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A comparative evaluation of marginal integrity of retroplast, KETAC-N100 and gutta-percha before and after post space preparation using fluid filtration technique: An *in-vitro* study

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Abstract
The aim of the present *in-vitro* study was to evaluate and compare the apical microleakage of Retroplast, Ketac-N100 and heat burnished gutta-percha before and after post space preparation using fluid filtration system. A total of 60 freshly extracted human maxillary anterior teeth were decoronated to obtain a uniform length of 15 mm. each. Mean microleakage of all three materials before and after post space preparation were compared using Two way ANOVA test and multiple comparisons between the groups were done using Bonferroni test. The results showed that group 4 showed least mean microleakage (0.10µl/min), and group 3 showed maximum microleakage (0.33µl/min). Between the materials, Retroplast showed least mean microleakage followed by Ketac-N100 and maximum microleakage was exhibited by heat burnished gutta-percha, and the results were statistically significant. All the three materials showed significantly more micro leakages when the fillings were done before post space preparation. Within the limitations of this in-vitro study it was concluded that Retroplast has better bonding to resected root surface followed by Ketac- N100. Heat burnished gutta-percha showed maximum apical microleakage compared to Retroplast and Ketac-N100. Post space preparation done with peeso-reamers had significant effect on the apical leakage of Retroplast, Ketac-N100 and Heat burnished gutta-percha, when apical 5mm. of remaining gutta-percha was present. The post space preparations followed by root end restorations exhibited significant reduction in apical microleakage.

Keywords: Retroplast, ketac-n100, Guttapercha

Introduction

Currently successful root canal therapy is based on diagnosis and treatment planning, knowledge of anatomy and morphology, and traditional concepts of debridement, sterilization, and obturation [1]. The procedural errors such as loss of length, canal transportation, perforations, loss of coronal seal and vertical root fracture have been shown to adversely affect the apical seal in turn leading to endodontic failures. Coronal leakage or contamination during post space preparation may jeopardize apical healing. Therefore, a high quality of both cleaning and sealing of the apical portion of the root canal is essential to success [3]. The aim of both conventional root canal therapy and apicoectomy is to effectively seal the root canal system to prevent irritation of periapical tissues by noxious stimuli [12]. The quality of the root filling is an important determinant of healing after periapical surgery [13]. The important criteria for a successful apicoectomy with a retrograde filling are: a retrograde cavity preparation, the creation of a dry surgical field, a densely packed filling, and a biocompatible retrofill. In the past a number of materials have been used as retrograde filling materials: Gutta-Percha, Gold foils, Silver amalgam, Glass Ionomers, Composites, and Zinc oxide eugenol cements etc. The availability of newer materials such as Mineral Trioxide Aggregate, Retroplast, Cyanoacrylates and Apatite cements are showing promising results. The desirable characteristics of a retrograde filling material are biocompatibility, non-resorbability, good resistance to bacteria and toxins, permanent seal, easy application, resistance to moisture, and radio-opacity [14]. Almost every available dental restorative material or cement has at one time or another been suggested for use as a root end filling material.

Most of the retrograde filling materials exhibited significant short comings in one or more areas (solubility, leakage, biocompatibility, handling properties, moisture incompatibility) [15].

The solubility of sealer in the peri-radicular tissue fluids may result in delayed leakage and long term failure if a root end filling is not placed, emphasizing the need for a root end filling material [15]. The restoration of root canal treated teeth often requires the use of posts but their use may affect the quality of the seal of root canal filling and the retrograde filling. Traditionally a cast post and core or commercially available prefabricate posts have been used for this purpose [21]. This procedure calls for partial removal of the root canal filling to prepare a post space, the depth of which is dictated by biomechanical considerations. During mechanical preparation of the post space the root filling may be disturbed, with consequent disruption of the apical seal [22].

The apical leakage has been measured by degree of penetration of a dye, radio-isotope penetration, bacterial penetration, electrochemical means, or scanning electron microscopy. These techniques require the destruction of samples and they only indicate leakage in one plane and not quantitatively [23]. The fluid filtration method overcomes the disadvantages and reflects the leakage of entire sample and is quantitative and hence the aim of present study was to evaluate and compare the apical microleakage of Retroplast, Ketac-N100 and heat burnished gutta-percha before and after post space preparation using fluid filtration technique. This paper deals to evaluate and compare the apical microleakage of Retroplast, Ketac-N100 and heat burnished gutta-percha before post space preparation and Retroplast, Ketac-N100 and heat burnished gutta-percha after post space preparation.

Materials and Methods

Source of samples

Sixty freshly extracted maxillary anterior teeth were collected from department of oral and maxillofacial surgery, D. A. P. M. R. V Dental College.

Armamentarium

Retroplast (Retroplast RP; Denmark), Na-EDTA gel (18%), Gluma Desentitizer (Heraeus Kulzer, Germany.), Ketac Nano light cure glass ionomer restorative – N100. (3M-ESPE), 05. Ketac-N100 glass ionomer primer, Miniature brush, Bluephase LED light Curing unit, Carborundum discs, Peeso-reamers (MANI, INC. JAPAN) K-Files, Gates-Glidden drills (MANI, INC. JAPAN). Zinc oxide eugenol sealer, Fluid filtration system, Sodium hypochlorite 2.5%, Normal saline RC-Prep. (Premier) 0.2% taper G.P points (DENTSPLY MAILLEFER, CHINA), Spreaders, Scale, Stainless steel ball burnisher, Round carbide bur.

Method of Collection of Samples

Sixty maxillary anterior teeth were collected from the Department of Oral and Maxillofacial surgery, D. A. Pandu Memorial R. V. Dental College, Bangalore, which were indicated for extraction due to poor periodontal prognosis.

