A COMPARATIVE EVALUATION OF THREE HEMOSTATIC MEDICAMENTS ON THE FLUID ABSORBENCY OF DIFFERENT TYPES OF RETRACTION CORDS- AN IN VITRO STUDY

By
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Under the guidance of
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2020-2023

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"A comparative evaluation of three hemostatic medicaments on the fluid absorbency of different types of retraction cords- An in vitro study"** is a bonafide and genuine research work carried out by me under the guidance of **Professor and HOD Dr.George Francis,** Department of Prosthodontics and Crown & Bridge, St Gregorios Dental College, Chelad, Kothamangalam.

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DR JINSON JAMES PUTHUPARAMBIL

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ABSTRACT

Background and Objectives:

Accurate replication of finish lines during tooth preparation and impression making is crucial for longevity of any prosthesis. In order to obtain an adequate impression along with the finish line of a prepared tooth located in or below the gingival margin, it is necessary to perform drying of the gingival sulcus and retraction of gingival tissue using retraction cord impregnated with adequate retraction agents. This will ensure good gingival marginal seal thereby maintaining healthy periodontium around the prosthesis.

The absorption of medicaments on to the retraction cords and its subsequent release plays a vital role in achieving sufficient retraction. This study will evaluate the incorporation of different medicaments into the retraction cords to obtain gingival retraction during impression procedures

The objective of this study was to compare and evaluate the fluid absorbency of different types of retraction cords after immersing in three different gingival retracting medicaments.

Methods:

- Three different types of retraction cords–Braided (LDcords), Knitted (Smartcord) and Twisted (Gingi pak Z twist) of size 00 will be taken of length 5cm.
- Each type has 1control group to weigh the dry weight and 3 test specimens to weigh the wet weight.
- 15.5% ferric sulphate will be obtained by dissolving 15.5 gm of Ferric Sulphate in distilled water in glass beaker.
- 100% alum will be obtained by dissolving 100 gm of aluminum sulphate (Alum) in distilled water in a glass beaker. To accelerate dissolution of aluminum sulphate, the solution was heated upto 60℃ using heating mantle. A clear solution of 100% alum will obtained after heating.

- 4% epinephrine will be prepared by mixing 4 vials of 4mg epinephrine to form 4% racemic epinephrine
- Dry weight will be the weight of dry retraction cord pre immersion and wet weight will be the weight of retraction cord post immersing into human plasma for 20 mins. All weights will be recorded using electronic analytical balance. The difference between post and pre weight of cords will give the amount of fluid absorbency without medicaments.
- To evaluate the effect of medicaments on fluid absorption the difference in weights of medicated cords, post and pre insertion in human plasma will be calculated. All weights will be recorded using electronic analytical balance
- Each group will have 10 samples which gives total of 40 samples for each type. 3 types of retraction cords are used, so total of 120 samples (3x40=120 samples) will be taken.

Results and Conclusion

Within the limitations of the study, the following conclusions are drawn:

- There is a significant association between the type of retraction cords and medicaments in absorbing fluids.
- Medications for retraction showed clinically acceptable absorbency onto retraction cords which may enhance retraction
- Knitted retraction cord showed maximum fluid absorption and least was found for braided retraction cord without medicaments.
- After immersing in of 15.5% FeSO4 also, knitted retraction cord showed maximum absorption of fluids and least was found for braided retraction cord.
- With medicament 4% Epinephrine, knitted retraction cord showed maximum absorption of fluids and least was found for braided retraction cord.
- For medicament 100% Alum, both knitted retraction cord and twisted retraction cord showed similar amount of fluid absorbency.
- 15.5% FeSO4 medicament showed maximum absorption into cords, irrespective of the type of retraction cords followed by 100% Alum and 4% epinephrine.

There is a significant association between retraction cord and medicaments during chemo-mechanical method of gingival retraction.

According to this study it is concluded that the use of 15.5 % $FeSO_4$ with knitted retraction cord is a better method for gingival retraction.

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INTRODUCTION

INTRODUCTION

Accurate impression making for fixed dental prosthesis involves precise recording of the finish lines, ensuring perfect adaptation of the gingival marginal around the prosthesis thereby enhancing the integrity of the margins[1]. In addition to creating a clean dry field free of fluid and debris, the marginal gingival tissue must be retracted to expose the finish line for accurate replication of prepared tooth and finish lines. Gingival tissue can be displaced either laterally or vertically. Lateral retraction displaces the tissue so that an adequate bulk of impression material can be interfaced with the prepared tooth.[3,4] Vertical retraction exposes the uncut portion of the tooth apical to the finish line.

To ensure accurate replication with vinyl polysiloxane (VPS) impression materials, at least a 0.2-mm thickness of impression material is needed in the sulcular area. The goal of gingival retraction is to a traumatically provide access for impression material to flow beyond the preparation margins, while allowing sufficient thickness to prevent tearing and distortion upon removal. Impressions with less sulcular width have higher incidences of voids and imperfections, which may result in decreased marginal accuracy and integrity[5,7]

The marginal integrity is the most important criteria of the principles of tooth preparation. The placement of margin or finish line in relation to the gingival margin has direct effects on the health of the periodontal tissue of the prepared teeth[7.] For instances, in demand for esthetics, the dentist may be forced to place them subgingivally[28]. According to Benson et al (1985) and Donovan et al (1985), gingival retraction measures fall into one of four major categories: (1) simple mechanical methods, (2) chemo-mechanical methods, (3) rotary gingival curettage, and (4) electro-surgical methods. Among these four categories, the chemo-mechanical method of gingival retraction is the most widely used[11,12] However, the action of the medicament is different according to their mechanism of action. The medicaments used along with retraction cords can be broadly classified into vasoconstrictors astringents. Vasoconstrictors acts through ∝1 receptor thereby reducing the blood flow and astringents acts by protein precipitation. Commonly used Vasoconstrictors is epinephrine and Astringents includes aluminium potassium sulfate, aluminium chloride, ferric sulfate, etc.[52]

The chemico-mechanical method of using a retraction cord impregnated or soaking into various medicaments is the most frequently used method of gingival retraction. This involves immersing the retraction cords into some medications and mechanically placing it into gingivalsulcus. The retraction cords mechanically displace the gingival tissue as well as absorbs fluids from the gingival sulcus, while the medications control hemorrhage and shrink the gingival tissues.[28] Hemostatic agents are important for successful gingival retraction and in achieving hemostasis.[13,20,22,5] The mechanical aspect of chemico-mechanical method involves placement of a string into the gingival sulcus to displace the tissues physically. The chemical aspect of the method involves treatment of the string with one or more of a number of compounds that will induce temporary shrinkage of the tissues and should also control the hemorrhage and fluid seepage that often accompany sub gingival margin preparation.[36,39]

Substances most often used for chemical aspect are: racemic epinephrine, 0.1% solution or 8% impregnated cord; alum; Aluminium chloride, 5% or 25%; ferric sulfate, 13.3%; or zinc chloride, 8% or 40%. Aluminium chloride and Zinc chloride are caustic to gingival tissues and thus are not recommended.[23]

Ferric sulfate acts as a clotting agent, and often, does not cause considerable shrinkage of the tissues. It does not traumatize the tissue noticeably, and healing is more rapid. Ferric sulfate coagulates blood so quickly while placing against the bleeding tissue. The resulting tissue displacement is maintained for around 30 minutes.

Alum acts mainly as an astringent and is found to be safe and highly effective as a tissue-displacing agent. Alum (Potassium aluminum sulfate) in a 100% concentration has been shown to be only slightly less effective in shrinking the gingival tissues. Negligible tissue injury was noted in a 10-minute application, and was completely healed in 10 days. Fischer stated that alum is kind to the tissue.[2]

Epinephrine, either supplied as a separate solution or incorporated into the string, has been widely used. Epinephrine used to saturate the retraction cord creates local vasoconstriction of the gingival tissues and seems to have fairly minimal systemic effects if used in an intact sulcus. Epinephrine acts primarily on the walls of small arterioles and to a lesser degree on the walls of capillaries, venules, and large arterioles.[11,13,23,29]. It should be used cautiously in patients with cardiac problems.

Mechanical manners are achieved effectively by the placement of a cord (generally impregnated with a medicament), but it may traumatize epithelial attachment. Also, there is a chance of subsequent bleeding after removing the retraction cord, which occurs in 50% of the cases.[61]

Hence, use of minimal force of 0.2N is recommended when placing retraction cord, as excessive force may lead to crevicular bleeding, gingival inflammation and shrinkage of the marginal tissues.[12] the packing of cords was normally done using Fisher's cord packer. However, use of a single retraction cord often provides inadequate gingival retraction; in these cases, larger cords are often used in an attempt to provide adequate gingival displacement.[60]

Subgingival margin placement is often unavoidable. Literature suggests that even slight encroachment on the subgingival tissue can lead to deleterious effects on the periodontium. Furthermore, deep margin placement risks invading the soft tissue attachment of the gingiva to the tooth, often leading to a more pronounced plaque-induced inflammatory response[64]

AIMS AND OBJECTIVES

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AIM:

To compare and evaluate the amount of fluid absorbency of different types of retraction cords after immersing in three hemostatic agents

OBJECTIVES:

1. To evaluate the amount of fluid absorption into three different types of retraction cords – Braided (LC cords), Knitted (Smart cord) and Twisted (Gingi Pak Z twisted) of size 00.
2. To evaluate the effect of medicaments incorporation (15.5% Ferric Sulfate, 100% Alum and 4% Racemic epinephrine) on the amount of fluid absorption into retraction cords.
3. To evaluate the medicament that best diffused into retraction cords.
4. To compare the amount of fluid absorption on three different types of retraction cords – Braided (LC cords), Knitted (Smart cord) and Twisted (Gingi Pak Z twisted) of size 00
5. To compare the effect of medicaments (15.5% Ferric Sulfate ,100% Alum and 4% Racemic epinephrine) on the amount of fluid absorbency of retraction cords.

HYPOTHESIS

Null Hypothesis [H_0]

There is no significant difference between the amount fluid absorption of 3 different types of retraction cords – Braided, Knitted and Twisted of size 00 and no difference in absorption of fluids after incorporation of medicaments (15.5% Ferric Sulfate and 100% Alum and 4% Racemic Epinephrine)

Research Hypothesis [H_1]

There is difference between the amount of fluid absorption on 3 different types of retraction cords – Braided, Knitted and Twisted of size 00 and shows increase in absorption of fluids with medicaments (15.5% Ferric Sulfate and 100% Alum and 4% Racemic Epinephrine)

BACKGROUND AND REVIEW OF LITERATURE

Harrison JD (1961)[1] did experiments on dogs to evaluate the effect of retraction cord in humans on the basis of these findings, he concluded: 1. Mechanical and chemical retraction materials used with elastic impression materials can injure the gingival sulcus epithelium. The injuries, those caused by the zinc chloride concentrations, healed within 7- 10days periods and may be considered temporary. 2. Tin incorporated string is a safe retraction material for periods from 5-30 minutes and is recommended when bleeding or seepage is not a problem. String saturated with 1:1000 epinephrine is a safe retraction material for periods from 5 to 30 minutes and is recommended when bleeding is a problem. 3. String saturated with 8 % epinephrine or 100 % alum solution may be used when heavier bleeding must be controlled. They are recommended for 5 and 10, minutes retraction periods. 4. String saturated with 8 or 40 % zinc chloride is not recommended as a retraction material.

Woyschesein F (1964)[2] Conducted a study to evaluate drugs used for gingival retraction and he concluded that most of the drugs used for gingival retraction are effective in shrinking the gingival tissues. He also stated Zinc chloride is caustic and high concentrations will cauterize the tissue. He claimed Negatan is very acid and decalcifies the teeth. Felix also stated that when high concentrations of epinephrine are applied locally to lacerated tissue, epinephrine can be absorbed and cause an increase in the heart rate and blood pressure, which could be dangerous for patients with cardiovascular disease, hyper thyrodism, and to some hypersensitive individuals. He also concluded that the application of high concentrations of epinephrine to large areas of lacerated or abraded gingival tissues should be avoided.

Leer JH and Gillmore HW (1967)[3] stated problems and suggestions associated with different phases of tissue management: 1. Mechanical laceration of the tissue because of improper cavity preparation is minimized when the rubber dam is used. The bigger and heavier types of rubber dam cause compression of the tissue and improvement in vision. A simple technique should be used to apply the rubber dam, and the resultant environment should be used, whenever possible, in operative procedures. 2. Inadequate control of hemorrhage or seepage near to the cavity preparation is reduced by carefully placing the instrument and by drying the tissue and crevice with air and absorbent cotton before the procedure. 3. Improper cleaning of the cavity preparation is avoided when 3 % hydrogen peroxide is used, preferably using the spray attachment, to penetrate the crevice before placement of the selected strings. The material is removed when rinsing with water, and the

teeth are dried to ensure a clean cavity preparation. 4. Improper control of the string is minimized by a dry field and by a string and drug contact of 5 to 20 minutes. The string occasionally slips from the crevices because of excessive moisture or applications.

Ramadan FA (1970)[4] he conducted a study to estimate the amount of epinephrine absorbed from commercial retraction cords during actual gingival retraction in patients in the dental clinic. This study concluded that patients were exposed to substantial levels of l-epinephrine during a typical gingival retraction with the use of cotton cord impregnated with epinephrine. Although the physiologic relevance of this exposure was not monitored in this study, the data supported findings from other investigations demonstrating cardiovascular changes in animals and humans subjected to gingival retraction with cords containing epinephrine. Although it is highly unlikely that the rapid elevation in plasma I-epinephrine concentrations is the result of extensive vasoconstriction, it would seem prudent to avoid using epinephrine-impregnated cords in patients with cardiovascular problems.

Nemetz H (1974)[5] he described a method of tooth preparation and gingival-tissue management for Ceramometal crowns. He stated that elastic impression materials by themselves cannot initiate displacement of the gingival tissue, and the impression will not reproduce the subgingival area unless a visible space exists between the gingiva and the tooth. Gingival displacement should retract the tissue laterally from the tooth, not apically. Mis-applied, it may lead to trauma of the gingival tissues followed by recession. A wet aluminium sulfate cord is placed onto the sulcus and allowed to remain there for ten minutes. Placing the cord when wet allows better handling, and there is less chance of tearing the tissue. There are no contraindications to the use of aluminium sulfate so far. Its only demerit is its bitter taste. The cord is removed at the end of ten minutes, and the area is washed with anample amount of water. Impressions can be made with any reversible hydrocolloids, mercaptans, and silicones product which gives excellent results.

Pelzner RB *et al* (1978)[6] conducted a study to evaluate the human blood pressure and pulse rate response to racemic epinephrine retraction cord and they concluded that the pulse rate of patients after application of racemic epinephrine-impregnated retraction cords depends more on the level of anxiety and stress than on the level of the epinephrine. They also proposed that Blood pressure is elevated by placement of racemic epinephrine-impregnated retraction cords

upon an exposed vascular bed or lacerated tissue. They found out 4 percent racemic epinephrine-impregnated retraction cords cause less elevation of blood pressure than 8% racemic epinephrine cords. Although the elevations in blood pressure from 8% cord occur Within a narrow range, this range may be hazardous to cardiac patients: Therefore, 4% racemic epinephrine cord can be used if needed. A desirable amount of tissue retraction is achieved by 4% racemic epinephrine cord.

Ruel J *etal* (1980)[7] conducted a study to evaluatethe effect of retraction procedures like retraction cord, copper band and electrosurgery on the periodontium in humans and they concluded on the basis of wound healing and gingival recession caused by the three procedures, the copper band retraction method was the most satisfactory. This tentative conclusion is based on the following factors: 1. Retraction methods must be evaluated relative to the impression procedure and also fit of the restoration. The long-range importance of the marginal fit are probably the most important factor for enhancing periodontal health. 2. This study involved only healthy periodontia of adult patients. Different healing can be observed in tissues characterized by gingivitis or periodontitis. 3. This study involved teeth which had an adequate level of attached gingiva. More complicated healing and perhaps altered sequences can be observed if the procedures were performed on gingival margins of alveolar mucosa, thin gingival walls, or areas of root prominence and thin cortical bone.

