemann, Karin C. Huth, Reinhard Hickel, Karl-Heinz Kunzelmann, and Ingrid Rudzki-Janson ; Effect of different bonding agents on prevention of enamel demineralization around orthodontic brackets ; Am J Orthod Dentofacial Orthop 2009;135:603-12.
17. Elizabeth Cho, Hugh Kopel, Shane N. Wliite ; Moisture susceptibility of resin-modified glass ionomer materials; Quintessence Int 1995:26:351-358
18. Enas T Enan, Shaza M Hammad; Microleakage under orthodontic bands cemented with nano-hydroxyapatite modified glass ionomer, An in vivo study; Angle Orthod 2013; 83:981-986

19. Erdem Hatunoglu; Firat Ozturk; Tugca Bilenler; Sertac Aksakalli; Neslihan Simsek ; Antibacterial and mechanical properties of proposils added to glass ionomer cement ; Angle Orthod 2014;84:368-373.
20. Foley Timothy, Manish Aggarwal and Sahza Hatibovic-Kofman; A comparison of in vitro enamel demineralization potential of 3 orthodontic cements; AJODO 2002;121:526-30
21. Fricker JP, A 12 month clinical comparison of resin modified light activated adhesives for the cementation of orthodontic molar bands. AJODO 1997; 112:239-43
22. Fricker JP, mclauchlan MD. Clinical studies on GIC. Part 2. A 2 year clinical study comparing GIC with $ZnPO_4$. Aust Orthod Journal, 1987; 10: 12-14
23. Gale MS, Darvell BW, Cheung GSP. Three dimensional reconstruction of microleakage pattern using a sequential grinding technique. J Dent 1994; 24:370-5.
24. Geiger, Gorelick, Gwinnett, Griswold. Effect of fluoride program on white spot formation; AJODO 1988, Jan 29-37;
25. Gillgrass T.J, Benington M, Millet D.T; Modified composite or conventional glass ionomer for band cementation? A comparative clinical trial; AJODO 2001;120:49-53
26. Gorelick A, Arnold M Geiger, John Gwinnett A. White spot formation after bonding and banding; AJODO 1982, July 62-67
27. Gorton J, Featherstone JD. In vivo inhibition of demineralization around orthodontic brackets. Am J Orthod Dentofacial Orthop 2003;123:10–14
28. Hassan Z.Movahhed, Bjorn Ogaard and Morten Syverud ; An in vitro comparison of the shear bond strength of a resin-reinforced glass ionomer cement and a composite adhesive for bonding orthodontic brackets ; European Journal of Orthodontics 2005; 27: 477- 483.

29. Hirschfield RE, Johnston LE, Decalcification under orthodontic bands, Angle Orthod 1974, July, 44(3), 218-221
30. Hodges SJ, Gilt Horpe MS, Hunt NP; The effect of micro etching on the retention of molar bands, a clinical trial, European Journal of orthod, 2001 Feb 23(1), 91-97
31. Hsiang Yu Cheng, Chien Hsiu Chen, Chuan Li Li, Hung Huey Tsai, Ta Hsiung Chou and Wei Nan Wang ; Bond strength of orthodontic light-cured resin-modified glass ionomer cement ; European Journal of Orthodontics 2011; 33;180-184.
32. Hyo-Beom Ahn, Sug-Joon Ahn, Shin-Jae Lee, Tae-Woo Kim, and Dong-Seok Nahm ; Analysis of surface roughness and surface free energy characteristics of various orthodontic materials ; Am J Orthod Dentofacial Orthop 2009;136:668-74.
33. Ira L.Shannon ; Comparison of Orthodontic cements containing sodium fluoride or stannous fluoride ; AJO-DO 1980 Dec; 640-45.
34. Jasmine Gorton, John D.B and Featherstone; Invivo inhibition of demineralization around orthodontic brackets, AJODO 2003; 123:10-4
35. John C. Cameron, Gerald T. Charbeneau, and Robert G. Craig; Some Properties of dental cements of specific importance in the cementation of orthodontic bands ; 1963 October; Vol 33, No 4: 233-235
36. Kan K.C, Messer L.B and Messer H.H; Variability in cytotoxicity and fluoride release of resin-modified glass-ionomer cements; J Dent Res, August 1997; 76(8): 1502-1507,
37. Kavita Sachdeva, Anil Singla, Vivek Mahajan; effect of storage media on shear bond strength of orthodontic brackets : An invitro study; Journal of Indian Orthodontic society, 2012, 46(4), 203-209
38. Kevin James Donly; Shayne Istre, Todd istve;, Kvam E et al; Invitro enamel remineralization at orthodontic band margins cemented with GIC, AJODO 1995; 107:461-4