Inclusion Criteria

Teeth with completely formed roots, Teeth with normal anatomical roots.

Exclusion criteria

Teeth with fractured roots, Restored teeth, Teeth with open apices and Calcified root canals

Procedure

The surfaces of all the 60 selected teeth were debrided of all adhering tissues. They were then disinfected by overnight immersion in 2.5% sodium hypochlorite. These teeth were then rinsed and stored in moist atmosphere during the study period at room temperature. The samples were decoronated using carborundum disc with a slow speed micromotor handpiece to obtain a uniform length of 15mm. each. Orifices of the roots were enlarged using Gates Glidden no. 3 size drill. The working length was determined by reducing 0.5mm from 15mm of the root length. The cleaning and shaping of canals was performed using K-files and RC-Prep, with an apical enlargement of up to size 50 k-file. Copious irrigation with 2.5% sodium hypochlorite and saline was done followed by obturation using 0.2% taper G.P points and Zinc oxide eugenol sealer with cold lateral condensation. All the teeth were then stored for 24hrs at room temperature. The teeth were then randomly divided into 6 groups, with ten teeth in each group. (n=10).

Divided Into 6 Groups

Group 1: From the 10 obturated teeth, apical 2mm was resected and a shallow concave cavity was prepared using a round carbide bur. These cavities were etched with Na-EDTA gel for 20secs using a miniature brush. The surfaces were then rinsed with water followed by moderate drying with compressed air. The Dentin bonding agent (GLUMA) was applied on to the resected root surfaces for 20 secs., with a miniature brush and dried for a few seconds with compressed air. Equal proportions of Retroplast A and B were mixed on a pad until a homogenous (10 secs.) mix is obtained. The resected root surfaces were covered with the mix using Teflon coated hand instrument within 1-1.5 min after mixing. The surplus of material was removed with a small round bur after ten minutes of curing. Then the post space preparation was done, removing gutta percha completely from the coronal 8mm, using a Peeso-Reamer no 3 size drill, such that apically 5mm of gutta-percha is remaining intact.

Group 2: All 10 obturated teeth in this group underwent root resection and root end cavity preparation as in group 1. Ketac-N100 primer was applied on the prepared cavity using a miniature brush. The primer was applied for 15secs, and the primed surfaces were light cured for 10 secs. using Bluephase LED light curing unit. Ketac-N100 light cure glass ionomer restorative was dispensed using a clicker dispenser. It is designed to dispense both pastes in equal volumes, in a ratio of 1.3/1.0. Both the pastes were mixed for 20 secs. using an agate spatula. The mix was then placed on to the preparation. The Ketac N100 restorative was light cured by exposing its entire surface to light curing device for 20secs. The post spaces were then prepared as in group 1.

Group 3: All 10 teeth in this group underwent 2mm of root resection in an oblique manner. Then the gutta- percha at the root ends was burnished with a heated round ball burnisher. Then the post space preparation was done as in group1.

Group 4: Teeth in this group underwent post space preparation first and then root end resection was done and restored with Retroplast root end filling as in group 1.

Group 5: The teeth in this group underwent post space preparation and then root end resection was done and restored with Ketac N100 light cure glass ionomer restorative as in group 2.

Group 6: The teeth in this group underwent post space preparation and then root resection was done and root ends were heat burnished as in group 3.

Fluid Filtration System: A pressurized nitrogen cylinder was connected to a buffer reservoir, which was filled with saline solution. The exit end of this reservoir was connected to a silicone tube, which is 3 mm in diameter. This silicone tube was then connected to a micropipette with an inner diameter of 1mm. The other end of the micropipette was connected to a silicone tube, which in turn was connected to a 3 way valve, to which syringe and silicone tubes were connected. The 3 way valve will connect only two ends at a time disconnecting one end completely. At one end of this silicone tube the tooth is inserted in a coronal direction and affixed with cyanoacrylate glue applied only on the outer surface of the tooth, so that the orifice is not blocked. After the system is assembled, a syringe was used to introduce an air bubble into the system. After introducing the air bubble into the micropipette, the three way valve is turned so that the fluid movement occurs towards the silicon pipe containing the sample. A 15-psi pressure was applied to the saline reservoir and the movement of the air bubble, signifying the fluid movement towards the root sample was recorded. The micro leakage was recorded in millimetres for a period of 1 hour. The millimetre per hour linear recordings was then converted into volumetric readings of micro litres per minute. The microleakage evaluation of the samples using the fluid filtration technique was done at the Centre for Manufacturing Research and Technology Utilization, R.V. Engineering College, Bangalore.

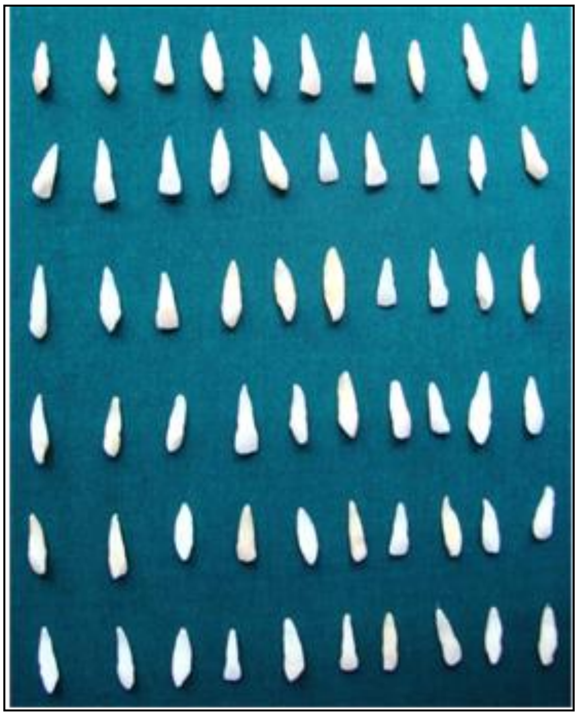


Fig 1: Human Maxillary anterior teeth used in the study.