Shaw DH *et al* (1980)[8] conducted a study to determine the effects of dilute and concentrated solutions of aluminium chloride on the gingiva. He concluded that AICl3 when used in a solution 0.033% with retraction cord produced minimum detectable additional inflammation of the gingiva whereas a concentrated solution of AICl3 produced severe and noticeable inflammation with ulceration within 24 to 36 hours. In these circumstances concentrated solutions of AICl3 are contraindicated in retracting the gingiva.[8]

De Gennaro GG *et al*(1982)[9] conducted a study to compare gingival inflammation related to retraction cords. They used three drugs to determine the effect on the sulcus of (1) 0.1% epinephrine, (2) 8% epinephrine, (3) 100% alum, (4) 8% zinc chloride, and (5) 40% zinc chloride and they came to a conclusion that 1. Potassium aluminum sulfate, aluminum chloride, and 8% racemic epinephrine did not demonstrate practical differences, although potassium aluminum sulfate produced fewer inflammatory changes than the other agents.

Azzi R *et al* (1983)[10] analyzed three commonly used methods of gingival retraction: (1) retraction cord, (2) electrosurgery, and (3) rotary gingival curettage. All these above methods were tested clinically and histologically in dogs. Postoperative periods analysed ranged from 6 hours to 14 days. All methods induced and formed some kind of minor damage. Recession of clinical amount was induced only by rotary gingival curettage. Apical migration of the junctional epithelia was not seen evidently. Hence they concluded Gingival recession was greater and of probable clinical significance with the rotary gingival curettage technique, minimal with electro surgery, and non-existent with the cord

Donovan TE, Gandara BK, and Nemetz H (1985)[11] outlined the results of the survey and, with knowledge available from previously published studies, compares the concepts that are currently popular with generally accepted criteria for gingival retraction procedures. Data from the survey of 495 dentists shows that most dentists used the mechanical-chemical method of gingival-deflection; 79.39% of them used cord containing epinephrine. They concluded that epinephrine can be easily absorbed systemically from the local anaesthetic solution, that secretion of endogenous epinephrine in response to stress occurs, often at levels sufficient to cause measurable changes in hemodynamic variables, and that absorption of epinephrine from impregnated strings occurs. Equally effective astringent gingival retraction agents such as alum, aluminium sulfate, and aluminium chloride induced no systemic effects. Therefore, there is little indication for use of epinephrine-containing retraction cords.

Benson BW *et al* (1986)[12] studied various mechano chemical method in which he concluded Epinephrine used in concentrations of 0.1% and 8% for saturating the retraction cord creates local vasoconstriction of the gingival tissues and seems to have fairly minimal systemic effects if used in an intact sulcus. Alum (potassium aluminium sulfate) in a 100% concentration has shown to be only slightly less effective in shrinking the gingival tissues than epinephrine, and it gives good tissue recovery. Ferric sulfate (13.3%) used for tissue displacement has recently been reported in literature. It does not traumatize the tissue as noticeably, and healing is more rapid and evident than with aluminium chloride. Zinc chloride (bitartrate) has been used in 8% and 40% solution. Gingival displacement effectiveness of the 8% solution is about equal to that of epinephrine, while the 40% solution is a far more effective. The 8% solution caused severe necrosis and inflammation of the tissue that did not heal for 60 days. Tannic acid (20% and 100%) is less effective than epinephrine

but shows very appreciable tissue recovery. Negatol solution is a 45% concentrated product of meta cresol sulfonic acid and formaldehyde.

Runyan DA, Reddy Jr TG, and Shimoda LM (1988)[13]did a study to evaluate Fluid absorbency of retraction cords after soaking in aluminium chloride solution and they concluded that Soaking retraction cord in an aluminium chloride solution before placing into gingival sulci does not lessen the cord's ability to absorb fluid and they also concluded plasma absorbed increases in linear proportion with the size of the cord

Curtis MA *et al* (1990) [14] conducted a study on Gingival crevicular fluid (GCF) As the initial stage of a longitudinal study into the characterization of disease markers, GCF sampled from 104 sites in 74 adolescents was examined via sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS/PAGE). In this population, which had varying degrees of gingivitis but little evidence of destructive periodontitis, there was a highly evident homologous GCF protein profile. The plasma components, albumin, transferr in and IgG, were major constituents of all samples taken. In addition, a second group of non-plasma derived proteins, with molecular weights 37 kDa, 47 kDa, 57 kDa and 59 kDa, was also commonly detected in samples. The high frequency of occurrence of these components suggests that they may represent products of normal turnover of the periodontal tissues. Analysis of GCF taken from patients with progressing destructive disease revealed a different SDS/PAGE profile particularly with respect to proteins of non-plasma origin.

Rice CD, Dykstra MA, and Gier RE (1991)[15] conducted a study on Bacterial contamination in irreversible hydrocolloid impression material and gingival retraction cord. The study identified and enumerated viable bacteria and other microorganisms in unopened containers of irreversible hydrocolloid impression material and gingival retraction cord. The irreversible hydrocolloid sample size was 10 times as large as the retraction cord's sample size. The contamination frequencies of the irreversible hydrocolloid were much significantly higher than the frequencies of the retraction cord. They concluded that a significant number of irreversible hydrocolloid samples were found to be contaminated. But, the number of retraction cord samples containing organisms was not significant. A majority of the contaminated samples of both materials was found to contain common environmental contaminants, which may represent a hazard only to immuno compromised patients or other

patients under medications. A small percentage of the irreversible hydrocolloid samples were found to contain pathogens (group D Streptococcus and Bacteroides fragilis), which may represent an infection or disease.

Kellam SA, Smith JR, and Scheffel SJ (1992)[16] conducted a study to estimate the amount of epinephrine absorbed from commercial retraction cords during actual gingival retraction in patients in the dental clinic. Fluorospectrophotometry without radiolabelling was used to determine the epinephrine level in cord segments before and after placement in the gingival sulci. They concluded that patients were exposed to substantial levels of l-epinephrine during a gingival retraction with the use of commercial cotton cord impregnated with epinephrine. Although it is highly unlikely that the rapid elevation in plasma I-epinephrine concentrations is the result of extensive vasoconstriction, it would seem wiser to avoid using epinephrine-impregnated cords in patients with cardiovascular problems.

Laufer BZ *et al* (1994)[17] conducted a study to compare the dimensional accuracy of impressions and dies made from a metal model simulating prepared abutments and having gingival sulci of varying widths. Measurements of the abutments, impressions, and stone dies were made using a travelling microscope, and the number of defects in each impression was recorded and labelled. The impressions and dies made from abutments with thinner sulci showed greater distortions. Analysis of variance and the Fisher PLSD post hoc test indicated significant differences between the group having a sulcular width of 0.08 mm and the groups having larger sulcular widths for the impressions and for the dies ($P < .05$). The large coefficient of variation occurring groups having 0.08-, 0.13-, and 0.18-mm sulcular widths illustrated the difficulty of consistently obtaining good impressions of abutments having such narrow sulcular widths. Around 50% and 90% of abutment impressions having sulcular widths of 0.08 and 0.13 mm had defects.

Ferrari M (1996)[18] conducted a preliminary study to evaluate in a clinical trial with 10 selected abutments and merocele strips. Merocel strip is a predictable and good retraction material in relation to impression procedures. The material was again evaluated by scanning electron microscopy and demonstrated promise in this investigation. Merocel strip shows potential for other applications, but limitations of this material indicated that evolution of

atraumatic gingival retraction should continue and flourish. He concluded merocel strips performed suitably, especially with vulnerable width or thickness of adherent gingival tissue

Laufer BZ *et al* (1997)[19] conducted a study on the closure of the gingival crevice following gingival retraction for impression making and concluded that scant attention has been paid to the effectiveness of chemo-mechanical displacement of the gingiva prior to impression making for fixed partial dentures. The closure of the gingival crevice after removal of medicated retraction cord was observed using a miniature video camera. Sulcular widths were measured at fixed time intervals at the mid-buccal and transitional line angle areas. The closure rate of the transitional line angle area was significantly faster than that of the mid-buccal area during the first 90s. An average sulcular width of 0-2 mm was reached at the transitional line angle after less than 30 seconds.

Livaditis GJ (1998)[20] conducted a study on comparison of the new matrix system with traditional fixed prosthodontic impression procedures that compares the methods and effectiveness of traditional fixed partial denture impression systems, which includes the matrix impression system, in relation to the registration of the finish lines and sulci of tooth preparations in the formation of a full arch impression, They discussed four main categories of impression systems: (1) copper-tube and resin-coping, (2) syringe/tray, (3) putty/wash or impression/reline, and (4) matrix. The favorable as well as the unfavorable points of each system were analyzedfollowing which a new system was described that eliminates most of the unfavorable points while retaining the favorable points. Interim fixed prosthodontic restoration was discussed and by no means is an impression procedure, however, it is closely related because many of the steps are similar and it primarily led to the development of the new matrix impression system. This article also specifically discusses some related procedures such as custom trays in fixed prosthodontics, retraction of gingival tissues, hemostasis, sulcular cleansing, collapsing forces acting on the soft tissue during the impression procedure, viscosity of impression materials, and configuration of the sulcular flange. For some, it will become the standard procedure, whereas for others, it may be preferred only for complex impressions and procedures.

Jokstad A (1999)[21] did Clinical trial on gingival retraction cords and the following conclusions were drawn: Knitted gingival retraction cords were ranked much better than

twined cords, Cords containing epinephrine performed clinically no better than aluminium sulfate cords. They also stated dentists should carefully learn and consider the benefits and disadvantages of gingival retraction cords containing epinephrine in light of the potential risk of adverse effects and apparent lack of significant improved clinical performance.

Del Rocio Nieto-martinez M *et al* (2001)[22]did a study on effects of diameter, chemical impregnation and hydration on the tensile strength of gingival retraction cords, The study aimed to establish under experimental conditions the extent to which tensile strength is affected by variation in cord diameter; impregnation with ferric sulphate or aluminium sulphate and cord hydration (wet/dry). They concluded that the cord hydration had no significant effect on tensile strength, whereas impregnation with aluminium sulphate or ferric sulphate, a smaller diameter, and/or being a cotton cord decreased tensile strength, they also concluded hydrated commercial cords had higher tensile strength than dry specimens; hydrated or dry cotton cords were not different. The ferric sulphate-impregnated cotton cords had lower tensile strength than aluminium sulphate impregnated or control cords that didn't contain any, and the effect was greater at higher ferric sulphate concentrations. This study is one of the first evaluations of the physical properties of cords, highlighting characteristics that may minimize the risk of tearing of retraction cord

Bader JD, Bonito AJ, and Shugars DA (2002)[23] conducted a study to identify any additional risks of adverse cardiovascular outcomes to hypertensive individuals represented by use of epinephrine-containing anesthetic solutions and epinephrine impregnated retraction cords and they concluded that the increased risk for adverse events among uncontrolled hypertensive patients was found to be low and the reported occurrence of adverse events in hypertensive patients associated with the use of epinephrine in local anesthetics was minimal

Padbury Jr A *et al* (2003)[24]Conducted a study regarding Interactions between the gingiva and the margin of restorations. They discussed the complete concept of the biologic width and its relationship to periodontal health and restorative dentistry. The importance of restorative margin location, materials, and contours related to periodontal health is also addressed. They further stated restorative margins, undoubtedly is preferable if margins can remain coronal to the free gingival margin. Obviously, subgingival margin placement is often unavoidable. However, care must be taken to involve as minimum of the sulcus as

possible. Evidence suggests that even minimal encroachment on the subgingival tissue can lead to deleterious effects and recession on the periodontium. Furthermore, deep margin placement risks invading the soft tissue attachment of the gingiva to the tooth, often leads to a more pronounced plaque-induced inflammatory response.

Csempesz F, Vag J, and Fazekas A (2003)[25] conducted a study to determine the optimal soaking time for 3 retraction cords of different thickness to ensure adequate uptake of the hemostatic solution. They concluded, that 20 minutes of soaking time was necessary and apt for saturation of the cords before use, provided that air trapped within the cords was removed. In addition to the soaking time, the saturation of the cords with the solutions largely depended on the wetting of the cords sufficiently.

Liu CM *et al* (2004)[26] Conducted a study to determine the cytocompatibility of three different extracts of gingival retraction cords and to compare the cytotoxic effect of these materials on human gingival fibroblasts. Gingival retraction cords impregnated with aluminium sulphate (Gingi-Aid), DL-adrenaline HCl (Gingi-Pak) and non-drug impregnated cord (Gingi-Plain) were eluted in relation to culture medium for 10 min and 24 hr. They concluded that gingival retraction cords applied alone almost completely inhibited cell viability, the results also stated that the eluates from aluminium sulphate-impregnated cord, DL-adrenaline HCl impregnated cord and non-drug-impregnated cord were cytotoxic to primary human gingival fibroblast cultures. They also concluded that gingival retraction cords have significant potential for gingival toxicity. Careful management of gingiva retraction cords would lower the risk of potential gingival tissue damage during clinical application procedure and thus increase the success of prosthodontic procedures.

Tsai TH *et al* (2005)[27]Conducted a study to investigate the clinical outcomes with a newly developed non-aluminium chloride-containing injection-type retraction material (Korlex-GR®) in terms of gingival retraction, gingival recession, and patient comfort and also to compare it with 2 other commercial retraction materials (Ultrapak 1®, a medicated retraction cord, and Expasyl®, an injection-type retraction material containing 15% aluminium chloride) they also concluded that an increase in the sulcus width after retraction by all 3 materials but no statistical difference was noted among these materials. Significant gingival recession was also observed for all the above said test materials after retraction. However,

when the 3 materials were compared, the medicated cord seemed to produce significantly more gingival recession than the other 2 injection-type material. In regards to pain during retraction, the medicated cord was also significantly more painful than the injection types. They hence concluded that the non-aluminium chloride-containing injection-type retraction material is good and better for gingival retraction than the other two materials but produces less pain and limits injury to the gingival tissue during the procedure. It is therefore can be recommended for clinical use

Feng J *et al* (2006)[28] Conducted a study to examine the effects of placement of retraction cord subgingivally upon periodontal indices including Plaque index (PI), Gingival index (GI), Pocket depth (PD), Bleeding on probing (BOP), and Attachment level (AL), as well as gingival crevicular fluid (GCF) and TNF-α levels. They concluded gingival retraction causes an acute injury that heals clinically soon in 2 weeks as is indicated by the GI. It also provides the first and important evidence that gingival retraction results in an elevation of the proinflammatory cytokine, TNF-α, in GCF

Csillag M *et al* (2007)[29] Conducted a study to identify the effective concentration of epinephrine that may prevent the hyperemic response and consequently keep the crevicular fluid production low after cord removal without local or systemic side effects. They stated that it is way better to use low-concentration epinephrine solution for gingival retraction due to its superior ability in keeping the gingival sulcus relatively dry during the impression procedure. They concluded it is advisable to use epinephrine for gingival retraction without concern for the side effects. A low concentration of 0.01% may prevent both hyperemia and production of crevicular fluid in the marginal gingiva after cord removal without affecting systemic circulatory parameters and without causing prolonged ischemia

Kumbuloglu O *et al* (2007)[30] conducted a study to determine whether any of the commonly used gingival retraction medicaments could influence the surface characteristics of the impression material and to evaluate the clinical performance of retraction cords. They took sixteen cord systems in different shapes, sizes, and medications were used in this study. The clinical performances of cords were verified and evaluated with a blind experimental study design, according to predetermined criteria. They concluded that the applied gingival retraction cord systems had no influence on the surface characterization of the polyvinyl

siloxane material tested. Gingival margin quality of the impression and clinical application procedures will be affected by the retraction systems. Untreated, medium-braided, and epinephrine-incorporated cord systems were clinically successful. However, the potential systemic effects of epinephrine must be kept in mind.