39. Klara Kim, Kristin Heimisdottir, Urs Gebauer, and G.Rutger Persson ; Clinical and microbiological findings at sites treated with orthodontic fixed appliances in adolescents ; Am J Orthod Dentofacial Orthop 2010;137:223-8.
40. Kubo S, Yokota H, Sata Y, Hayashi Y. Microleakage of self-etching primers after thermal and flexural load cycling. Am J Dent 2001;14:163-9
41. Kvam E, Brosch J, Nissen Meyer. Comparison between a zinc phosphate and glass ionomer cement for cementation of orthodontic bands. Eur J Orthodontics 5:307-313
42. Lee JJ, Nettey-Marbell A, Cook A Jr, Pimenta LA, Leonard R, Ritter AV; Using extracted teeth for research: the effect of storage medium and sterilization on dentin bond strengths; J Am Dent Assoc. 2007 Dec;138(12):1599-603
43. Leonard Gorelick, Arnold M. Geiger, and A. John Gwinnett ; Incidence of white spot formation after bonding and banding ; AJO-DO 1982 Feb(93-98).
44. Linda Wang, Daniela, Regina Guenka, Marilia Afonso, Maria Teresa; Short-term insitu/ex vivo study of the anticariogenic potential of a resin-modified glass ionomer cement associated with adhesive systems; Quintessence Int 2010; 41:e192-199
45. Marcel M. Farret, Eduardo Martinelli de Lima, Eduardo G. Mota, Hugo M. S. Oshima, Valdir Barth, Silvia D. De Oliveira ; Can we add chlorhexidine into glass ionomer cements for band cementation? Angle Orthod 2011;81:496-502.
46. Maria Teresa Atta, Short-term in situ/ex vivo study of the Anticariogenic potential of a resin-modified glassionomer cement associated with adhesive systems; Quintessence Int 2010;41:e192–e199
47. Mark L Underwood; Clinical evaluation of a fluoride-exchanging resin as an orthodontic adhesive; AJODO 1989;96:93-9
48. Meijer R, Smith DC. A comparison between $ZnPO_4$ and GIC in orthodontics, AJODO 1988; 93:273-279

49. Mennemeyer V A, Neuman P, Powers J M; Bonding of hybrid ionomers and resin cements to modified orthodontic band materials. American Journal of Orthodontics and Dentofacial Orthopedics 1999; 115: 143–147
50. Mervyn Y.H Chin, Andrew Sandham, Elena N.Rumachik, Jan L.Ruben, and Marie-Charlotte D.N.J.M. Huysmans ; Fluoride release and cariostatic potential of orthodontic adhesives with and without daily fluoride rinsing ; Am J Orthod Dentofacial Orthop 2009;136:547-53.
51. Michael Behr, Martin Rosentritt, Hans Loher & Gerhard Handel; Effect of variations from the recommended powder/liquid ratio on some properties of resin modified cements. Acta Odontologica Scandinavica, 2006; 64: 214-220
52. Millet D.T, Nunn J.H, Welbury R.R, Gordan P.H ; Decalcification in relation to brackets bonded with glass ionomer cement or a resin adhesive ; Angle Orthod 1999;69(1):65-70.
53. Millet DT, Cummings A, Letters S, Roger E, Love J. Resinmodified glass ionomer, modified composite or conventional glass ionomer for band cementation? – an invitro evaluation. Eur Journal Orthod 2003; 25:609-614
54. Millet DT, Duff S, Morrison L, Cummings A, Gilmour WH. Invitro comparison of orthodontic band cements, AJODO 2003; 123:15-20
55. Millet DT, Kamahli K, mccoll J. Comparative laboratory investigation of dual cured vs conventional glass ionomer cements for band cementation, Angle Orthod. 1998;68:345-350
56. Millett D T, Mccabe J F, Bennett T G, Carter N E, Gordon P H. The effect of sandblasting on the retention of first molar orthodontic bands cemented with glass ionomer cement. British Journal of Orthodontics; 1995, 22,161–169