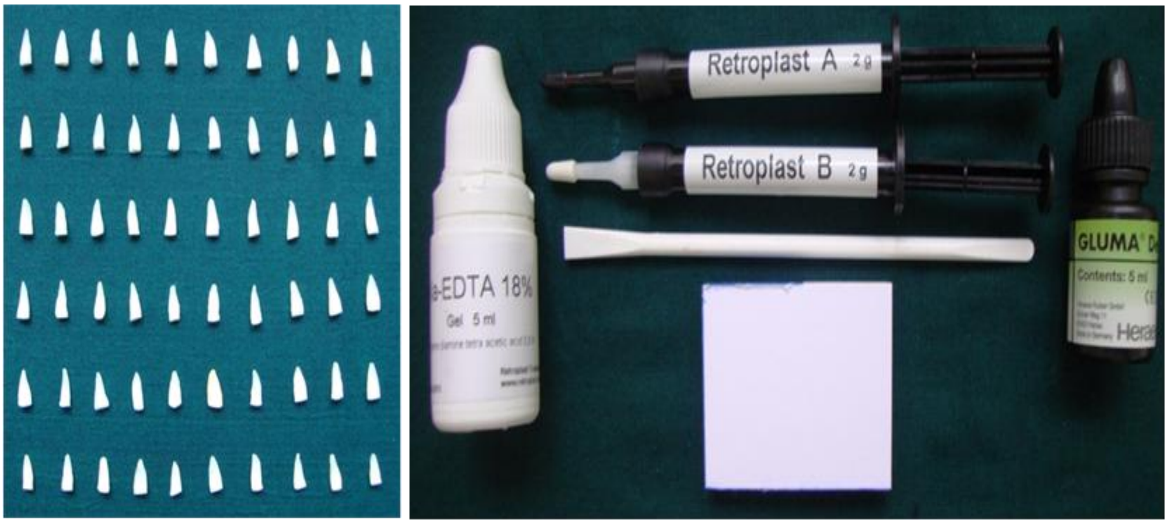


Fig 5: Retroplast, used in group 1 and group 4.

Fig 6: Root end cavity preparation

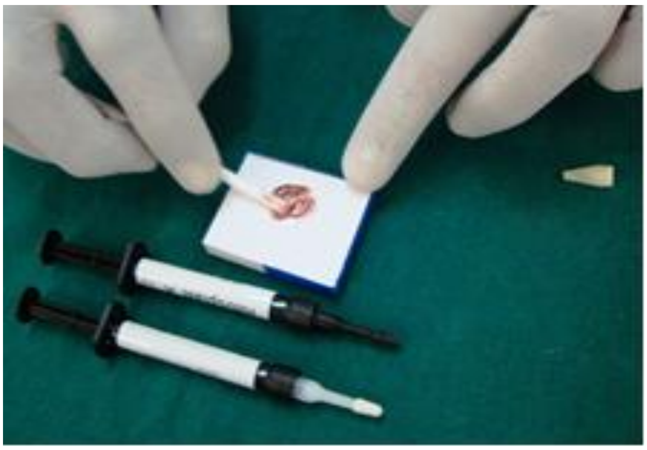


Fig 7: Manipulation of Retroplast

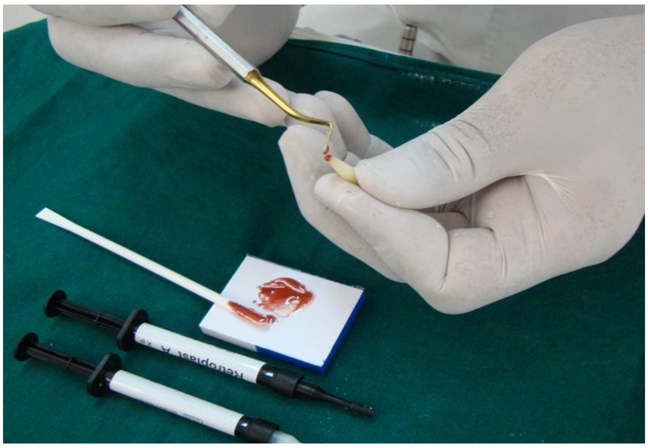


Fig 8: Retrograde filling of Retroplast

Fig 9: Ketac-N100, used in group 2 and group 5.

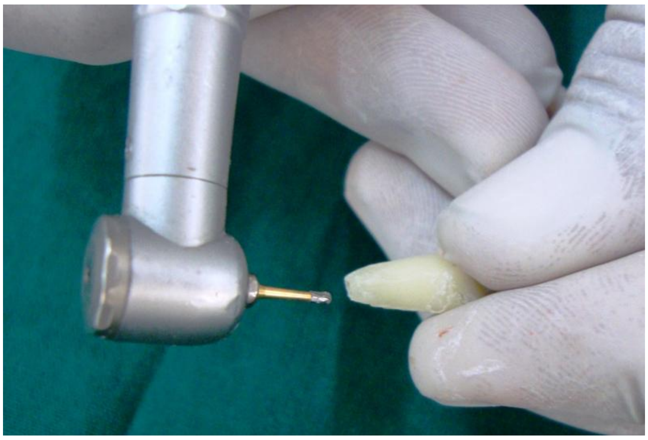


Fig 10: Retrograde cavity preparation.