Sábio S *et al (*2008)[31] Conducted a study to evaluate the physical and chemical properties of four impression materials [a polysulfide (Permlastic), a polyether (Impregum), a condensation silicone (Xantopren) and a polyvinylsiloxane (Aquasil)] when polymerized in contact with of one conventional (Hemostop) and two experimental (Vislin and Afrin) gingival retraction solutions. They concluded the experiment into the following -1 The tensile strength of the polysulfide decreased after contact with Hemostop and Afrin. 2. None of the chemical solutions hindered the polymerization of the polysulfide; 3. The polyether presented lower tensile strength after polymerization in contact with the three gingival retraction agents; 4. The polyether had its polymerization inhibited only by Hemostop; 5. None of the chemical solutions affected the tensile strength of the condensation silicone; 6. Only Hemostop inhibited the polymerization of the condensation silicone; 7. The polyvinylsiloxane samples polymerized in contact with Hemostop had significantly lower tensile strength; 8. Neither one of the chemical solutions (Afrin and Vislin) affected the tensile strength of the polyvinylsiloxane and the condensation silicone; 9. Results of the tensile strength and polymerization inhibition tests suggest that Vislin can be used as substance of gingival retraction without affecting the tested properties of four impression materials

Wo¨stmann B *et al* (2008)[32] Conducted a study to compare the marginal fit in fixed restorations using two modes of gingival retraction and two different impression techniques in an animal model. Two set of impressions per jaw were taken in a two-step putty-wash technique (TPW) and a one-step putty-wash technique (OPW), respectively. They concluded There was a small but not significant difference between electro-surgery and the retraction cords whereas TPW produced significantly better results than OPW. Hence finally they stated the use of gingival retraction cords as well as electro-surgery led to acceptable results. The difference between TPW and OPW attributing to the marginal discrepancies can be regarded as clinically insignificant

Abadzhiev M (2009)[33] Conducted a study on the necessity of a second retraction cord used to ensure dryness of the gingival sulcus, thus allowing ingress of the impression material and exact impression of the marginal detail. They concluded that the accuracy of the impression taken in the prosthetic area is extremely important both for the health and the esthetics of the treated patients. When a second retraction cord is applied it retracts the gingival sulcus permanently, keeps it dry and allows a deep ingress of the impression material. Such a technique might take some more time and incur additional expenses, but the accuracy of the impression and the esthetic and prophylactic prosthetics make it worth any additional expenditure or time. Double cord retractions technique should be a standard in preparation of soft and hard tissue for impressions in fixed prosthodontics whenever necessary

Phatale S *et al* (2010)[34] conducted a study to evaluate the effect of different retraction materials, such as, Expasyl, Magic Foam Cord, and impregnated retraction cord on the gingival sulcular epithelium. This study included 30 cases of bilateral Premolar extraction and with patients of Loe and Silness gingival index zero. Retraction materials were kept in the dry, isolated labial gingival sulcus for the allocated time. The retraction materials were removed by rinsing with ample amount of water. Retracted gingiva of 2 – 3 mm from the gingival margin along with the tooth was extracted and the decalcified sections were promptly microscopically studied. This study showed promising results with retraction paste as compared to the retraction cord, and there was a significant association between retraction materials and the relative amount of injury to the sulcular epithelium. He concluded There is a significant association between retraction materials and gingival sulcular epithelium. It can be concluded that impregnated retraction cord, may be used commonly but it needs proper tissue manipulation and is technique sensitive which limits its usage. Newly advanced material in the form of retraction pastes like Expasyl or Magic Foam Cord was found to be better than cord as assessed histologically, it respects periodontium but the cost is another factor to think about.

Al-Ani A *et al* (2010)[35] Conducted a study to identify the techniques most commonly used in New Zealand for gingival retraction for impressions of natural teeth and implants in fixed prosthodontics and they found out Dentists in New Zealand undertake a considerable amount of fixed prosthodontic and implant work. Gingival retraction techniques around natural teeth is used commonly, while only a small number of participants report using it for implants. A

surprising finding was the relatively high number of participants who reported using surgery for gingival retraction around natural teeth[35]

Prasad KD *et al* (2011)[36] Conducted a study discussing the current methods that are applied for displacement of gingival tissues so that adequate amount of unprepared tooth structure can be recorded with least distortion of impression material as well as minimal damage to attachment apparatus of the tooth**,** they also stated while using chemico mechanical means of gingival retraction, absorption of chemicals, like epinephrine, at the sulcus interface is dependent on patient's gingival health. Healthy gingiva acts, to some extent, as a barrier to the absorption of epinephrine. Surgical retraction procedures are rapid and effective but at the same time destructive and involve excision of tissue. Clinicians should be able to make a good use of an injectable matrix for gingival retraction as it offers the opportunity to perform an atraumatic procedure as much as possible.

Kostić I *et al (*2012)[37] Conducted a study to carry out comparative analysis of advantages and disadvantages of commercially available gingival retraction agents and they concluded retraction agents should provide adequate retraction thereby not giving any local or systemic side effects. Preference should be given to astringent agents based on metal salts as compared to epinephrine-based agents regarding similar therapeutic effects and fewer adverse systemic effects.

Shivasakthy M and Ali SA (2013) [38] Conducted a study to determine whether the polyvinyl acetate strips are able to effectively displace the gingival tissues in comparison with the conventional retraction cord. Full metal ceramic preparation with supra-gingival margin was performed in fourteen maxillary incisors and gingival retraction was done using Merocel strips and conventional retraction cords alternatively in 2 weeks' time interval. The amount of displacement was compared using a digital vernier caliper. They concluded Merocel strip produces more gingival displacement than the conventional retraction cord.

Singh R et *al* (2013) [39] Conducted a study to check the effect of different retraction cord medicaments on surface detail reproduction of polyvinyl siloxane impression materials and compare this effect on any two brands of commercially available polyvinyl siloxane impression material and stated as Surface detail reproduction of the polyvinyl siloxane impression materials is adversely affected by the retraction cord medicaments. The presence

of moisture or any traces of the medicaments should be removed from the tooth surface to provide a dry field for the correct reproduction of the surface detail of these materials**.**

Raghav D *et al* (2014) [41] conducted a study to evaluate the efficacy of three different gingival retraction systems, i.e., Magic Foam Cord, expasyl paste, and aluminium chloride-impregnated retraction cord. They concluded though the maximum retraction was produced by aluminium chloride-impregnated retraction cord and even there were statistically significant difference in the width of retracted gingival sulcus among three systems except between expasyl paste and impregnated retraction cord, which was statistically insignificant but enlargement achieved in all the three systems was way more than the minimum required. Merits with expasyl paste and Magic Foam Cord over the retraction cord were their ease of application, painless, quick, and without agony to the patient.

Mohadeb JV *et al* (2015)[42] Conducted a study Primarily to assess the efficacy of cordless versus cord techniques in achieving hemostasis control and gingival displacement and their influence on gingival/periodontal health and they found out, a paste system, in general, was documented to be more comfortable to patients and user-friendly to the operator.

Sumanthi CH *et al* (2016) [43] tried to identify the methods used by dental professionals for gingival displacement before making impressions for fixed prostheses. Of 600 dentists who received the questionnaire, 63.3% returned properly filled forms. Sixty-eight percentage of respondents advocate gingival displacement for all fixed prostheses cases, 23% of respondents use for long span fixed prostheses cases, and 9% of respondents use gingival displacement only for selected cases. Among the respondents, 69% preferred to use chemico-mechanical method, 16% surgical method, 9% of respondents preferred to use the mechanical method. Hence, they concluded the choice of technique and material for gingival displacement depends on the operator's judgment of the clinical situation apart from the availability of the materials.

Rajambigai MA *et al* (2016)[44] described the different advanced materials available. Which included retraction cord, expasyl, magic foam cord, matrix impression system, merocel, gingitrac, race gel, stay put, lasers. They drew a conclusion stating that using these materials, we can definitely improve the quality of impressions in fixed prosthodontics. Furthermore,

the procedure can be relatively painless, quick, and atraumatic. The selection of material has to be carefully done by the operator.

Vishnubhotla G *et al* (2016) [45]conducted a study to know the effect of various medicaments on the fluid absorbency of the retraction cords and also, to know whether the thickness of the retraction cords influences its fluid absorbency. They took cords of thickness 0,1,2 and medicaments 15.5% ferric sulfate and 10% aluminium chloride for a period of 20 minutes. They concluded that FeSO4 (15.5%) is a better medicament for absorption of fluid.

Tabassum S *et al* (2017)[46]did areview to assess the gingival retraction methods in terms of the amount of gingival retraction achieved and changes observed in various clinical parameters: Gingival index (GI), Plaque index (PI), Probing depth (PD), and Attachment loss (AL). they concluded the total number of teeth assessed in the 10 included studies was 400. The most common method used for gingival retraction was chemo mechanical. The results were heterogeneous with regards to the outcome variables. None of the methods seemed to be significantly superior to the other in terms of gingival retraction achieved.

Jain AR and Nallaswamy D(2018)[47]Conducted a study to investigate clinical efficacy of cord, paste system, and a strip gingival retractile material- ultrapak cord, merocel strip, and magic foam cord. They used three different gingival retraction systems and they found out merocel strip provided the maximum amount of vertical and lateral tissue displacement, followed by ultrapak cord and least with magic foam cord which was statistically significant.

Mellilli D *et al* (2018)[48]Conducted a study compare two systems used for conditioning the gingival sulcus and exposing the finish line before the final impression for a fixed denture: retraction cords and diode laser. They concluded the amount of gingival retraction and restoration to baseline resulting from use of gingival retraction cords or diode laser technique is similar, but diode laser required less time, was simpler for the operator and was more comfortable to the patient than retraction cords.

Kohli PK and Hegde V (2018)[49]conducted a study to compare and evaluate the clinical efficacy of two gingival retraction systems Ultrapak and Traxodent, on the basis of the amount of gingival retraction achieved in vertical and horizontal direction and their hemorrhage control. They concluded the mean retraction width and depth achieved with

retraction cord (Ultrapak) was significantly greater when compared with retraction paste. Although retraction paste (Traxodent) exhibited bleeding index significantly less when compared to that of retraction cord (Ultrapak).

Rayyan MM *et al* (2019)[50]conducted a study to evaluate the efficiency and gingival response of 4 cordless gingival displacement systems. They noted Immediate gingival displacement varied with the system used. For horizontal displacement, median values ranged between 150 mm (Tr) and 725 mm (Ez) for buccal displacement and between 93 mm (Tr) and 550 mm (Ez) for lingual displacement. Minimum and maximum displacements also varied and followed a similar trend, with Traxodent providing the least displacement. They concluded Significant differences were found among the 4 tested systems in both vertical and horizontal gingival displacement. 3M, Expasyl and Expazen Retraction exceeded the 200-mm requirements for horizontal displacement. Traxodent provided the least displacement in both horizontal and vertical dimensions

Kesari ZI *et al* (2019) [51] Conducted a study to compare and evaluate the efficacy of ViscoStat clear, Vasozine, and Racegel (with and without cord) with respect to the amount of lateral gingival displacement produced by them. They found out the largest mean gingival displacement was produced by Racegel with cord (0.2256 mm^2) and lowest by Racegel without cord (0.1414 mm^2). There was no significant statistical difference in the amount of gingival displacement produced between the four agents.

Beleidy M and SeragElddien AM (2020)[52]conducted a studyto assess cordless techniques compared to conventional cords in gingival displacement and effect on periodontal health. They concluded Cordless retraction systems showed similar horizontal gingival displacement compared to conventional cords. No Cord can be considered an alternative retraction system, providing an effortless placement, good gingival displacement and no bleeding. All techniques inflicted an interim gingival inflammation with Traxodent showing the highest level. Gingi Trac and Traxodent demonstrated delaying recovery

Kavita K *et al* (2020)[53]conducted a study to assess different gingival displacement systems such as aluminum chloride retraction cords, expasyl, and tetrahydrozoline-soaked retraction cord to record intracervical margins of tooth preparations. They concluded maximum

gingival retraction was achieved with aluminum chloride retraction cords followed by tetrahydrozoline and Expasyl

Qureshi SM *et al* (2020)[54]conducted an *in vivo* study to compare the efficacy of three recent gingival displacement materials in achieving gingival tissue displacement. Within the limitations of this study, astringent gingival retraction paste demonstrated the highest value for gingival displacement followed by stay-put retraction cord whereas, Expasyl showed the least value of all.

Jain RC *et al* (2021)[55] they conducted a study to compare different gingival displacement agents in achieving finish line. They made impressions with knitted retraction cord impregnated with 25% aluminum chloride, expasyl and Racegel They concluded gingival retraction obtained by al aluminum chloride was maximum as compared to expasyl and racegel

Shetty M *et al*(2021)[56] conducted a study to clinically evaluate the efficacy of the magic foam retraction system and conventional retraction cords on the basis of the relative ease of workingwith, the time required for placement, and the amount of gingival retraction. They concluded the magic foam retraction system appears to be a promising system with regard to reduced time for application and ease of placement. However, the amount of gingival retraction achieved with the magic foam retraction system was statistically less than the retraction cord system.

Hemavardhini A *et al* (2021)[57] they tried to present the technique that involves the fabrication of a customized gingival cuff for abutment tooth by 3D printing technology using thermoplastic polyurethane material. They found out This technique greatly reduces the marginal discrepancy of the final restoration with minimal trauma to the gingival tissues and achieve a desirable emergence profile of the restoration usually when the finish line is at, or just within the gingival sulcus.

Sorrentino R*et al* (2022) [58] aimed to shed light on the use of laser systems for gingival retraction procedures necessary for the exposure of juxta- and sub-gingival finish lines before impression making in fixed prosthodontics and they concluded Laser systems are efficient in gingival retraction, allowing better intraoperative hemostasis control and postoperative

patient comfort than other surgical troughing procedures. Laser-mediated gingival displacement seems to be safer and more acceptable, particularly in the case of thick gingival biotype.

Madaan R *et al* (2022)[59] conducted a study toevaluate the clinical efficacy of four gingival retraction systems, namely, impregnated retraction cord, gingival retraction capsule, retraction paste, and polyvinyl acetate strips. They concluded the maximum value for gingival displacement was found in polyvinyl acetate strips (Merocel), followed by impregnated retraction cord (SURE-Cord), and retraction capsule (3M ESPE), and the lowest value was found in retraction paste (Traxodent)

Adnan S *et al* (2022)[60]stated thata wide variety of procedures require the retraction of gingival tissues. Therefore, the clinician should have a thorough knowledge and must be familiar with the various methods that can be employed to achieve gingival retraction in different clinical scenarios. The factors responsible for the longevity and aesthetics of a restoration are intimately linked to the gingival and periodontal tissues. The placement of any restoration in close proximity to the gingival tissues will require adequate access and isolation, for which various gingival retraction methods and materials are available in market. These are broadly classified as mechanical, chemo-mechanical, cordless and surgical techniques. She concluded since gingival retraction is an integral part of clinical practice, the clinician should make an effort to utilize different methods and products available for retraction of gingival tissues in various clinical scenarios. Sometimes a combination of methods may be needed, and some things may work for one clinician and not for another. The effort put into the appropriate retraction of gingival tissues pays off in terms of longevity of restorations, better margins and aesthetics.