57. Millett D.T, Cummings A, Letters S, Roger E and Love J ; Resin modified GIC, modified composite or conventional glass ionomer for band cementation, an invitro evaluation EJO 2003 Vol 125, no 6, 609-614;
58. Millett D.T, Hallgren A, McCluskey; A clinical retrospective evaluation of 2 orthodontic band cements; Angle Orthod 2001; 71:470-476
59. Millett DT, Gordon PH. The performance of first molar orthodontic bands cemented with GIC – A retrospective analysis. Br J Orthod, 1992; 19: 215-220
60. Mills RW, Jandt KD, Ashworth SH. Dental composite depth of cure with halogen and blue light emitting diode technology. Br Dent J 1999;186:388-91
61. Mizrahi E ; Surface distribution of enamel opacities following orthodontic treatment, AJODO 1983 Oct; 84:323-331
62. Mizrahi E, Further studies in retention of orthodontic bands, Angle Orthod 1977 July, 47(3), 232-238
63. Mizrahi E, Glass ionomer cements in orthodontics – An update, AJODO 1988, June 93(6), 505-507
64. Mizrahi E, Retention of the conventional orthodontic band, Br J Orthod, 1977, 4(3), 133-137
65. Mizrahi E, Smith DC. The band strength of a Zinc polycarboxylate cement. British Dental Journal, 1969, 4:410-414
66. Mizrahi E; The recementation of orthodontic bands using different cements; Angle Orthodontist 1979 October; Vol 49, No 4
67. Norris DS, Mclnnes-Ledoux p, Schwaninger B, Weinberg R. Retention of orthodontic bands with new fluoride releasing cements, AJODO 1986, 89: 206-11

68. O'Reilly M.M and Featherstone J.D.B ; Demineralization and remineralization around orthodontic appliances : An in vivo study ; Am J Orthod Dentofac Orthop 1987;92:33-40.

69. Ogaard B, Rolla G, Arends J. Orthodontic appliances and enamel demineralization. Part 1. Lesion development. Am J Orthod Dentofacial Orthop 1988;94:68-73.

70. Oliveira.S.R, Rosenbach.G, Brunhard I.H.V.P, Almeida.A and O.Chevitarese ; A Clinical study of glass ionomer cement ; European Journal of Orthodontics 2004; 26; 185-189.

71. Ozturk NA, Usumez A, Ozturk B, Usumez S. Influence of different light sources on microleakage of class V composite resin restorations. J Oral Rehabil 2004;31:500-4

72. Rezk-hega F, Ogaard B, Arends J; An invitro study on the merits of two glass ionomers for the cementation of orthodontic bands; AJODO 1999; 162-167

73. Rich JM, Leinfelder KF, Hershey HG. An invitro study of cement retention as related to orthodontics. Angle Orthod 1975; 45: 219-225

74. Rishi Seth, Hardev Singh, Priya Seth,. Suruchi Seth; Resin modified glass ionomer cement, an orthodontic perspective; Indian Journal Of Comprehensive Dental Care; July-Dec 2011 , Vol 1 , Issue 1

75. Rogerio L. Dos Santos, Matheus Melo Pithon, Fernanda O. Martins, Maria Tresa V. Romanos and Antonio Carlos O. Ruellas ; Evaluation of cytotoxicity and degree of conversion of glass ionomer cements reinforced with resin ; European Journal of Orthodontics; 2012; 34362-366.

76. Sabri llhan Ramoglu; Tancan Uysal; Mustafa Ulker; Huseyin Ertas ; Microleakage under ceramic and metallic brackets bonded with resin-modified glass ionomer ; Angle Orthod 2009;79:138-143.

77. Sadowsky P.L, Dent M, Retief D.H; A Comparative study of some dental cements used in orthodontics ;1976 Vol 46, No 2:171-181
78. Sadowsky P.L, Dent.M, Retief and Bradley E.L. Enamel fluoride uptake from orthodontic cements and it's effect on demineralization; AJODO 1981 May, 523-524
79. Saito K, Hayakawa T, Kawabata, Meguro D, Kasai K. In vitro antibacterial and cytotoxicity assessments of an orthodontic bonding agent containing benzalkonium chloride. Angle Orthod 2009 ; 79: 331-337
80. Selim Arici, Cem Mustafa Caniklioglu, Nursel Arici, Mete Ozer, Benan oguz, ; Adhesive thickness effects on the bond strength of a light-cured resin-modified glass ionomer cement ; Angle Orthod 2005;75:254-259.
81. Sevil Akkaya, Oktay Uner, Alev Alacam, and Tuncer Degim ; Enamel fluoride levels after orthodontic band cementation with glass ionomer cement ; European journal of orthodontics, 1996;18:81-87.
82. Siddik Malkoc; Bayram Corekci; Hayriye Esra botsali; Muhammet Yalcin; Abdulkadir Sengun ; Cytotoxic effects o resin-modified orthodontic band adhesives ; Angle Orthod 2010;80:890-895.
83. Sidney Brandt, Editors corner, J Clin Orthod, 1968, Dec 2(12); 491. Some properties of resin-modified cements; Acta Odontologica Scandinavica, 2006; 64: 214-220
84. Steffen Mickenautsch and Veerasamy Yengopal; Demineralization of hard tooth tissue adjacent to Resin-modified glass-ionomers and composite resins: A quantitative systematic review; Journal of Oral Science, 2010 Vol. 52, No. 3 : 347-357,
85. Stephen Norris D ; Pamela Mclnnes-Ledoux ; Bernhard Schwaninger, Dr.Med.Dent and Roger Weinberg; Retention of orthodontic bands with new fluoride releasing cements, AJODO;1986March: 206-211