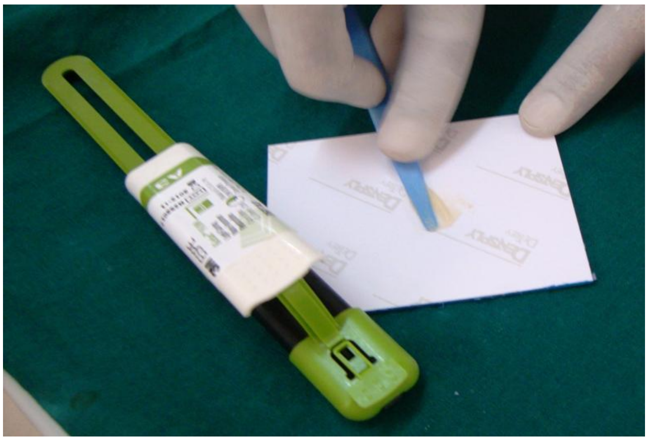


Fig 11: Manipulation of Ketac-N100

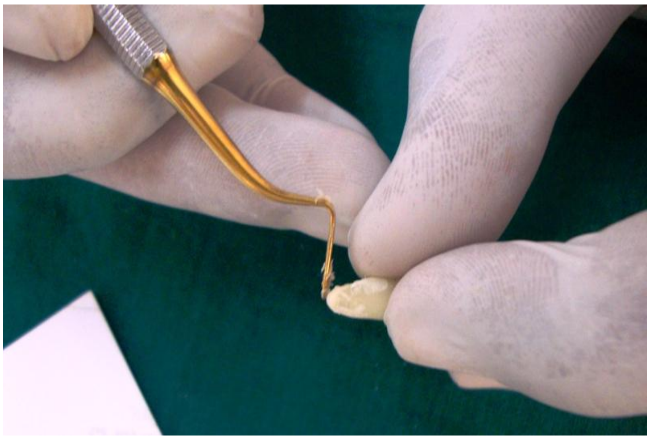


Fig 12: Retrograde filling of Ketac-N100.

Fig 13: Fluid filtration model assembled for evaluation of apical microleakage

Fig 14: Air bubble movement in micropipette and fluid leakage seen at root apex.

Results

In the present study there are two factors influencing micro leakage (µl/min), the material and post space preparation. Three types of materials are used: Retroplast, Ketac-N100 and GP, post space preparation is of two types: before and after. The factors and their levels are tabulated below:

Factor	Levels
Materials	Retroplast, N100, GP,
Post Space	Before, After

Test Procedure
Null Hypotheses
H_0 (a): There is no significant difference between the different types of materials.

H0 (b): There is no significant difference between the two types of post space preparation.

H0 (c): The interaction (joint effect) of material & post space preparation is not significant.

Alternate Hypotheses
H1 (a): There is a significant difference between the different types of materials.

H1 (b): There is a significant difference between the two types of post space preparation.

H1 (c): The interaction (joint effect) of material & post space is significant.

Level of significance: α=0.05.

Decision Criterion: The p-values were compared with the level of significance. If $P<0.05$, the null hypothesis will be rejected and accept the alternate hypothesis. If $P>0.05$ the null hypothesis will be accepted. If there is a significant difference, multiple comparisons (post hoc-test) will be carried out using Bonferroni method to find out among which pair or groups there exists a significant difference.

Statistical technique used: Two-Way ANOVA

Computations: The tables below give the various computations and P-values.

Table 1: Mean micro leakage (µl/min) recorded in the different materials:

Material	Mean	Std dev	Median	Min	Max
Retroplast	0.11	0.02	0.10	0.09	0.14
N100	0.16	0.03	0.17	0.09	0.19
GP	0.30	0.04	0.31	0.26	0.39

Table 2: Mean micro leakage (µl/min) recorded in the combination of materials and post spaces:

Material	Post Space	Mean	Std dev	Median	Min	Max
Retroplast	Before	0.12	0.01	0.12	0.10	0.14
	After	0.10	0.01	0.10	0.09	0.12
N100	Before	0.18	0.01	0.18	0.16	0.19
	After	0.14	0.03	0.14	0.09	0.17
GP	Before	0.33	0.03	0.32	0.31	0.39
	After	0.28	0.02	0.27	0.26	0.31

ANOVA

Source	df	Sum of Squares (SS)	Mean SS	F	P-Value
Material	2	0.412	0.206	498.947	<0.001*
Post Space	1	0.022	0.022	52.497	<0.001*
Material * Post Space	2	0.004	0.002	4.520	0.015*
Error	54	0.022	0.000	---	---
Total	59	0.459	---	---	---

*denotes significant difference.

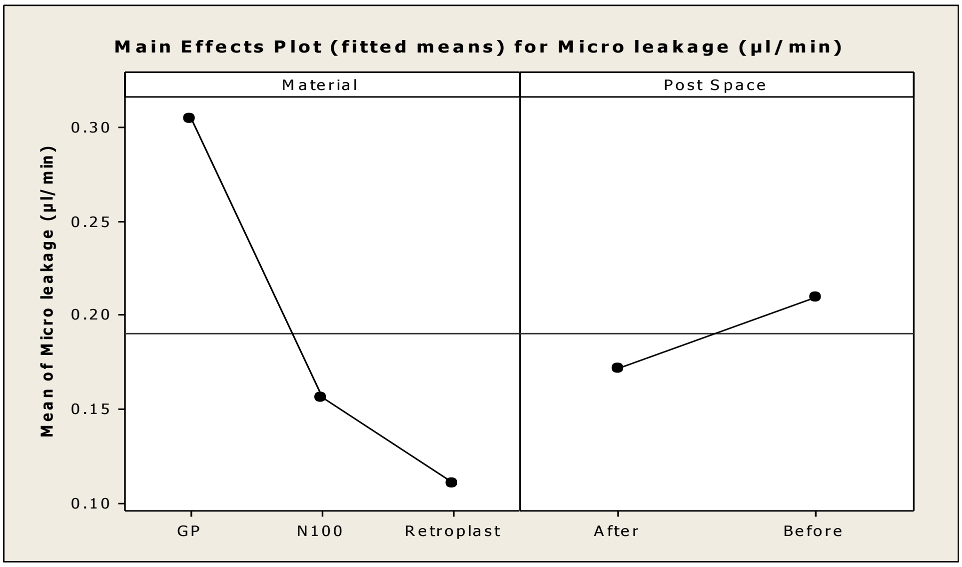
There is a significant difference between the three materials with respect to mean micro leakage ($P<0.001$). The difference in mean micro leakage between before and after post space is also found to be statistically significant ($P<0.001$). Also, the interaction (joint effect) of material & post space is found to be statistically significant ($P<0.05$).
In order to find out among which pair of materials there exist a significant difference, multiple comparisons was carried out using Bonferroni method.