Al-Nasser H *et al* (2022)[61] they described a novel nontraumatic gingival retraction method, without cords, chemicals, surgery, or any special equipment. They stated an accurate elastomeric impression is achieved using a custom tray as it decreases the volume of the material and reduces in turn the stresses during impression removal and the subsequent thermal contraction. Therefore, the Provisional Crown-Impression technique was developed using a silicon matrix to have an accurate impression as much as possible. They found that this manner has produced a satisfactory marginal fit clinically and radiographically

Merchant A*et al*(2022)[62] conducted a study to compare the effectiveness of local and topical anaesthesia during gingival retraction in prepared abutment teeth**.** They concluded there was no significant difference in pain, discomfort and gingival bleeding during gingival retraction using topical and local anaesthetic agents they also found that topical anaesthesia was equally effective as infiltration anaesthesia in managing the pain, discomfort and bleeding during gingival retraction by cord packing in prepared abutment teeth

Felipe MV *et al* (2022)[63] conducted a study to compare gingival displacement with conventional cords and cordless techniques and determine the reliability of the measurement methodologies. They found 9 studies were selected, and the most common risks of the bias was random sequence generation, blinding of outcome assessment, and absence of sample size calculation. Most of the studies reported a favorable result obtaining a width greater than 0.2 mm. The retraction cord technique resulted in increased displacement when compared with the cordless technique. The evaluation of sulcular width with digital microscope images obtained from sectioned gypsum casts is an adequate and versatile experimental methodology for measuring displacement between cord and cordless technique .

Abdelhamid AA *et al* (2022)[64] this study was conducted to compare between two techniques of gingival retraction (retraction cord and diode laser) regarding the amount of tissue displacement both laterally and vertically. Also, Patient satisfaction during their application. Two groups Group I: Patients receiving retraction with the retraction cord. Group II: Patients receiving retraction of gingival tissue with diode laser. There was a statistically significant difference between the two groups regarding lateral and vertical displacement. Laser troughing give not only more amount of vertical but also more lateral retraction. For the patient satisfaction there was a significant difference between both groups, with laser troughing give better results. They concluded there was significant difference between the two groups regarding lateral and vertical displacement. Laser troughing give not only more amount of vertical but also more lateral retraction whereas for the patient satisfaction there was a significant difference between both groups, with laser troughing give better results. They found out diode laser troughing gives more amount of retraction both laterally and vertically when compared to retraction cord. Laser troughing was more satisfactory to the patient and produced less pain

Vaishnav K *et al* (2022)[65]conducted a studyto evaluate clinical efficacy of Expasyl and medicated retraction in subgingivally prepared teeth. This is done by evaluating and comparing vertical displacement of gingiva. Clinical efficacy of Expasyl retraction system as well as medicated cord retraction system were studied for adequate vertical gingival displacement by direct assessment of the sulcus dilation on the prepared teeth with help of flexible measuring strip pre and post retraction, which includes paired abutments of any one segment of either maxillary or mandibular arch. Statistical analysis was done to compare the above said two systems. They concluded that the amount of vertical gingival retraction obtained by Expasyl and medicated cord was significantly similar but Expasyl retraction system is not cost effective when compared with cord system.

RELEVANCE

RELEVANCE

- When making an impression, creating a clean dry field free of fluid and debris is utmost important Gingival tissue should be displaced to expose the finish line. In order to achieve this, a retraction cord has been the most frequently employed material. Gingival tissues must be displaced to allow sufficient impression materials to assure sufficient flow of impression material into the expanded gingival crevice.

- The retraction cord mechanically displaces the gingival tissue and absorbs fluids from the gingival sulcus, while the chemical agents control hemorrhage and shrink the gingival tissue. Gingival tissue can be displaced vertically or laterally. Lateral retraction displaces the gingival tissue so that an adequate bulk of impression material can be interfaced with the prepared tooth and finish line. Vertical retraction mainly exposes the uncut portion of the tooth apical to the finish line
- Various methods of tissue management such as mechanical methods, mechanochemical methods, electro surgery, rotary gingival curettage, or gingetage have been described. Among that mechano-chemical method of using a retraction cord impregnated or soaked in various chemicals is the most frequently used method.
- Using retraction cord often involves the aid of medicaments, which may be impregnated or soaked into the cord to retract, displace, constrict, or shrink the gingival tissues
- Many different medicaments have been used for impregnation of the retraction cords. These include ferric sulphate ($FeSO_4$), aluminium chloride ($AlCl_3$), aluminium sulfate (Alum), epinephrine, and zinc chloride, among others. It has been evident from literature that retraction cords with no medicaments were less suitable for hemostatic purposes than those impregnated with medicaments.
- When used along with medicaments whether these medicaments help to improve the absorption of fluid or affect the fluid absorption by decreasing the efficiency of the retraction cord is still unknown.

METHODOLOGY

METHODOLOGY

The study was conducted in the Department of Prosthodontics and Crown and Bridge, St. Gregorios dental college, Chelad in collaboration with Mahatma Gandhi University, Kottayam.

MATERIALS AND METHODS:

Table 1: List of Materials used for the study

Sl No.	Materials used	Brand Name and Company
1	Aluminum Sulphate	Nice, Nice Chemicals Pvt, Ltd
2	Ferric Sulphate	Nice, Nice Chemicals Pvt, Ltd
3	Racemic epinephrine	Adrenore, Samarth life Sciences Pvt, Ltd
4	Knitted Retraction Cord	Smart cord, Eastdent Dental Supplies Pvt, Ltd
5	Braided Retraction Cord	Gingi Pak, Henry Schein dental Supplies
6	Twisted Retraction Cord	LD cord, Libral Traders Pvt, Ltd
7	Distilled water	Mahatma Gandhi University
8	Human Plasma	St Joseph hospital, Labtech Medico Pvt, Ltd

Table 2: List of Equipments used for the study

Sl No.	Equipments used	Specifications
1	Electronic Analytical Balance	AS220.R2PLUS
2	Universal Heating Machine	ROTA MANTLE

Table 3: List of Armamentarium used for the study

Sl No.	Armamentarium used	Specifications
1	Stainless steel spatula	Manipal Acharya
2	Glass rod	Manipal Acharya
3	Stop watch	Laboratory timer
4	50ml Plastic test tube	Recombigen
5	Glass slab	Vijay Dentals (local supplier)
6	Blotting paper	Vijay Dentals (local supplier)

SAMPLING

a) **Sample size**

- Sample size is calculated by using G*POWER 3.1.9.2
- Effect size f = 0.40
- α error prob = 0.05
- Power (1-β err prob) = 0.8
- Number of groups = 12
- **Total sample size = 120**

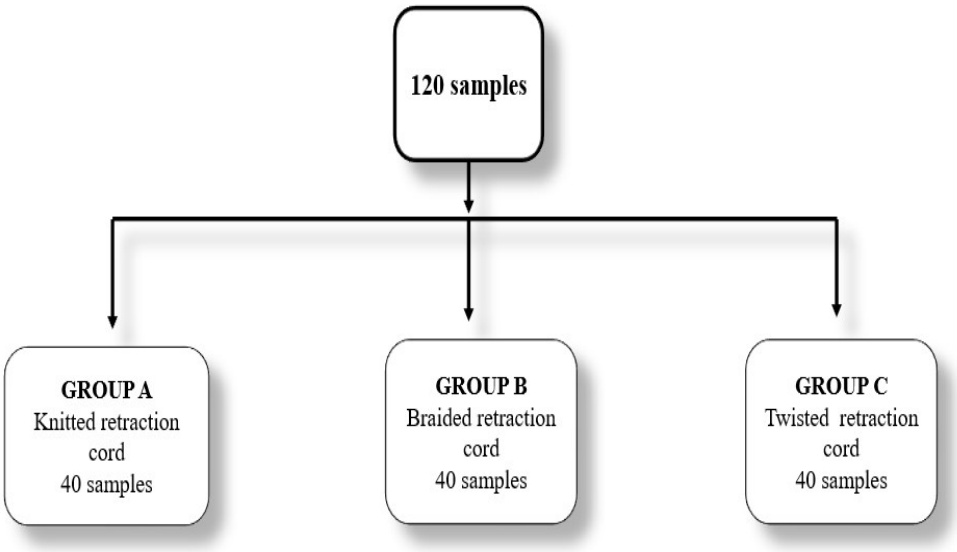
Sample per group =10

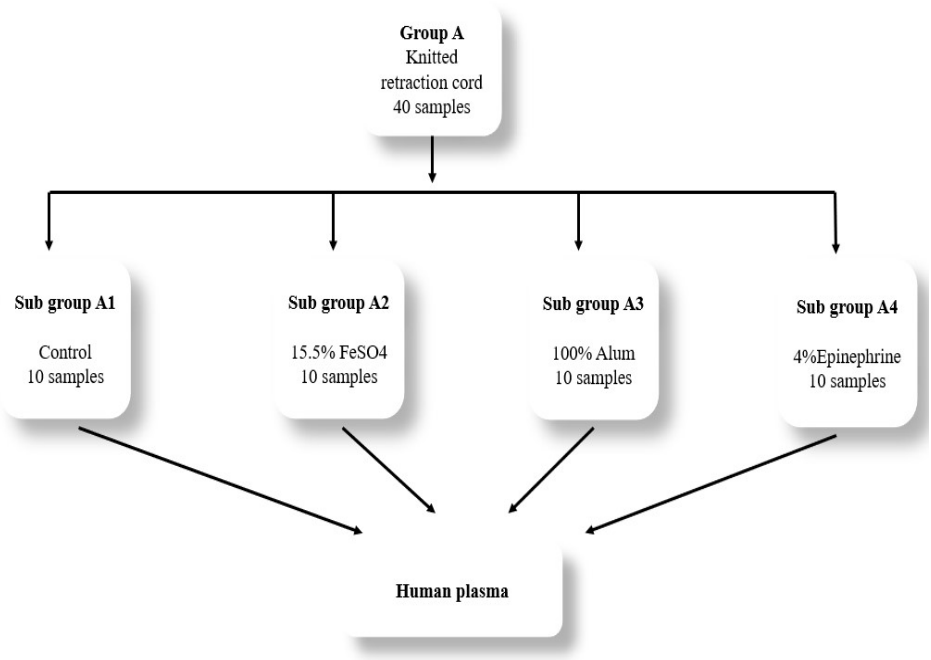
Table 4: Description of sample groups

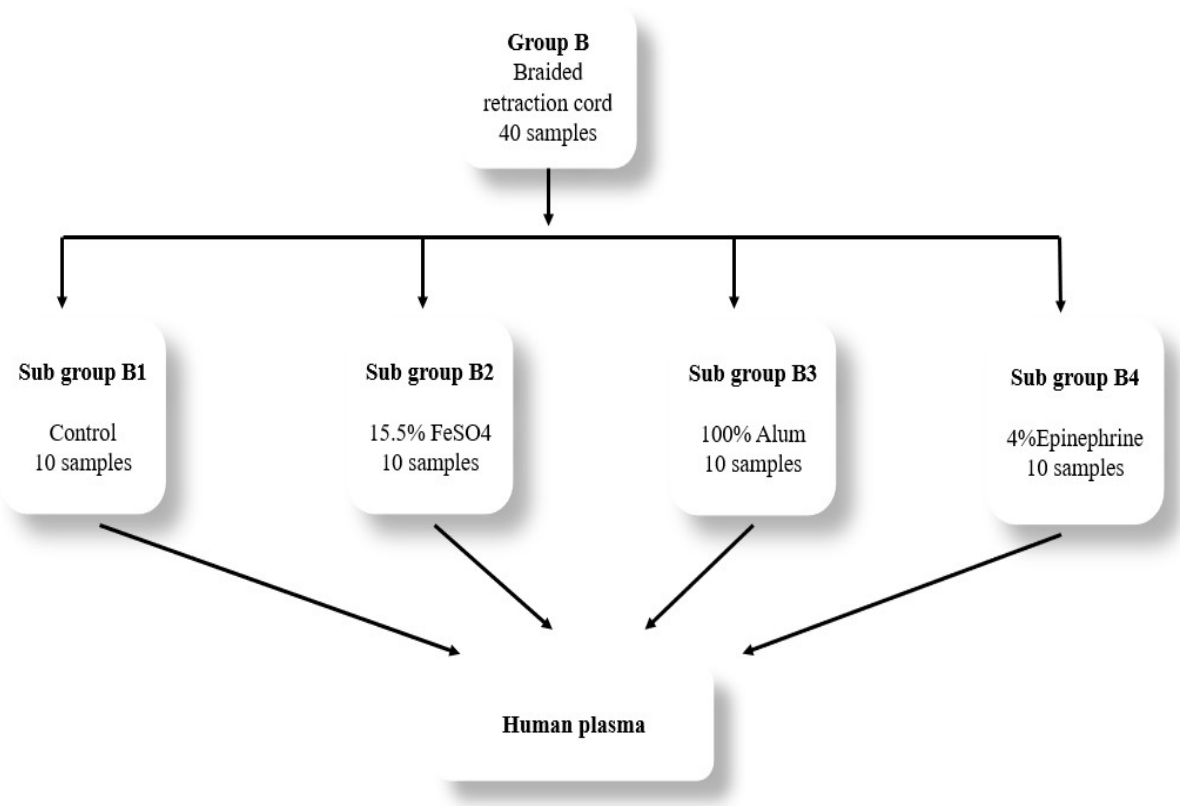
Group A	**Knitted retraction cord**
Sub group A1	Knitted retraction cord without any medicaments(Control)
Sub group A2	Knitted retraction cord immersed in 15.5 % FeSO4
Sub group A3	Knitted retraction cord immersed in 100% Alum
Sub group A4	Knitted retraction cord immersed in 4% epinephrine

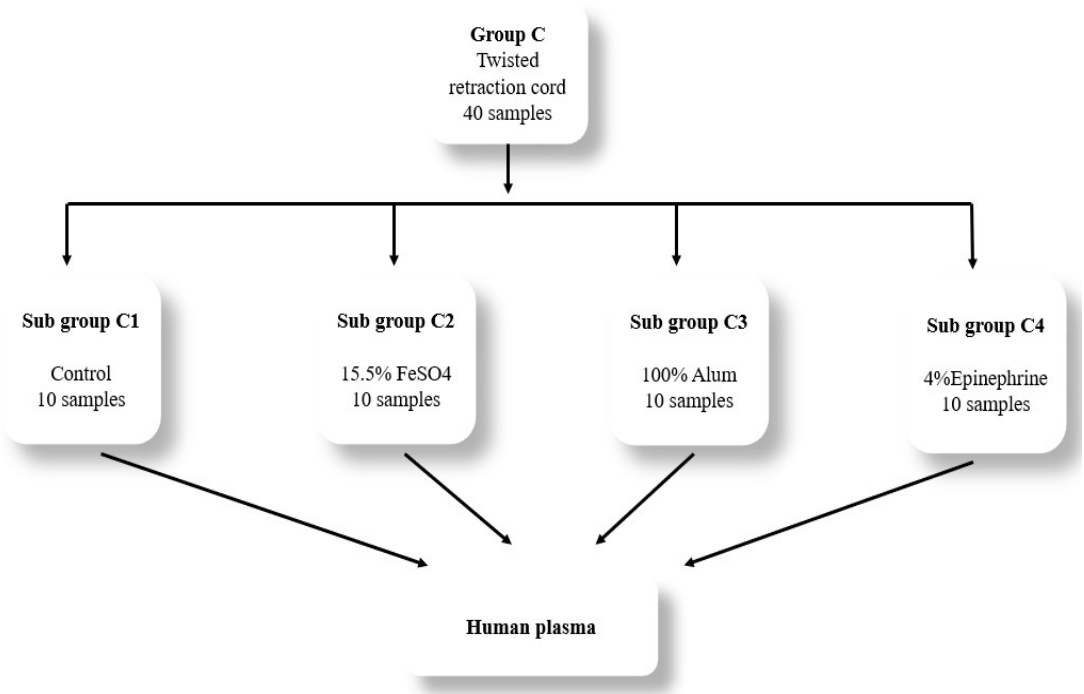
Group B	**Braided retraction cord**
Sub group B1	Braided retraction cord without any medicaments (Control)
Sub group B2	Braided retraction cord immersed in 15.5 % FeSO4
Sub group B3	Braided retraction cord immersed in 100% Alum
Sub group B4	Braided retraction cord immersed in 4% epinephrine

Group C	**Twisted retraction cord**
Sub group C1	Twisted retraction cord without any medicaments (Control)
Sub group C2	Twisted retraction cord immersed in 15.5 % FeSO4
Sub group C3	Twisted retraction cord immersed in 100% Alum
Sub group C4	Twisted retraction cord immersed in 4% epinephrine


120 samples
GROUP A
Knitted retraction cord
40 samples
GROUP B
Braided retraction cord
40 samples
GROUP C
Twisted retraction cord
40 samples


Group A
Knitted retraction cord
40 samples
Sub group A1
Control
10 samples
Sub group A2
15.5% FeSO4
10 samples
Sub group A3
100% Alum
10 samples
Sub group A4
4%Epinephrine
10 samples
Human plasma


Group B
Braided
retraction cord
40 samples
Sub group B1
Control
10 samples
Sub group B2
15.5% FeSO4
10 samples
Sub group B3
100% Alum
10 samples
Sub group B4
4%Epinephrine
10 samples
Human plasma


Group C
Twisted
retraction cord
40 samples
Sub group C1
Control
10 samples
Sub group C2
15.5% FeSO4
10 samples
Sub group C3
100% Alum
10 samples
Sub group C4
4%Epinephrine
10 samples
Human plasma

SAMPLE PREPARATION

RETRACTION CORDS PREPARATION

- 3 different types of retraction cords – **Braided, Knitted and Twisted (Fig 1,2,3) size 00** was taken of length 5cm. **A total of 120 samples were prepared similarly.**
- Each type **has 1 control group to weigh the dry weight and 3 test samples to weigh the wet weight.**
- The difference between the wet and dry weight gives the amount of fluid absorbency.