86. Sug-Joon Ahn, Bum-Soon Lim, and Shin-Jae Lee ; Surface characteristics of orthodontic adhesives and effects on streptococcal adhesion ; Am J Orthod Dentofacial Orthop 2010;137:489-95.
87. Sumie Yoneda, Jumpei Sugizaki, Toshimoto Yamada. Short-term clinical evaluation of a resin-modified glass-ionomer luting cement ; Quintessence Int 2005;36:49–53
88. Sumitha Upadhyay, Arathi Rao, Ramya Shenoy; Comparison of the amount of fluoride release from nanofilled resin modified glass ionomer cements; Conventional and resin modified glass ionomer cements; www.jdt.tums.ac.ir March 2013; Vol. 10, No. 2
89. Takami Itoh, Noriatsu Matsuo, Tadao Fukushima, Yusuke Inoue, Yasuhisa Oniki, Mitsunari Matsumoto, Angelo A. Caputo; Effect of contamination and etching on enamel bond strength of new light-cured glass ionomer cements ; Angle Orthod 1999;69(5):450-456.
90. Tancan Uysal, Sabri Ilhan Ramoglu, Mustafa Ulker, and Huseyin Ertasd; Effects of high-intensity curing lights on microleakage under orthodontic bands; Am J Orthod Dentofacial Orthop 2010;138:201-7
91. Tancan Uysal, Sabri Ilhan Ramoglu, Huseyin Ertas, and Mustafa Ulker; Microleakage of orthodontic band cement at the cement-enamel and cement-band interfaces; Am J Orthod Dentofacial Orthop 2010;137:534-9.
92. Tracy Herion, Jack L Ferracane; Three cements used for orthodontic banding of porcelain molars; Angle Orthodontist 2007; Vol 77, No 1, 94-99
93. Walter B. Shepherd, Karl F. Leinfelder, Garland Hershey H; The effect of mixing method, Slab temperature, and Humidity on the properties of zinc phosphate and zinc silicophosphate cement ; 1978, Vol 48, No.3 : 219-226

94. Warren J. Cohen, William A. Wiltshire, MDent, Colin Dawes, and Chris L. B. Lavelle, Long-term in vitro fluoride release and rerelease from orthodontic bonding materials containing fluoride; Am J Orthod Dentofacial Orthop 2003;124:571-6
95. Williams P.H, Sherriff M and Ireland J; An investigation into the use of two polyacid-modified composite resins (Compomers) and a resin-modified glass poly(alkenoate) cement used to retain orthodontic bands; European Journal of Orthodontics 2005; 27:245-251
96. Wood DP, Palenczny GJ, Johnson LN. The effect of sandblasting on the retention of orthodontic bands, Angle orthod 1996, May, 66(3), 207-14.

INSTITUTIONAL ETHICAL COMMITTEE

KSR INSTITUTE OF DENTAL SCIENCE & RESEARCH

KSR Kalvi Nagar, Tiruchengode-637 215, Tamilnadu.
Phone : 04288-274981, Fax : 04288-274761,
email : ksrdentalcollege@yahoo.com

Ref.: 030 /KSRIDSR/EC/2013 **Date : 01.02.2013**

To

Dr.Akhil Gopi,
Postgraduate Student,
Dept. of Orthodontics,
KSR Institute of Dental Science & Research,

*****

Your dissertational study titled "MICROLEAKAGE OF RESIN MODIFIED GLASS IONOMER CEMENTS AT THE CEMENT – ENAMEL AND CEMENT - BAND INTERFACES" presented before the ethical committee on 29th Jan.2013 has been discussed by the committee members and has been approved.

You are requested to adhere to the ICMR guidelines on Biomedical Research and follow good clinical practice. You are requested to inform the progress of work from time to time and submit a final report on the completion of study..

Signature of Secretary
(Dr.G.S.Kumar)