The results are given below in table 3:
Multiple Comparisons
Dependent Variable: Micro leakage (µl/min)
Bonferroni

(I) Material	(J) Material	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
GP	Retroplast	.1940*	.00642	.000	.1781	.2099
	N100	.1485*	.00642	.000	.1326	.1644
Retroplast	GP	-.1940*	.00642	.000	-.2099	-.1781
	N100	-.0455*	.00642	.000.	-.0614	-.0296
N100	GP	-.1485	.00642	.000	-.1644	-.1326
	Retroplast	0.455	.00642	.000	0.296	.0614

Based on observed means.
The mean difference is significant at the .05 level.

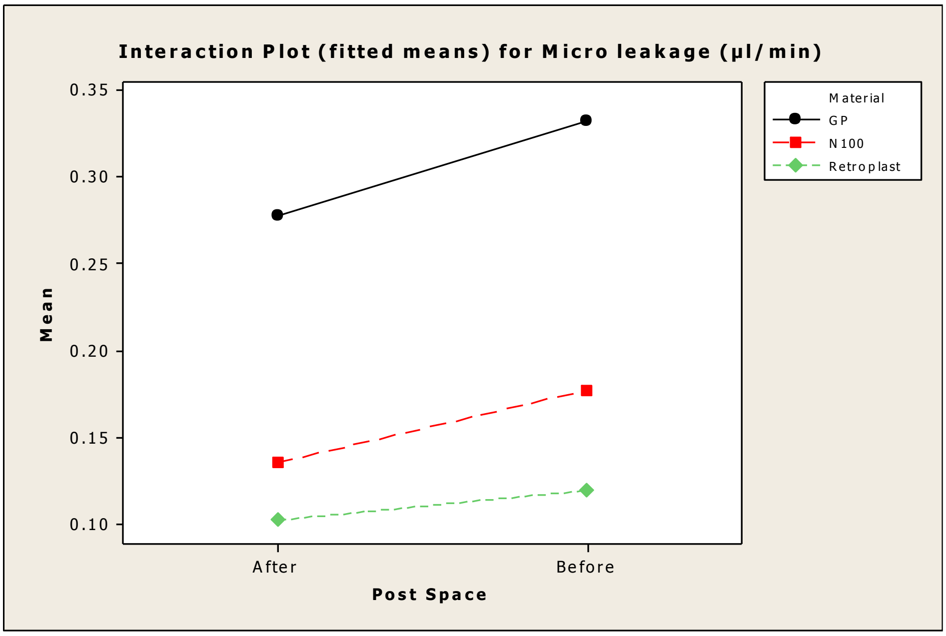
The differences in mean micro leakage was found to be statistically significant between GP & Retroplast ($P<0.001$), GP & N100 ($P<0.001$) as well as Retroplast & N100 ($P<0.001$).



Graph 1: Main Effects Plot: (Shows the effect of different levels of each factor on micro leakage)

Among the three materials, higher mean micro leakage was recorded in GP followed by N100. The least micro leakage was recorded in Retroplast. The difference in mean micro leakage among the groups is found to be statistically significant (*P*<0.001).

The mean micro leakage is found to be higher in retrograde fillings done before post space preparation compared to after post space preparation and the difference between them is found to be statistically significant (*P*<0.001).



Graph 2: Interactions Plot: (Shows the mean micro leakage recorded in various levels of different factors)

Gutta-percha yielded a higher mean micro leakage compared to the other two materials before and after post space preparation. The next highest micro leakage was recorded for Ketac-N100 and it was higher before post space and lesser in after post space preparation. The lowest micro leakage was recorded for Retroplast after post space preparation. The interaction of these factor-levels was found to be statistically significant (*P*<0.001).

Discussion

The goal of endodontic and restorative dentistry is to retain natural teeth with maximum function and pleasing aesthetics. Restoration of endodontically treated teeth replaces missing tooth structure, maintains function and esthetics, and protects against fracture and infection. Successful endodontic debridement and apical sealing are essential criteria for the restoration of the nonvital tooth [1].

A successful endodontic treatment has to be complemented with an adequate post endodontic restoration to make the pulpless tooth function indefinitely as an integral part of masticatory apparatus [62]. The diminished volume of tooth structure from the combined effects of prior disease, dental procedures and endodontic therapy significantly weakens nonvital teeth. In such cases careful selection of post endodontic restorations has to be made. Various factors like amount of remaining tooth structure, anatomic position of the tooth, occlusal forces on the tooth, and esthetic requirements determines whether posts, cores or crowns are indicated [1].