MEDICAMENTS PREPARATION

1. **15.5% Ferric sulphate (fig 4)**

   15.5 gm of ferric sulphate was taken using spatula and weighed on electronic analytic balance.**(Fig 5)**

   15.5 gm of Ferric Sulphate was dissolved in distilled water in glass beaker to form 100ml solution **(Fig 6)**

2. **100 % Alum (Aluminum Sulphate) (Fig 7)**

   100gm of alum (aluminum Sulphate) was taken and weighed on electronic analytic balance **(Fig 8)**

   100 gm of aluminum sulphate (Alum) was dissolved in distilled water in glass beaker to form 100 ml **(Fig 9)**

   To accelerate dissolution of aluminum sulphate, the solution was heated upto 60℃ using heating mantle. **(Fig 10)**. A clear solution of 100% alum was obtained after heating **(Fig 11)**

3. 4% racemic epinephrine

4 vials of 4mg epinephrine were mixed to form 4% racemic epinephrine **(Fig 12)**

Finally, the prepared 3 medicaments and stored in test-tube using a test tube stand **(Fig 13)**

4. Human plasma

Blood as well as saliva may be present in the gingival sulcus during tooth preparation and impression making which should be properly removed prior to impression making. Also, micro- hemorrhage may occur while placement of gingival retraction cord. In order to simulate this oral condition, human plasma was chosen in the present study, as plasma contains proteins similar to gingival crevicular fluid and blood. **(Fig 14)**

SAMPLING

- 5cm of size 00 knitted, braided and twisted retraction cord were measured respectively using vernier caliper and cut accordingly.
- A total of 120 specimens were prepared similarly for 3 Groups.
- The samples were selected randomly and assigned as GROUP A, GROUP B and GROUP C for knitted, braded and twisted respectively, and the remaining 10 in each group will act as Controls in subsequent Sub-groups.
- Each group were subdivided as follows

1. GROUP A Sub-Groups

- Sub-group A1- 10 specimen in control group without any medicaments on knitted retraction cords.
- Sub-group A2- 10 specimen of knitted retraction cords immersed for 20 minutes in 15.5% Ferric sulphate.
- Sub-group A3- 10 specimen of knitted retraction cords immersed for 20 minutes in 100% Alum
- Sub-group A4- 10 specimen of knitted retraction cords immersed for 20 minutes in 4% Epinephrine

2. GROUP B Sub-groups

- Sub-group B1- 10 specimen in control group without any medicaments on braided retraction cords.
- Sub-group B2- 10 specimen of braided retraction cords immersed for 20 minutes in 15.5% Ferric sulphate.
- Sub-group B3- 10 specimen of braided retraction cords immersed for 20 minutes in 100% Alum
- Sub-group B4- 10 specimen of braided retraction cords immersed for 20 minutes in 4% Epinephrine

3. GROUP C Sub-groups

- Sub-group C1- 10 specimen in control group without any medicaments on twisted retraction cords.
- Sub-group C2- 10 specimen of twisted retraction cords immersed for 20 minutes in 15.5% Ferric sulphate.
- Sub-group C3- 10 specimen of twisted retraction cords immersed for 20 minutes in 100% Alum
- Sub-group C4- 10 specimen of twisted retraction cords immersed for 20 minutes in 4% Epinephrine

EXPERIMENT TESTING

Estimation of fluid absorbency (HUMAN PLASMA) without incorporation of medicament

- 10 samples of control in each group were weighed in electronic analytical balance **(Fig 15)** This gave the Dry weight (which does not contain any medicaments).

- In order to obtain the wet weight of control in each subgroup, the specimens were immersed in human plasma for 20 minutes and weighed in electronic analytic balance (BR BIOCHEM, AS 220.R2 PLUS)(**Fig 16)**
- The amount of fluid absorbency among the control groups were determined as the difference of wet and dry weight in all groups

Estimation of fluid absorbency (HUMAN PLASMA) of Knitted, Braided and twisted cords after incorporation of medicament- 15.5% FeSO4

- To obtain the fluid absorbency after incorporation of medicament 15.5% FeSO4**(Fig 17)**, the specimens viz Group A subgroup A2, Group B subgroup B2, Group C subgroup C2 were immersed in human plasma for 20 minutes **(Fig 20)**
- The samples were pre-weighed and post-weighed, using electronic analytical balance (BR BIOCHEM, AS 220.R2 PLUS) to obtain the dry and wet weight respectively
- The difference in weight of retraction cord (knitted, braided, twisted) immersed in 15.5% Ferric Sulphate and weight obtained after immersion of same specimen in human plasma determines the amount of fluid absorbed after incorporation of medicament (15.5% Ferric sulphate) in respective Subgroups.**(Fig 21,22)**.

Estimation of fluid absorbency (HUMAN PLASMA) after incorporation of medicament- 100% Alum

- To obtain the fluid absorbency after incorporation of medicament 100 % Alum, the specimens viz Group A subgroup A3, Group B subgroup B3, Group C subgroup C3 were immersed in human plasma for 20 minutes **(Fig 18)**
- The samples were pre-weighed and post-weighed, using electronic analytical balance (BR BIOCHEM, AS 220.R2 PLUS) to obtain the dry and wet weight respectively.
- The difference in weight of retraction cord (knitted, braided, twisted) immersed in 100 % Alum and weight obtained after immersion of same specimen in human plasma determines the amount of fluid absorbed after incorporation of medicament(100% Alum) in respective Subgroups.

Estimation of Fluid absorbency (HUMAN PLASMA) after incorporation of medicament- 4% epinephrine

- To obtain the fluid absorbency after incorporation of medicament 4% epinephrine, the specimens the specimens viz Group A subgroup A4, Group B subgroup B4, Group C subgroup C4 were immersed in human plasma for 20 minutes **(Fig 19)**
- The samples were pre-weighed and post-weighed, using electronic analytical balance (BR BIOCHEM, AS 220.R2 PLUS) to obtain the dry and wet weight respectively.
- The difference in weight of retraction cord (knitted, braided, twisted) immersed in 4% epinephrine and weight obtained after immersion of same specimen in human plasma determines the amount of fluid absorbed after incorporation of medicament(4%Epinephrine) in respective Subgroups.

Fig 1 - Knitted retraction cord

Fig 2- Braided retraction cord

Fig 3 -Twisted retraction cord

Fig 4 -Ferric sulphate powder

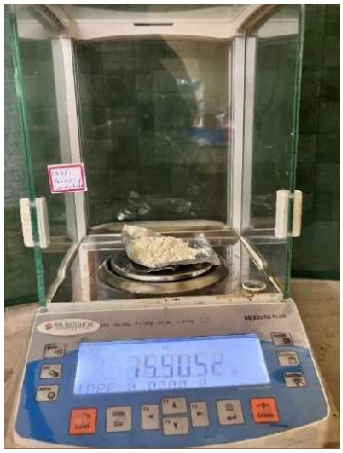


Fig 5 – 15mg of Ferric sulphate weighed on electronic analytic balance

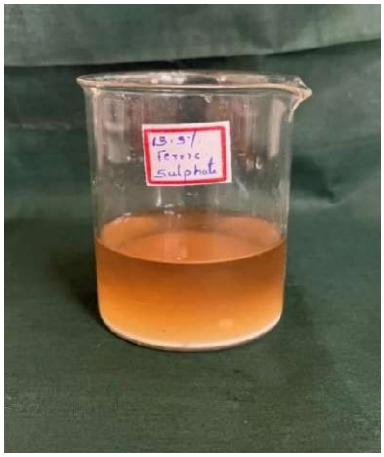


Fig 6 – Ferric sulphate solution

Fig 7 – Aluminium sulphate

Fig 8 – 100mg of aluminium sulphate weighed on electronic analytic balance

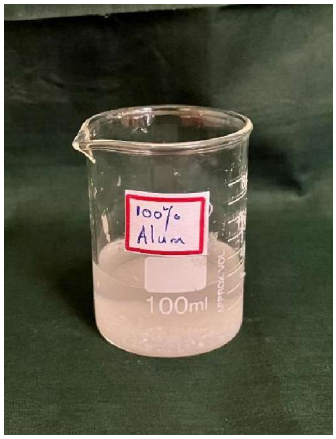


Fig -9 Aluminium crystals dissolved in 100 mal waters but residue crystals sediment at bottom of beaker

Fig 10 - Aluminium crystals heated around 60℃ on heating mantle to accelerate dissolution

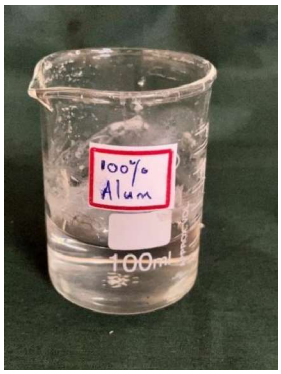


Fig 11 - Clear solution of 100% alum obtained

Fig 12 - 1 vial of 4% racemic epinephrine

Fig 13 – All three medicaments prepared and stored in plastic test tube on test tube stand

Fig 14- Human plasma

Fig 15 -Dry weight of retraction cord

Fig 16- Weight of control after immersing in human plasma

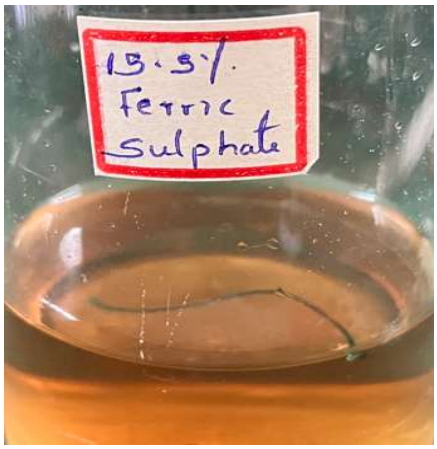


Fig 17 - Retraction cord immersed in 15.5% ferric sulphate

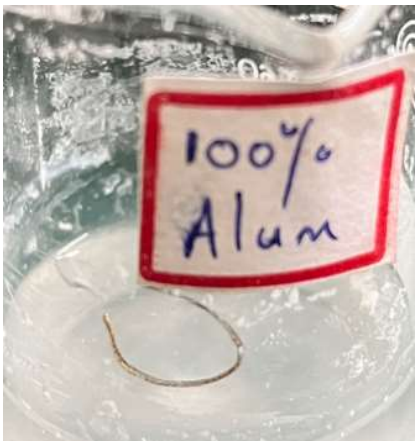


Fig 18 - Retraction cord immersed in 100% Alum

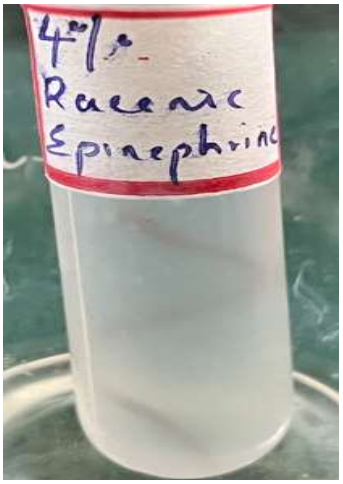


Fig 19- Retraction cord immersed in 4% epinephrine

Fig 20- Test specimen immersed in human plasma

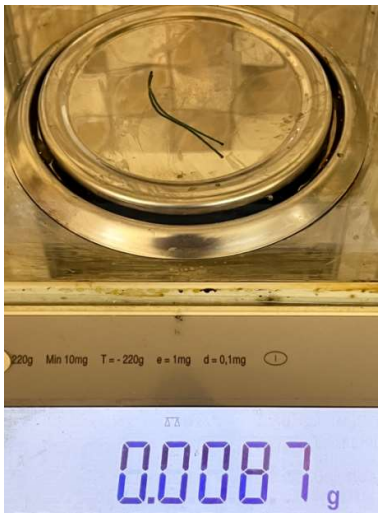


Fig 21 -Test specimen weighed in electronic analytical balance after immersing in medicaments

Fig 22 -Test specimen weighed in electronic analytical balance after immersing in human plasma

RESULT

Table 1: Weight of knitted retraction cord before immersing into human plasma (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	62	91	75	71
	66	85	75	72
	63	81	74	71
	64	85	77	70
	62	79	73	69
	67	88	77	70
	72	93	81	79
	66	89	76	71
	64	86	73	68
	62	87	70	68

Table 2: Weight of knitted retraction cord after immersing into human plasma (mg)

S No	Control (Untreated)	15.5% FeSO4 Treated	100% Alum treated	4% epinephrine treated
	154	267	190	166
	157	258	190	167
	163	259	189	169
	154	256	187	168
	157	261	193	169
	154	267	188	161
	154	258	194	163
	155	259	191	167
	152	256	189	166
	157	261	195	169

Table 3: Weight of braided retraction cord before immersing into human plasma (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	59	77	68	65
	56	76	67	63
	57	74	67	62
	61	73	66	65
	57	76	69	60
	61	78	70	66
	63	78	70	69
	63	77	71	67
	60	74	71	65
	61	75	70	65

Table 4: Weight of braided retraction cord after immersing into human plasma (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	134	190	176	155
	142	194	177	148
	139	195	174	146
	140	193	178	150
	141	201	189	149
	128	188	179	149
	138	178	175	144
	132	177	178	151
	143	197	183	154
	138	177	164	146

Table 5: Weight of twisted retraction cord before immersing into human plasma (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	59	81	70	67
	61	81	73	69
	62	79	70	67
	62	77	71	69
	66	78	71	68
	67	80	70	69
	69	83	76	71
	68	80	78	72
	65	76	72	69
	62	79	73	68

Table 6: Weight of twisted retraction cord after immersing into human plasma (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	156	240	189	169
	165	239	188	175
	161	238	188	171
	157	236	185	172
	168	241	188	173
	158	239	189	174
	159	240	187	168
	162	242	190	173
	154	247	194	172
	141	230	174	161

Table 7: Difference in the weight of knitted retraction cord after immersing into human plasma and before immersing into human plasma to obtain the amount of fluid absorption (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	81	194	105	94
	82	190	105	96
	82	189	103	96
	84	187	103	93
	87	190	103	97
	89	189	106	96
	77	190	105	88
	75	189	101	87
	75	187	100	89
	73	190	104	84