The post, the core, and their luting or bonding agents together form a foundation restoration to support a coronal restoration for the endodontically treated tooth. The post is a restorative dental material placed in the root of a structurally damaged tooth in which additional retention is needed for the core and coronal restoration. The purpose of the post is to hold on to the core and consequently the crown. It also helps protect the apical seal from bacterial contamination caused by coronal leakage [1].

The first step in making a post and core is the removal of a portion of the gutta-percha from root canal space [1]. The preparation of a dowel space is known to disrupt the apical seal of the gutta-percha and this may be affected by factors such as the technique of obturation, the choice of sealer, and root end filling material [55]. The technique of gutta-percha removal for post space preparation also might affect the apical seal, hence the gutta-percha removal technique should be safe and efficient and should not disturb the apical seal [27, 32].

In cases where a root end surgery is recommended followed by a root end restoration, an efficient apical seal has been regarded as the single most important factor for successful periapical surgery, where the apical filling material itself plays a crucial role [29, 30]. Few cases may demand post placement for coronal restoration and also root resection, followed by root end restoration for apical seal. In such cases the clinician may be in a dilemma to either do the post space followed by root end restoration or vice-versa. Hence this study was done to evaluate the apical microleakage of three different root end filling materials before and after post space preparation.

The present study utilized lateral compaction technique for obturating root canals, as several authors have shown that lateral condensation of gutta-percha along with a sealer can provide an adequate apical seal and it is the most popular root canal filling technique [33, 36, 56].

Previous studies showed that Thermoplasticized gutta-percha, as well as laterally condensed gutta-percha filled teeth, exhibited homogenous root canal fillings and presence of filled or unfilled accessory or lateral canals had no apparent effect on the apical leakage values [28].

Various concerns must be addressed when contemplating gutta-percha removal during post space preparation and its effect on apical seal, which includes post length, remaining level of gutta-percha and the method of removal used. The gutta-percha removal technique should be safe and efficient. Three techniques are commonly used to remove gutta-percha: (1) chemical method: using solvents such as chloroform to soften gutta-percha before its removal with files; (2) thermal method: using hot endodontic pluggers; and (3) mechanical, using rotary instruments like peeso reamers or gates glidden drills. Chemical methods are safe but have shown to result in increased leakage because of dimensional changes of the gutta-percha after solvent evaporation. Various authors have suggested that the apical seal of endodontically treated teeth might be affected when using chloroform to remove gutta-percha. Thermal methods like heated endodontic pluggers, were thought to be the safest means of gutta-percha removal for post space preparation due to its conservation of tooth structure and insignificant effect on the apical seal. However in small canals the efficiency of this technique decreases because of the rapid heat lost from thin endodontic pluggers and the inability to remove adequate amounts of gutta-percha. Mechanical gutta-percha removal techniques are time efficient, relatively easy to manipulate, and result in canal enlargement, but have highest potential for canal stripping and lateral perforations [27, 32].

Peeso Reamers were used to prepare the post space, since it is the most common and popular technique of gutta-percha removal in clinical situation. Previous studies have showed that there was no significant difference in the amount of apical microleakage (linear or volumetric) during either immediate or delayed removal of gutta-percha [27].

The amount of gutta-percha remaining at the apex was found to be equally important to ensure a good apical seal. It is seen that 4 to 5mm of residual gutta-percha retained apically, will ensure an adequate apical seal. Previous studies did not find any statistically significant difference in linear apical dye leakage when gutta-percha was removed by flame-heated endodontic pluggers or peeso-reamers retaining the 5 mm of apical gutta-percha and alternative obturation methods to lateral condensation method yielded no statistically different difference in apical leakage provided 4 to 5 mm of gutta-percha was left at apex [36].

Studies also indicate that 4mm of remaining gutta-percha ensures a good apical seal, but stopping precisely at 4mm is difficult. Radiographic angulation errors could lead to retention of less than 4mm. of gutta-percha. Therefore, 5mm of gutta-percha should be retained apically. This seal is complemented by the seal provided by the post and core, and the overlying crown [13]. Peri-apical surgery may be indicated in selected cases in which the obturation to the point of resection may be considered good. This may occur in cases in which the need for surgery was created by a separated instrument in apical root canal space or in cases in which the apical portion of the root canal system cannot be properly prepared and obturated, resulting in persistent symptoms [31].

The ultimate goal of root end resection is to provide optimal conditions for the growth of cementum and subsequent regeneration of the periodontal ligament across the resected root surface. Two important aspects of this process are the surface topography of resected root surface and chemical treatment of the resected root end [1].

The conventional axiom for surface preparation of resected root end has been to produce a smooth, flat root surface without sharp edges or spurs of root structure that might serve as irritants during healing process. A smooth root end is therefore considered advantageous [1]. Hence the root end resection was done with round, multi-fluted carbide bur to get a smooth root end surface.

Root end cavity preparation for bonded root end filling materials requires a change in standard root end cavity preparation. A shallow, scalloped preparation of the entire root surface should be made using a round or oval bur; the preparation should be at least 1mm at deepest of concavity. The root ends in all 3 groups were resected around 2mm and the resected surfaces were concave. Then the root end filling material in group 1 and group 2 were placed in a dome shaped fashion and bonded to the entirety of the resected root surface.

Root surface conditioning removes the smear layer and provides a surface conducive to mechanical adhesion and cellular mechanisms for growth and attachment. Three solutions have been advocated for root surface modification: citric acid, tetracycline and ethylenediamine tetra-acetic acid. All three solutions have shown to enhance fibroblast attachment to the root surface in vitro [1].

Citric acid traditionally has been the solution of choice, till recently it has been questioned the benefit of etching dentine with low pH agents. At low pH the adjacent vital periodontal tissues may be compromised. Previous studies have shown that application of 15% to 24% EDTA for approximately two minutes produces the optimal root surface for better bonding of root end filling material. The present study utilized 17% EDTA to etch root end surfaces in group 1. In a similar study researchers have concluded that EDTA, at neutral pH, was able to selectively remove minerals from dentin surface, exposing the collagenous matrix, thereby increasing the bond strength between retrograde filling material and root surface. So during peri-radicular surgery EDTA might be a more appropriate solution [1].

Ingle *et al* reported that 63% of all endodontic failures were due to apical percolation as a result of incomplete obturation of the apical root canal space and in same study he stated that if there was any chance whatsoever that the apical seal was inadequate, and then a reverse filling must be placed. Ideally, the seal created should be fluid tight [31].

Till date variety of root end filling materials has been recommended and used but an ideal root end filling material should seal the contents of the root canal system within the canal prevents ingress of any bacteria, bacterial byproducts, or toxic materials into surrounding peri-radicular tissues, the material should be nonresorbable, biocompatible, and dimensionally stable overtime. It should be able to induce regeneration of the periodontal ligament complex, specifically cementogenesis, over the root filling itself. Many, materials have been used as root end filling materials including, gutta-percha, polycarboxylate cements, silver cones, amalgam, Cavit (3M-ESPE), zinc phosphate cement, gold foils, and titanium screws. In the past ten years commonly used root end filling materials are zinc oxide eugenol cements (IRM and Super-EBA), glass ionomer cement, Diaket, composite resins (Retroplast), resin-glass ionomer hybrids (Geristore), and mineral trioxide aggregate (ProRoot-MTA).

Retroplast which was used as retrograde filling material in group1, is a dentine-bonding composite resin system developed in 1984 specifically for use as root end filling material. The formulation was changed in 1990, when silver was replaced with Ytterbium trifluoride and ferric oxide. It is a two paste system that forms a dual cure composite resin when mixed. Paste A is composed of Bis-GMA/TEGDMA 1:1, Benzoyl peroxide N,N-di-(2-hydroxyethyl)-p-toluidine, and BHT(2,6-di-tert-butyl-4-methylphenol). This is mixed in equal parts with part B, which is composed of resin ytterbium trifluorideaerosil ferric oxide. A Gluma – based dentine bonding agent is used to adhere the material to the prepared root end surface. The working time is 90 secs. to 120 secs [1].

Gluma is a water based solution of 5% Glutaraldehyde and 35% 2- hydroxyethyl methacrylate (HEMA). After removal of superficial smear layer and apatite crystals from dentin with EDTA, Gluma reacts with dentinal collagen, whereby methacrylate groups are bonded to the NH- groups in collagen.

These methacrylate groups will react with dimethacrylates in a restorative composite resin by copolymerization, and a relatively strong bond is achieved. The bond strength between composite resin and Gluma treated dentin has been measured to be about 70% of the bond strength between composite resin and acid-etched enamel. Studies have shown a tight seal between Retroplast and cavity surface as observed in stereo electronic microscope [16].

The retrograde filling using Retroplast promises a new treatment principle, with a root canal efficiently sealed and peri-apical ligament restored after apicoectomy [17].

Ketac Nano Light Curing Glass Ionomer (Ketac-N100) was used as retrograde filling material in group 2. It is a new development that combines the benefits of a resin modified light cure glass ionomer and bonded nano filler technology [19]. Self-cure glass ionomers were introduced as retrograde filling materials to overcome the disadvantages of amalgam fillings [38]. The favourable tissue response of glass ionomer cements and their adhesive properties, have led to numerous experimental investigations into their use as a retrograde filling material. In clinical circumstances, the conventional glass ionomers will be used in humid surgical field, where they have disadvantage of their protracted setting time, which makes them vulnerable to moisture contamination. Hence introduction of light cure glass ionomer cements has been an important development in the field of dental materials because of their fast setting time following application of visible curing light.

Ketac-N100 is comprised of two part system supplied in clicker dispenser. Paste A: silane treated glass (40-50%); silane-treated ZrO2 silica (20-30%); silane treated silica (5-15%); PEGDMA (5-15%); HEMA (1-10%); BISGMA (< 5%); TEGDMA (< 5%). Paste B: silane treated ceramic (20-30%); silane treated silica (20-30%); water (10-20%); HEMA (1-10%); acrylic/itaconic acid copolymer (20-30%). It must be placed on the resected root surfaces only after priming the root surfaces with its primer. The primer consists of Water (40-50%); HEMA (35-45%) acrylic/itaconic acid copolymer (10-15%); and photo initiators. Studies have shown that nano RMGI bonded as effectively to dentin as conventional glass ionomer. The micro tensile bond strength (μTBS) of non-primed nano RMGI was significantly lower when compared to primed surfaces. The bonding mechanism was attributed to micro-mechanical interlocking provided by surface roughness, most likely combined with chemical interaction through its acrylic/itaconic acid copolymers [30].

Various investigators compared the adaptation and sealing ability of light cured glass ionomer cements with amalgam and conventional glass ionomers. Conventional glass ionomers have shown to adhere to enamel and dentin, they found out that within retrograde cavity, the light cured glass ionomer was often well adapted to cavity wall, but gaps were observed on the opposite cavity wall [13]. This may be caused by polymerization contraction of the material. Sealing ability of light cure glass ionomer was significantly better than that of amalgam, but not significantly different from conventional glass ionomer [30].

Amalgam in comparison with glass ionomers, gutta-percha and zinc-oxide eugenol cements, the marginal seal has been shown to be good. It was showed that zinc-free spherical amalgam had greater leakage. It was seen that high and low copper amalgams shrink after setting in first 3 months so if these amalgams contain zinc there is compensatory expansion [14]. Various literatures suggests that light cured glass ionomer produce less microleakage compared with amalgam and silver glass ionomer cement. In addition they are more biocompatible and easier to handle [38]. They have assessed the use of amalgam as root end filling along with metal post, and found that galvanic reaction may arise between the post and the amalgam. This may result in development of excess corrosion products which can lead to periapical inflammation [26].