Table 8: Difference in the weight of braided retraction cord after immersing into human plasma and before immersing into human plasma to obtain the amount of fluid absorption (mg)

S No	Control (Untreated)	15.5% FeSO4 treated	100% alum treated	4% epinephrine treated
	56	150	100	73
	60	149	99	71
	62	150	100	72
	60	151	97	70
	60	149	98	74
	57	146	99	73
	63	150	98	76
	57	146	99	72
	62	153	100	71
	68	145	95	71

Table 9: Difference in the weight of twisted retraction cord after immersing into human plasma and before immersing into human plasma to obtain the amount of fluid absorption (mg)

S No	**Control (Untreated)**	**15.5% FeSO4 treated**	**100% alum treated**	**4% epinephrine treated**
	72	187	107	86
	77	180	106	88
	80	179	105	93
	76	178	104	89
	78	182	107	88
	76	188	104	87
	78	184	106	83
	77	183	104	81
	77	190	102	93
	79	185	105	84

STATISTICAL ANALYSIS

Data was analysed using the statistical package **SPSS 22.0** (SPSS Inc., Chicago, IL) and level of significance was set at **p<0.05**. **Descriptive statistics** was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using **Shapiro Wilkinson test**. **Inferential statistics** to find out the difference between and within the groups was done using STUDENT **T TEST and ONE WAY ANOVA and TUKEYS POST HOC TEST.**

Table 1: Showing the Descriptive Statistics with mean and SD

	N	Minimum	Maximum	Mean	Std. Deviation
Dry weight					
DFKRCweight	10	86.00	95.00	**89.6000**	3.30656
DFBRCweight	10	56.00	68.00	**60.5000**	3.53553
DFTRCweight	10	73.00	93.00	**81.7000**	5.67744
FeSO4					
DF**FeS**2KRC	10	187.00	190.00	**189.0000**	1.15470
DFFeS2BRC	10	145.00	153.00	**148.9000**	2.51440
DFFeS2TRC	10	158.00	191.00	**172.2000**	14.75579
ALUM					
DFALKRC	10	100.00	106.00	**103.5000**	1.90029
DFALBRC	10	95.00	100.00	**98.5000**	1.58114
DFALTRC	10	90.00	107.00	**101.6000**	6.11374
EPI					
DFEpiKRC	10	76.00	80.00	**81.8000**	1.26930
DFEpiBRC	10	69.00	74.00	**71.6000**	1.50555
DFEpiTRC	10	73.00	89.00	**77.5000**	5.47317
Valid N (listwise)	10				

Table 1 shows the mean value and standard deviation of all the groups

Dry weight Knitted Retraction cord >Twisted Retraction cord >Braided Retraction cord
FeSO4 Knitted Retraction cord >Twisted Retraction cord >Braided Retraction cord

ALUM Knitted Retraction cord >Twisted Retraction cord >Braided Retraction cord

EPI Knitted Retraction cord >Twisted Retraction cord >Braided Retraction cord

Table 2: Results of the Independent Samples Test between dry and Plasma weight										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	P value. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
KRC	Equal variances assumed	.019	.892	-66.579	18	.000	-89.60000	1.34578	-92.42737	-86.77263
	Equal variances not assumed			-66.579	17.982	.000	-89.60000	1.34578	-92.42758	-86.77242
BRC	Equal variances assumed	3.211	.090	-28.232	18	.000	-60.50000	2.14295	-65.00216	-55.99784
	Equal variances not assumed			-28.232	14.488	.000	-60.50000	2.14295	-65.08169	-55.91831
TRC	Equal variances assumed	.671	.423	-31.842	18	.000	-81.70000	2.56580	-87.09055	-76.30945
	Equal variances not assumed			-31.842	17.332	.000	-81.70000	2.56580	-87.10547	-76.29453

Table 2 - Knitted Retraction cord, Twisted Retraction cord, Braided Retraction cord were compared for the difference in dry weight and plasma weight com

Results of the Independent Samples Test between dry and Plasma weight shows a significant difference with a *p*-value less than 0.05

Table 7: Results of one-way ANOVA for control					
DFweight					
	Sum of Squares	df	Mean Square	F	P value
Between Groups	4528.867	2	2264.433	122.035	.000
Within Groups	501.000	27	18.556		
Total	5029.867	29			

Table 3 Depicted the one-way ANOVA values compared between dry weight and plasma weight of the three different control groups

Results of the One-way ANOVA showing the difference between dry and Plasma weight of the three different groups shows a significant difference with a *p*-value less than 0.05

Table 4 Results of the Multiple Comparisons using Tuckey's test for control						
Dependent Variable: DFweight Tukey HSD						
(I) group	(J) group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
KRC	BRC	29.10000*	1.92642	.000	24.3236	33.8764
	TRC	7.90000*	1.92642	.001	3.1236	12.6764
BRC	KRC	-29.10000*	1.92642	.000	-33.8764	-24.3236
	TRC	-21.20000*	1.92642	.000	-25.9764	-16.4236
TRC	KRC	-7.90000*	1.92642	.001	-12.6764	-3.1236
	BRC	21.20000*	1.92642	.000	16.4236	25.9764
*. The mean difference is significant at the 0.05 level.						

Table 4 Depicted the Tuckey's test values compared between dry weight and plasma weight of the three different control groups

Results of the Multiple Comparisons using Tuckey's test showing the difference between dry and Plasma weight of the three different control groups shows a significant difference with a *p*-value less than 0.05

Comparison of difference in dry weight and plasma weight showed that

Knitted Retraction cord C >Twisted Retraction cord >Braided Retraction cord

Table 5: Results of one-way ANOVA					
DFFeSO4					
	Sum of Squares	df	Mean Square	F	P value
Between Groups	8110.467	2	4055.233	53.976	.000
Within Groups	2028.500	27	75.130		
Total	10138.967	29			

Table 5: Depicted Results of the One-way ANOVA showing the difference between dry and Plasma weight of the three different groups

FESO4 shows a significant difference with a *p*-value less than 0.05

Table 6 Results of the Multiple Comparisons using Tuckey's test						
Dependent Variable: DFFeSO4 Tukey HSD						
(I) group	(J) group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
KRC	BRC	40.10000*	3.87633	.000	30.4890	49.7110
	TRC	16.80000*	3.87633	.001	7.1890	26.4110
BRC	KRC	-40.10000*	3.87633	.000	-49.7110	-30.4890
	TRC	-23.30000*	3.87633	.000	-32.9110	-13.6890
TRC	KRC	-16.80000*	3.87633	.001	-26.4110	-7.1890
	BRC	23.30000*	3.87633	.000	13.6890	32.9110
*. The mean difference is significant at the 0.05 level.						

Table 6: Results of the Multiple Comparisons using Tuckey's test showing the difference between dry and Plasma weight of the three different FeSO4 groups shows a significant difference with a *p*-value less than 0.05

FeSO4 - Knitted Retraction cord C >Twisted Retraction cord >Braided Retraction cord

Table 7 Results of one-way ANOVA for Alum					
DFAL					
	Sum of Squares	df	Mean Square	F	P value
Between Groups	127.400	2	63.700	4.394	.022
Within Groups	391.400	27	14.496		
Total	518.800	29			

Table 7: Results of the One-way ANOVA showing the difference between dry and Plasma weight of the three different groups Alum shows a significant difference with a *p*-value less than 0.05

Table 8 Results of the Multiple Comparisons using Tuckey's test						
Dependent Variable: DFAL Tukey HSD						
(I) group	(J) group	Mean Difference (I-J)	Std. Error	P value.	95% Confidence Interval	
					Lower Bound	Upper Bound
KRC	BRC	5.00000*	1.70272	.018	.7782	9.2218
	TRC	1.90000	1.70272	.513	-2.3218	6.1218
BRC	KRC	-5.00000*	1.70272	.018	-9.2218	-.7782
	TRC	-3.10000	1.70272	.182	-7.3218	1.1218
TRC	KRC	-1.90000	1.70272	.513	-6.1218	2.3218
	BRC	3.10000	1.70272	.182	-1.1218	7.3218
*. The mean difference is significant at the 0.05 level.						

Table 8: Results of the Multiple Comparisons using Tuckey's test showing the difference between dry and Plasma weight of Alum in Knitted retraction cord and Braided retraction cord groups showed a statistically significant difference with a *p*-value less than 0.05

But when Braided retraction cord was compared with Twisted retraction cord showed no such statistically significant difference.

ALUM: Knitted retraction cord > Braided retraction cord

Table 9 Results of one-way ANOVA

DFEpi

	Sum of Squares	df	Mean Square	F	P value
Between Groups	524.467	2	262.233	23.252	.000
Within Groups	304.500	27	11.278		
Total	828.967	29			

Table 9: Results of the One-way ANOVA showing the difference between weight of epinephrine and Plasma weight of the three different groups shows a significant difference with a *p*-value less than 0.05

Table 10 Results of the Multiple Comparisons using Tuckey's test

Dependent Variable: DFEpi

Tukey HSD

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
KRC	BRC	5.90000*	1.50185	.002	2.1763	9.6237
	TRC	-4.30000*	1.50185	.021	-8.0237	-.5763
BRC	KRC	-5.90000*	1.50185	.002	-9.6237	-2.1763
	TRC	-10.20000*	1.50185	.000	-13.9237	-6.4763
TRC	KRC	4.30000*	1.50185	.021	.5763	8.0237
	BRC	10.20000*	1.50185	.000	6.4763	13.9237

*. The mean difference is significant at the 0.05 level.

Table 10: Results of the Multiple Comparisons using Tuckey's test showing the difference between dry and Plasma weight of Epinephrine three different control groups shows a significant difference with a *p*-value less than 0.05

Epinephrine: Knitted retraction cord >Twisted retraction cord >Braided retraction cord

Table 11 ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
KRC	Between Groups	76596.200	3	25532.067	5839.609	.000
	Within Groups	157.400	36	4.372		
	Total	76753.600	39			
BRC	Between Groups	46552.075	3	15517.358	2631.300	.000
	Within Groups	212.300	36	5.897		
	Total	46764.375	39			
TRC	Between Groups	55337.075	3	18445.692	232.533	.000
	Within Groups	2855.700	36	79.325		
	Total	58192.775	39			

Table 11: Results of the One-way ANOVA showing the between group comparison between dry and Plasma weight of the different groups shows a significant difference with a *p*-value less than 0.05

Table :12 Multiple Comparisons

Tukey HSD

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
						Lower Bound	Upper Bound
KRC	plasma	FeSO4	-99.40000*	.93512	.000	-101.9185	-96.8815
		Alum	-13.90000*	.93512	.000	-16.4185	-11.3815
		Epi	12.10000*	.93512	.000	9.5815	14.6185
	FeSO4	plasma	99.40000*	.93512	.000	96.8815	101.9185
		Alum	85.50000*	.93512	.000	82.9815	88.0185
		Epi	111.50000*	.93512	.000	108.9815	114.0185
	Alum	plasma	13.90000*	.93512	.000	11.3815	16.4185
		FeSO4	-85.50000*	.93512	.000	-88.0185	-82.9815
		Epi	26.00000*	.93512	.000	23.4815	28.5185
	Epi	plasma	-12.10000*	.93512	.000	-14.6185	-9.5815
		FeSO4	-111.50000*	.93512	.000	-114.0185	-108.9815
		Alum	-26.00000*	.93512	.000	-28.5185	-23.4815

BRC	plasma	FeSO4	-88.40000*	1.08602	.000	-91.3249	-85.4751
		Alum	-38.00000*	1.08602	.000	-40.9249	-35.0751
		Epi	-11.10000*	1.08602	.000	-14.0249	-8.1751
	FeSO4	plasma	88.40000*	1.08602	.000	85.4751	91.3249
		Alum	50.40000*	1.08602	.000	47.4751	53.3249
		Epi	77.30000*	1.08602	.000	74.3751	80.2249
	Alum	plasma	38.00000*	1.08602	.000	35.0751	40.9249
		FeSo	-50.40000*	1.08602	.000	-53.3249	-47.4751
		Epi	26.90000*	1.08602	.000	23.9751	29.8249
	Epi	plasma	11.10000*	1.08602	.000	8.1751	14.0249
		FeSO4	-77.30000*	1.08602	.000	-80.2249	-74.3751
		Alum	-26.90000*	1.08602	.000	-29.8249	-23.9751
TRC	plasma	FeSO4	-90.50000*	3.98309	.000	-101.2274	-79.7726
		Alum	-19.90000*	3.98309	.000	-30.6274	-9.1726
		Epi	-.10000	3.98309	1.000	-10.8274	10.6274

	FeSO4	plasma	90.50000*	3.98309	.000	79.7726	101.2274
		Alum	70.60000*	3.98309	.000	59.8726	81.3274
		Epi	90.40000*	3.98309	.000	79.6726	101.1274
	Alum	plasma	19.90000*	3.98309	.000	9.1726	30.6274
		FeSO4	-70.60000*	3.98309	.000	-81.3274	-59.8726
		Epi	19.80000*	3.98309	.000	9.0726	30.5274
	Epi	plasma	.10000	3.98309	1.000	-10.6274	10.8274
		FeSO4	-90.40000*	3.98309	.000	-101.1274	-79.6726
		Alum	-19.80000*	3.98309	.000	-30.5274	-9.0726
*. The mean difference is significant at the 0.05 level.							

Table 12: Results of the Multiple Comparisons using Tuckey's test showing the difference between dry and Plasma weight of the Knitted retraction cord in the four different control groups shows a significant difference with a *p*-value less than 0.05 **except for plasma and epinephrine for the Twisted retraction cord**

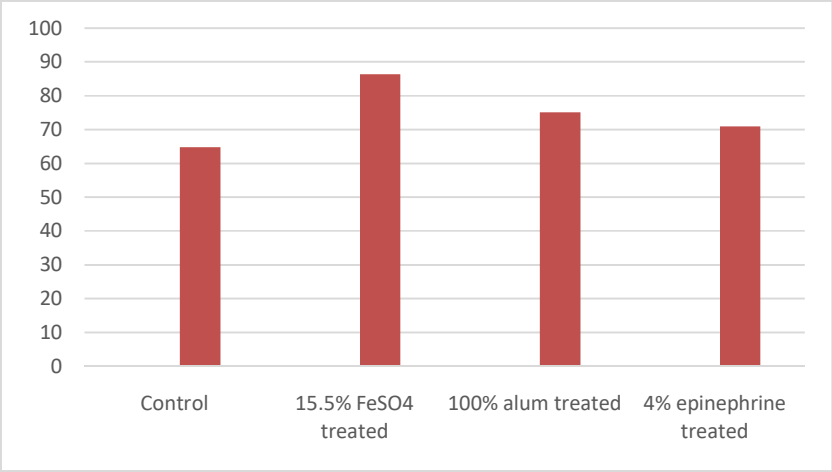
Dry weight Knitted Retraction cord C >Twisted Retraction cord >Braided Retraction cord

FeSO4 Knitted Retraction Cord C >Twisted Retraction cord >Braided Retraction cord

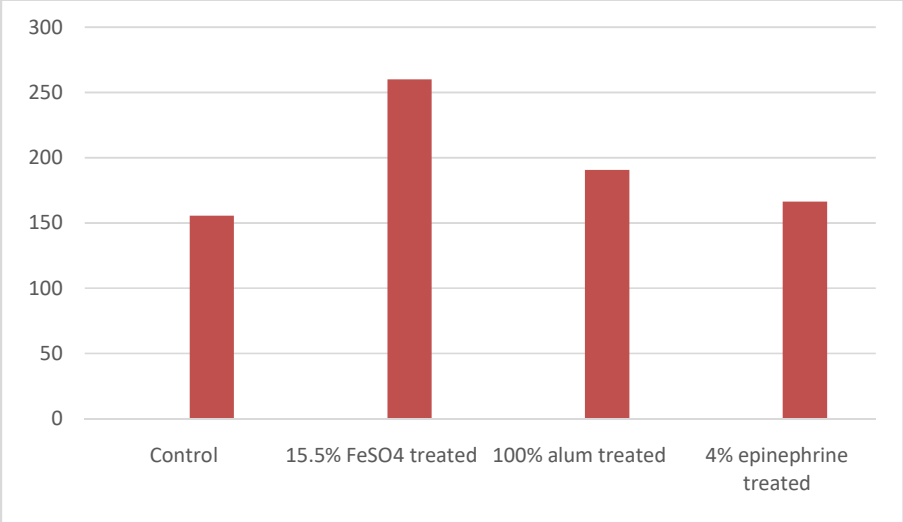
ALUM Knitted Retraction cord C >Twisted Retraction cord >Braided Retraction cord

EPI Knitted Retraction cord C >Twisted Retraction cord >Braided Retraction cord

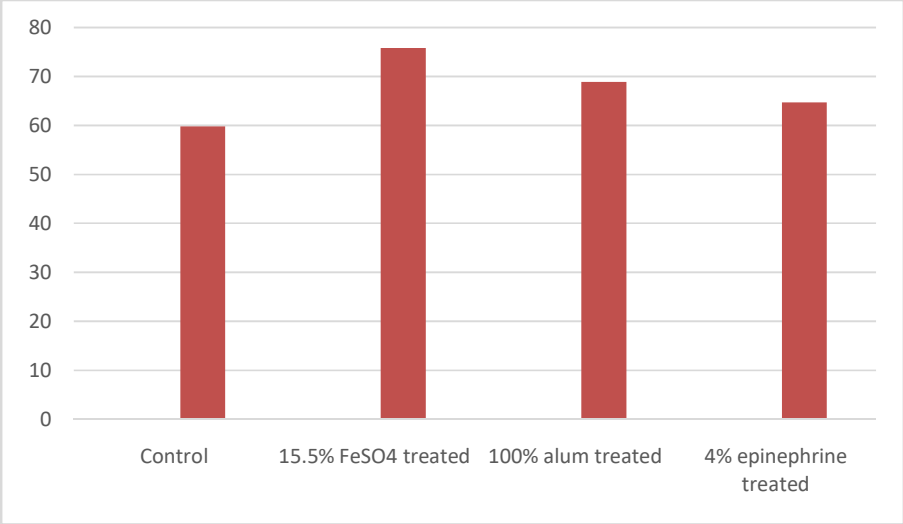
Graph 1 – Representing weight of knitted retraction cord before immersing into human plasma



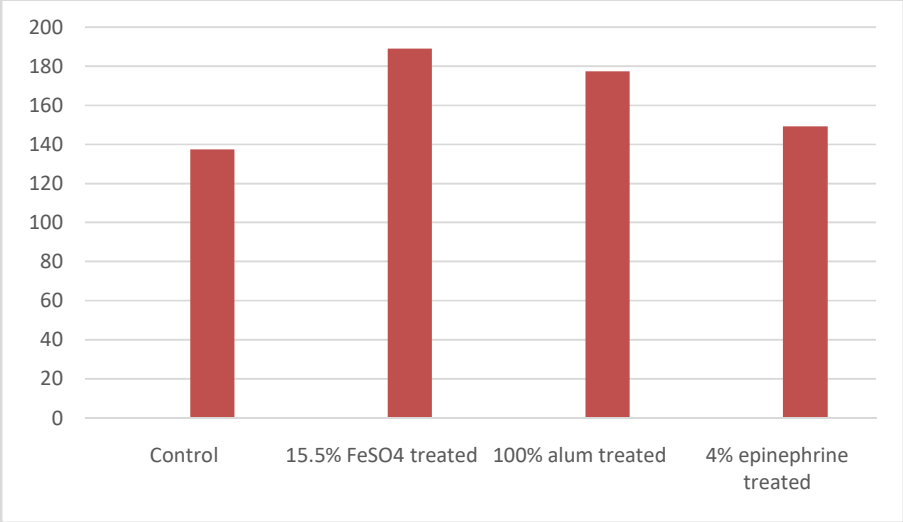
Graph 2 – Representing weight of knitted retraction cord after immersing into human plasma



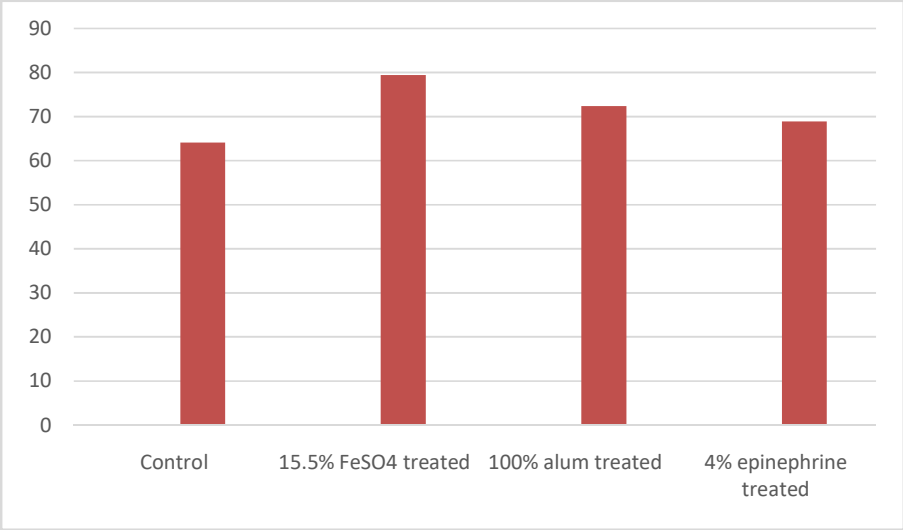
Graph 3- Representing weight of braided retraction cord before immersing into human plasma



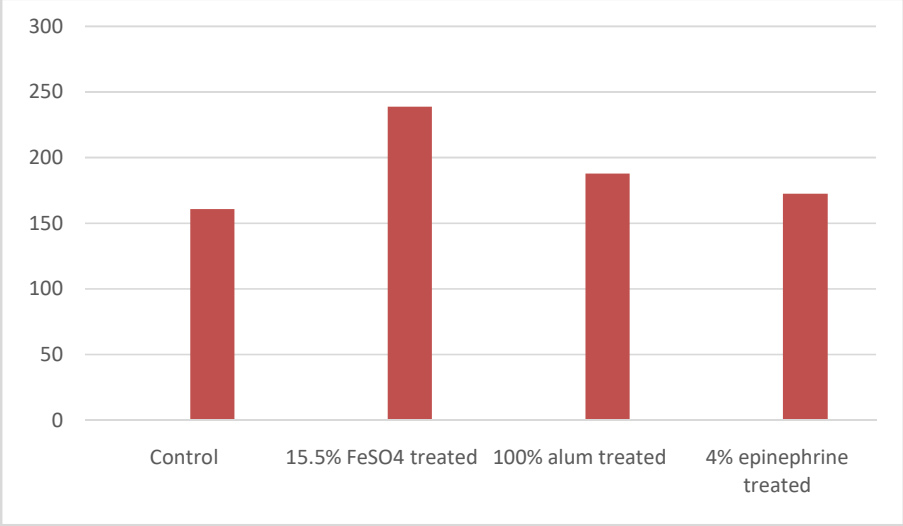
Graph 4: Representing weight of braided retraction cord after immersing into human plasma



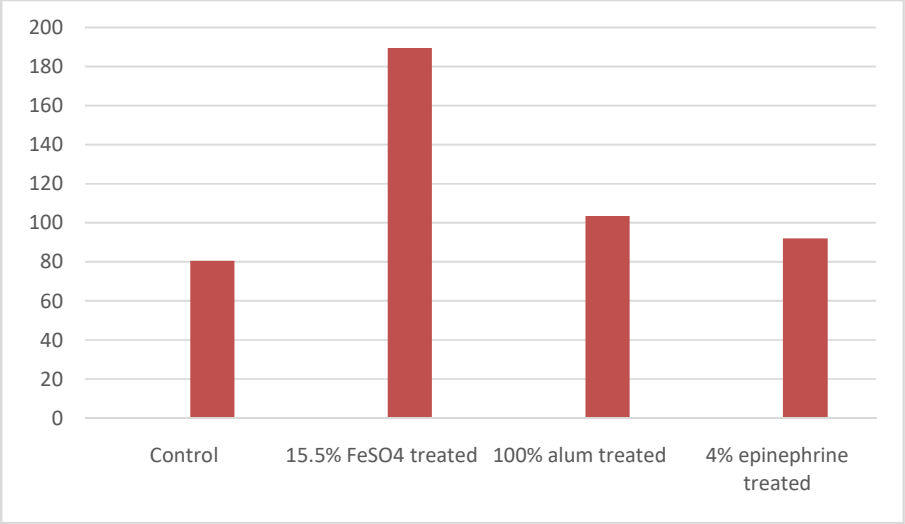
Graph 5- Representing weight of twisted retraction cord before immersing into human plasma



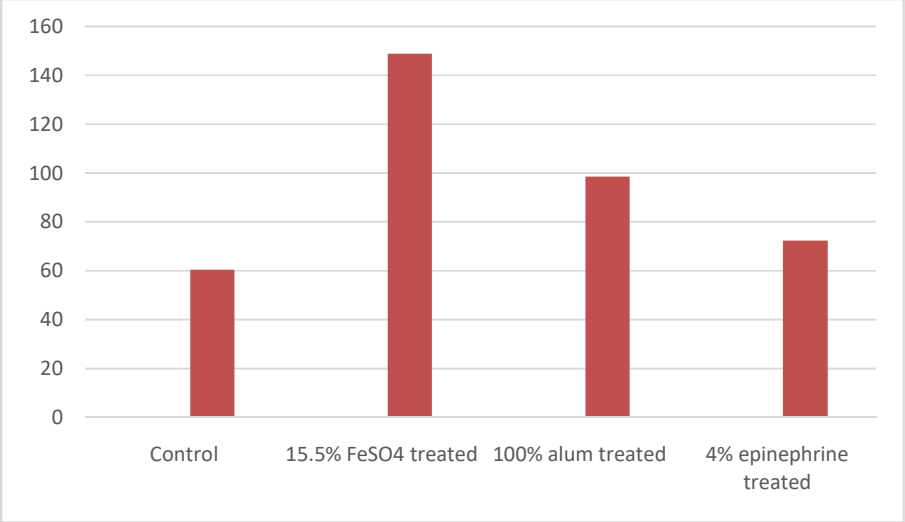
Graph 6- representing weight of twisted retraction cord after immersing into human plasma



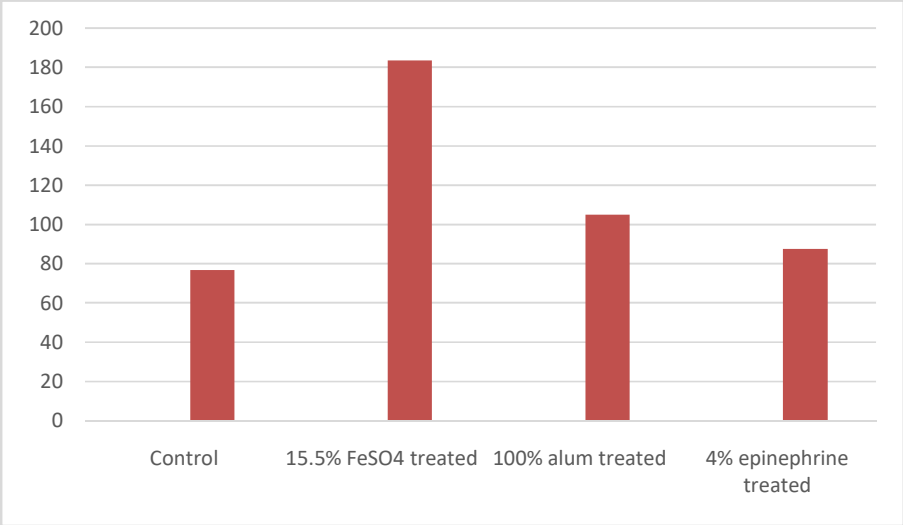
Graph 7- Representing difference in the weight of knitted retraction cord after immersing into human plasma and before immersing into human plasma to obtain the amount of fluid absorption



Graph 8- Representing difference in the weight of braided retraction cord after immersing into human plasma and before immersing into human plasma to obtain the amount of fluid absorption



Graph 9- Representing difference in the weight of twisted retraction cord after immersing into human plasma and before immersing into human plasma to obtain the amount of fluid absorption



DISCUSSION

DISCUSSION

Gingival tissue management in impression making is one of the most challenging aspects of crown and bridge treatment. This includes placing a retraction cord between the gingival tissues and the prepared tooth which will push away the gingival tissues from the prepared tooth margins so that the finish lines can be recorded precisely. No matter, the impression made conventionally with impression material or with a digital impression technique, the tooth margins need to be captured accurately to assure an excellent marginal fit for a lab fabricated restoration.[41]

There are many techniques to achieve retraction of gingival tissue, including retraction cords, chemical reagents, electrosurgery, laser tissue sculpting and hemostatic materials that displace tissue atraumatically. In most cases, gingival retraction cord is the highly effective and most commonly used method[37]

A clear dry field, free of blood is the most important element necessary to obtain a good impression. Sulcular bleeding must be controlled before taking the impression. Adequate retraction must be accomplished in all subgingival areas to guarantee that the impression material or digital scan registers beyond the preparation margin.[39]

According to Benson et al, gingival retraction measures fall into one of four major categories: (1) simple mechanical methods, (2) chemo-mechanical methods, (3) rotary gingival curettage, and (4) electro-surgical methods. [12]

Of these four categories, the chemo-mechanical method of gingival retraction is the most widely used. The mechanical aspect of this method involves placement of a string into the gingival sulcus to displace the tissues physically.

The chemical aspect involves treatment of the string with one or more of a number of compounds that will induce temporary shrinkage of the tissues and should also control the hemorrhage and fluid seepage that often accompany sub gingival margin preparation.

1. Mechanical Retraction – Cord

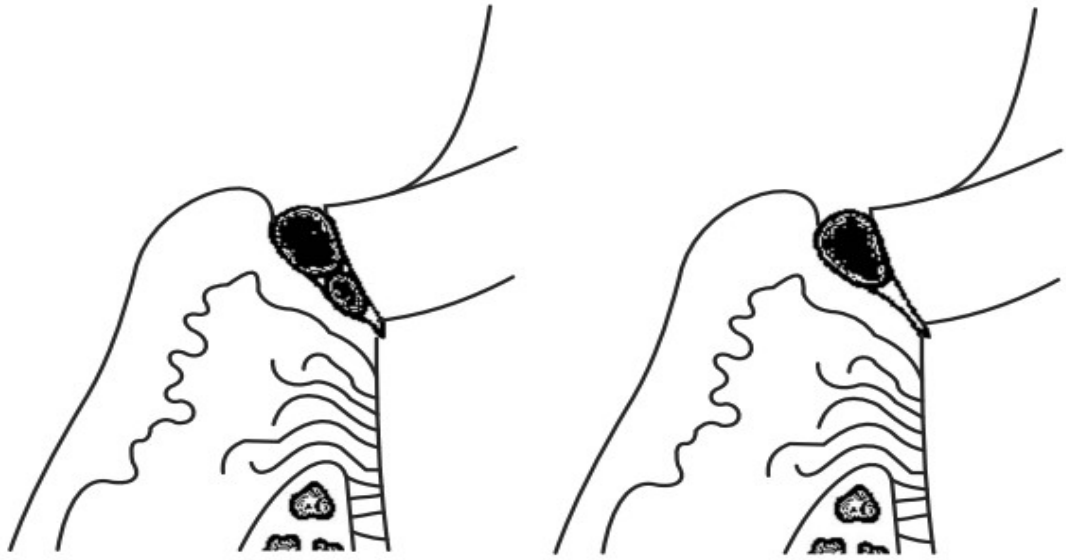
Clinicians place retraction cords by using cord-packing instruments. Some manufacturers make purpose-designed packing devices that have smooth, non-serrated circular heads while other manufacturers make devices with serrated circular heads for use with braided cords. The thin edges of these serrated circular heads sink into the cord, and the fine serrations keep it from slipping off and cutting the gingival attachment.

The advantage of using a cord is that it is inexpensive and can help in achieving varying degrees of retraction. But cords can be painful and uncomfortable for the patient. Also, the sulcus usually collapses soon after the removal of the cord. Hemostasis achieved is limited and the placement of the cord in the sulcus is time consuming. There are two main techniques for mechanical retraction, namely, single-cord and double-cord technique

Single-cord versus dual-cord technique:

Clinicians may place untreated plain cord safely in the sulcus for periods of five to 30 minutes, but the pressure of cords alone will not control sulcular hemorrhage. They provide more effective control of gingival hemorrhage when used in conjunction with medicaments than when used with no medicaments.[7]

The use of a single retraction cord usually provides inadequate gingival retraction. The dual-cord technique in which the first cord remains in the sulcus reduces the tendency for the gingival cuff to recoil and partially displace the setting impression material



Double cord technique

Single cord technique

2. Electrosurgery

An electrosurgery unit may be used for tissue removal before impression making. But electrosurgery is not recommended as the concentrated electrical current at the tip of electrodes can generate heat, which may cause osseous or mucosal necrosis and also there is a potential for gingival recession after treatment.[29]

3. Rotary curettage

It involves the use of a high-speed turbine to cut the gingival tissue quickly and create a trough around the margins. It helps to reduce and contour the gingival outline. For healthy, disease-free tissue around natural teeth, rotary curettage has minimum effect on gingival margin heights. However, for periodontally weak tooth, it may cause deepening of the sulcus[29]

Materials used for gingival retraction should satisfy the following criteria

1.Use of retraction cords concomitant with a medicament that provides sufficient lateral and vertical displacement of the gingival tissue providing tissue shrinkage, control of hemorrhage and fluid seepage. This allows the clinician to make an adequate impression of the finish line of the prepared tooth. Sufficient room must be provided in a lateral direction to provide adequate bulk of impression material to resist tearing.

2. Use of the materials which should not cause any significant irreversible tissue damage. It should be kept in mind that even the most meticulous retraction procedure results in tissue injury.' However, the damage should be reversible, and complete clinical and histologic healing should occur within 2 weeks. A slight apical positioning of the marginal gingiva can be expected, but it should only be in the order of 0.1 mm, which would be unlikely to be clinically significant in most instances.

3. Use of the materials which should not produce any potentially systemic effects and harm. The impregnated retraction cord is placed in the gingival sulcus, where the medicament may be absorbed into the systemic circulation. The amount of absorption significantly depends on the medicament used. Special care should be given to prevent adverse reactions from local anesthetics, systemic medications, endogenous secretions, and the patient's cardiovascular status[12]

Gingival Hemostatic Agents

Astringents and vasoconstrictors are commonly used for pre-soaking retraction cords. Astringents usually exert their action topically on the injured mucosal surface, whereas the hemostatic effect of vasoactive molecules is achieved through a direct vascular action. Various drugs are used for gingival displacement in retraction cord. They include

1. 8% and 4% Racemic epinephrine
2. 100% Alum solution (potassium aluminum sulfate)
3. 5% and 25% Aluminum chloride solutions
4. Ferric sulfate 15.5% (Monsel's solution)
5. 0.1% and 40% zinc chloride solution
6. 20% and 100% Tannic acid solution
7. 45% Negatol solution.

1. Epinephrine

Azzi et al, fisher et al, Nemetz et al [10,2,5] concluded that Epinephrine used in concentrations of 0.1% and 8% to saturate the retraction cord creates local vasoconstriction of the gingival tissues and seems to have fairly minimal systemic effects if used in an intact sulcus.

There is evidence of increased heart rate and elevated blood pressure when epinephrine is applied to lacerated gingiva and the capillary bed is exposed. This may occur in patients who do not fall into the contraindicated categories[6]

Pelzer et al[6] stated in his studies stated 4% racemic epinephrine-impregnated retraction cords causes less elevation of blood pressure than 8% racemic epinephrine cords. Although the elevations in blood pressure from 8% cord occur within a narrow range, this range may be hazardous to cardiac patients: Therefore, 4% racemic epinephrine cord should be used, thus a desirable amount of tissue retraction is produced by 4% racemic epinephrine cord

Epinephrine syndrome has also been reported in patients with none of the contraindications noted previously. The syndrome includes tachycardia, increased respirations, increased blood pressure, nervousness, fright on occasion, and postoperative depression.[2]

The symptoms appear either after the cord has been in for a few minutes or shortly after removal. It has been recommended that 0.1% epinephrine should be used rather than the 8% solution

Administration of epinephrine is contraindicated in patients with hyperthyroidism, and those receiving monoamine oxidase inhibitors for treatment of depression. In these patients, severe hypertensive episodes may occur because of slowed inactivation of epinephrine. Epinephrine is contraindicated in diabetic patients because it increases blood glucose by inhibiting glucose uptake in peripheral tissues and by promoting glycogenolysis. Diabetic patients who use oral contraceptives may have increased insulin requirements, which complicates the situation further.

2. Alum

According to **Benson et al [12]** Potassium aluminium sulfate in a 100% concentration has been shown to be only slightly less effective in shrinking the gingival tissues than epinephrine, and it shows good tissue recovery. Only slight tissue injury was noted in a lo-minute application, and that completely healed in 10 days[3]

3. **Aluminium chloride**

It is one of the most commonly used chemicals in concentrations of 5% and 25%. Studies have shown that solutions stronger than 10% can produce local tissue destruction. There are no known contraindications and minimal systemic effects[2,7]

4. Ferric sulfate

Ferric subsulfate, also known as Monsel's solution, has been advocated for use in gingival displacement. It is slightly more effective than epinephrine in gingival displacement and tissue recovery is good.[2,3]

15.5% FeSO4 used for tissue displacement does not traumatize the tissue as noticeably, and healing is more rapid than with aluminium chloride. Ferric sulfate is compatible with aluminium chloride but not with epinephrine[2]. Ferric sulfate coagulates blood so quickly when placed against the cut tissue.. The recommended use time is 1 to 3 minutes, but can be used for 10 to 20 minutes

According to studies by **Ahmadzadeh A et al**[42] biologic effects of 15.5% ferric sulfate solution showed satisfactory tissue changes

5. **Zinc chloride**

Zinc chloride (bitartrate) has been used in 8% and 40% solutions. Gingival displacement effectiveness of the 8% solution is about equal to that of epinephrine, while the 40% solution is a little more effective[1]

6. Tannic acid

Tannic acid (20% and 100%) is less effective than epinephrine but shows very good tissue recovery[2]

7. Negatol solution

Negatol solution is a 45% condensation product of meta cresol sulfonic acid and formaldehyde. It is highly acidic and decalcifies teeth in both 10% and 100% so1utions[2]

The present in vitro study compared and evaluated the amount of fluid absorption on three different types of retraction cords – Knitted (Smart cord) -GROUP A,braided (LD cords) - GROUP B, and Twisted (Gingi Pak Z twist) - GROUP C of size 00 pre and post incorporation of medicaments (15.5% Ferric Sulfate and 100% Alum and 4% Racemic Epinephrine).

A total of **120** specimens were prepared and assigned to three groups; GROUP A, GROUP B and GROUP C and each group was assigned 40 specimens respectively.

Each group was divided into 4 subgroups as follows

GROUP A- Subgroup (A1, A2, A3, A4)

GROUP B - Subgroup (B1, B2, B3, B4)

GROUP C - Subgroup (C1, C2, C3, C4)

Subgroup (A1, B1, C1) - Control specimens of knitted, braided and twisted retraction cord respectively (not immersed in any medicament)

Subgroup (A2, B2, C2) – Test specimen of knitted, braided and twisted retraction cord respectively after immersing in medicament – 15.5% Ferric sulphate

Subgroup (A3, B3, C3) – Test specimen of knitted, braided and twisted retraction cord respectively after immersing in medicament – 100% Alum

Subgroup (A4, B4, C4) – Test specimen of knitted, braided and twisted retraction cord respectively after immersing in medicament – 4% epinephrine

Each Group (A, B, C) contained 40 samples out of which each subgroup contained 10 specimens each.

Sub group (A1, B1, C1- Controls from each group) were weighed on electronic analytic balance to attain the dry weight (control). To obtain the wet weight, these specimens were immersed into human plasma for 20 minutes and weighed again. To attain the amount of fluid

absorbency, the difference between the weights after immersing in Human plasma (wet weight) and dry weight was calculated.

Sub group (A2, B2, C2-10 samples each) were incorporated with medicament 15.5% Ferric Sulphate by immersing for 20 minutes followed by immersing into human plasma for 20 minutes and weighed on electronic analytic balance. The difference in weights of medicated cords, post and pre insertion in human plasma gives the amount of fluid absorbed.

Sub group (A3, B3, C3-10 samples each) were incorporated with medicament 100% Alum by immersing for 20 minutes followed by immersing into human plasma for 20 minutes and weighed on electronic analytic balance. The difference in weights of medicated cords, post and pre insertion in human plasma gives the amount of fluid absorbed.

Sub group (A4, B4, C4-10 samples each) were incorporated with medicament 4% Epinephrine by immersing for 20 minutes followed by immersing into human plasma for 20 minutes and weighed on electronic analytic balance. The difference in weights of medicated cords, post and pre insertion in human plasma gives the amount of fluid absorbed

One way ANOVA was done to compare the difference between groups. Multiple comparison was done by post-hoc test. The results of the Multiple Comparisons using Tuckey's test shows the difference between groups and states that for control groups (without any medicaments) knitted retraction cord **89.6mg (3.30)** showed maximum fluid absorption and least was found for braided retraction cord **60.5mg (3.53).** After immersing in medicaments, 15.5% FeSO4 incorporated knitted retraction cord **189mg (1.15)** showed maximum absorption of fluids with least for braided retraction cord

For medicament Alum, both knitted retraction cord and twisted retraction cord showed similar amount of fluid absorbency **103.5mg (1.9)** and **101.6mg (6.11)** respectively with *p* value not significant >0.05

With medicament Epinephrine also, knitted retraction cord **81.8mg (5.47)** showed maximum absorption of fluids and least was found for braided retraction cord **71.6mg (1.50)**

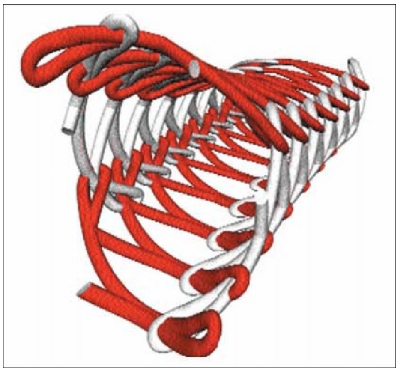
In the study human plasma was used to assess fluid absorbency as suggested by **Curtis et al**, which stated that human plasma contains proteins similar to crevicular fluid and blood[14]

immersed into the medicaments (15.5% Ferric sulfate, 100% Alum, 4% epinephrine) for 20 mins

The control group specimens and the test group were pre and posts weighed after immersing into human plasma for 20 mins using electronic analytical balance. the study was standardized accordingly with **Fischer et al and Gilmore et al** stating, cords saturated with medicaments can be safely left in the sulcus for as long as 20 minutes without adverse effect[2,3]

Knitted retraction cord impregnated with medicament 15.5% FeSO4 exhibited maximum fluid absorption substantiating the earlier studies of **Jokstad et al**, where he compared the knitted cords and twined cords, and he found that the knitted cords performed better[21]

This phenomenon may be attributed to the fact that, knitted retraction cords may have chain like interlocking loops which gives them an added advantage of bending multidirectional passively. The knitted retraction cord is longitudinally elastic, there by avoiding the tendency to become dislodged once packed. The knitted retraction cord is also transversely resilient, thereby tending to better conform to the gingival sulcus as well as better absorption of fluids. Henceforth it showed maximum fluid absorbency reinstating earlier studies.



Knitted retraction cord

This study revealed that the consistency of gingival retraction cord, twisted, braided or knitted, seems to be more important than the medicament. It is not surprising that the consistency of retraction cord has been associated with packing easiness and cord fraying

15.5 % Ferric Sulphate acts by forming ferric ion-protein complex on contact with blood. It forms agglutinated protein complex which seals the damaged vessels mechanically, thus producing hemostasis. This feature along with the molecular configuration of ferric sulphate crystals may propel increased fluid absorption onto the cords thereby accelerating diffusion. Also, it was proved in the literature by **Vishnubhotla et al** that 15.5% $FeSO_4$ medicament gave better hemostasis by a weak vasoconstrictor effect in addition to precipitation of tissue proteins with tissue contraction, inhibited transcapillary movements of plasma proteins, and subsequent arrest of capillary bleeding and hence is a better medicament for gingival retraction.

In all the groups evaluated, the medicament epinephrine showed the least diffusion onto the cords. It may be due to the increased molecular size of epinephrine which holds 9 carbon atoms, 13 hydrogen atoms , 1nitrogen atom and 3 oxygen atoms with a molecular mass of 183.204 Da which prevents proper penetration on to the cords.

The study proved that braided retraction cords have limited fluid absorbency, this is in accordance with previous study by Fischer et al. This demerit may be due to the fact that fibers in braided cords are weaved closely together and the spaces between the fibers are quite small when compared to knitted and thus smaller capacity for soaking up and retaining liquids.

The limitation of the present study was that it was carried out in vitro, which may not simulate the complete oral biological environment. Also, there could be oral fluids like saliva and blood in the oral cavity which would alter the properties of the materials when used clinically. Thus, further in- vivo studies may be required to confirm the present in-vitro findings

CONCLUSION

CONCLUSION

Within the limitations of the study, the following conclusions are drawn:

- There is a significant association between the type of retraction cords and medicaments in absorbing fluids.
- Medications for retraction showed clinically acceptable and significant absorbency onto retraction cords which may enhance retraction
- Knitted retraction cord showed maximum fluid absorption and least was found for braided retraction cord without medicaments.
- After immersing in of 15.5% FeSO4 also, knitted retraction cord showed maximum absorption of fluids and least was found for braided retraction cord.
- With medicament 4% Epinephrine, knitted retraction cord showed maximum absorption of fluids and least was found for braided retraction cord.
- For medicament 100% Alum, both knitted retraction cord and twisted retraction cord showed similar amount of fluid absorbency.
- 15.5% FeSO4 medicament showed maximum absorption into cords, irrespective of the type of retraction cords followed by 100% Alum and 4% epinephrine.

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BIBLIOGRAPHY

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ANNEXURES

ST. GREGORIOS DENTAL COLLEGE
UNDER THE MANAGEMENT OF MJSCE TRUST, PUTHENCRUZ
CHELAD , KOTHAMANGALAM, ERNAKULAM DIST, KERALA - 686681

SGDC/152/2021/4014 17/02/2021

ETHICAL CLEARANCE CERTIFICATE

To,

Dr. Jinson James
St. Gregorios Dental College
Chelad, Kothamangalam

Dear Dr. Jinson James

Subject: Ethics Committee Clearance-reg

Protocol: A comparative evaluation of three hemostatic medicaments on the fluid absorbency of different types of retraction cords-An in-vitro study.

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

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

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

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

St. Gregorios Dental College * Chelad - 686 681 *

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Secretary

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LIST OF ABBREVIATIONS USED

ADA	American dental association
%	Percentage
mm	millimetre
mg	milligram
N	Newton
min	minutes
Sd	Standard deviation
Fig	Figure
P value	Probability value
℃	Degree Celsius
FeSO4	Ferric sulphate