In the present study, root ends of specimens in group 3 were resected and the exposed gutta-percha was heat sealed, without undergoing any retrograde fillings. Since this technique is followed in some of clinical situations, this group was selected to compare the microleakage with other groups undergoing retrograde filling.

Various studies have compared the seal obtained with gutta-percha root canal obturation alone, heat sealed gutta-percha, retrograde amalgam filling, and concluded that there was dye leakage among all groups but no significant difference between them. They used fluorescent dye technique and SEM and found that amalgam group leaked more than heat sealed gutta-percha but neither amalgam nor heated gutta-percha provided effective seal against bacteria. Other studies have showed that the apical seal produced by retrograde amalgams allowed twice as much dye penetration as did cold gutta-percha [31].

All the samples were subjected to apical microleakage test using fluid filtration model. The different methods to detect apical microleakage are: dye penetration method, microbiological method, electrical current method and fluid filtration method. A variety of dyes have been used in dye penetration tests; these include India ink, erythrosine B solution, aqueous solution of Fuschin, fluorescent solution, methylene blue solution and others. Disadvantages of dye penetration studies are: the leakage cannot be assessed quantitatively; the tests were not carried under vacuum conditions, so this may have contributed to their air entrapment in interface preventing the penetration of the dyes.[47]The fluid filtration method, which was introduced and developed by Pashley *et al*, has been extensively used for 20 yrs to check apical and coronal microleakage. It presents several advantages: the samples are not destroyed, permits the evaluation of sealing efficiency overtime, results are automatically recorded in computerized fluid filtration models avoiding any operator bias, the results are accurate because very small volumes can be recorded, no tracer is needed with the related problems of molecular affinity for dentin, or pH as major problems in dye penetration studies, and no intricate materials are required as in bacterial penetration studies and radioactive tracer studies, hence the fluid filtration method was used to assess the apical microleakage [59].

The fluid leakages were recorded as linear readings, and then were converted to volumetric readings as microlitres per minute. The statistical analysis used to compare the microleakages between the three groups was two way Anova. The mean microleakage of Retroplast group was 0.11µl/min; Ketac-N100 group showed 0.16 µl/min and gutta-percha group showed 0.30 µl/min. Highest microleakage values were seen for heat burnished gutta-percha group, followed by Ketac-N100 group and least microleakage was seen for Retroplast group. The mean microleakages are depicted in table 1, and mean values are plotted in graph 1. Statistical analysis of mean microleakage of all three different materials showed that differences between them were statistically significant. The mean microleakage for Retroplast group was significantly lower than Ketac-N100 group. The microleakage value of Ketac-N100 group was also significantly lower than heat burnished gutta-percha group.

The reason for Retroplast showing least microleakage may be due to a good bonding and a tight seal between the composite and the cavity surfaces, and the use of Na-EDTA to etch the surface and application of Gluma also significantly increased the bond strength between the material and the etched root surface. Endodontically treated teeth with a eugenol containing root canal sealer did not affect the strength of bond between apical dentin and Retroplast [16].

The mean microleakage of Ketac-N100 group was significantly lower than the Heat burnished gutta-percha group. This may be due to good bonding between dentin and Ketac-N100. Studies have showed that Nano-RMGI bonded as effectively to dentin as conventional glass ionomers. The light cured glass ionomers produced less microleakage compared with amalgam and silver glass ionomer cements.

Among all groups, heat burnished gutta-percha group showed maximum leakage because of improper seal as there was no retrofillings done and the heat sealed margins had large marginal defects [31].

The present study also determines the effect of post space preparation on the apical microleakage of all three different materials. The microleakage values of these materials before and after post space preparation has been tabulated in table 2. The mean microleakage values of Retroplast group was 0.12µl/min when root end filling was done before post space preparation, but reduced to 0.10µl/min when the filling was done after post space preparation. The mean microleakage of Ketac-N100 group was 0.18µl/min before post space preparation and decreased to 0.14µl/min after post space preparation, similarly for gutta-percha group it was 0.33µl/min before post space preparation and decreased to 0.28µl/min after post space preparation. The interaction between the root end restorations and post space preparation has been depicted in table 2. In all the three study groups the differences in microleakages were statistically significant. The mean microleakage values increased for all three groups when the filling was done before post space preparation as compared to that seen after post space preparation. The same has been plotted in graph 2. It showed that the post space preparation had a significant effect on the bonding for all the root end filling materials.

These results indicate that the post space preparation has a profound effect on the seal between the resected root surface and the root end filling materials which is evident in a similar in-vitro study by Arindam *et al*. using Glass ionomer as root end filling before and after the post space preparation, it was shown that post space preparation had a significant effect on the apical microleakage. The effect of post space preparation on the apical seal might be due to the vibrational energy of Peeso reamers, which were used for post space preparation may affect the seal between the material and root ends [55].

Table 3 shows multiple comparisons carried out between one group with other two groups using Bonferroni test. The results showed significant differences between Retroplast and gutta-percha group, gutta-percha and Ketac-N100 group, and Retroplast and Ketac-N100 groups. Hence when a clinical situation necessitates peri-apical surgery and post space preparation on the same tooth, first post space preparation is recommended followed by root end restoration. It is always better to do a retrograde cavity preparation followed by retrograde filling rather than heat burnishing the exposed gutta-percha. A minimum of 5mm. of remaining gutta-percha at apical third and a good retrograde filling will ensure sufficient apical seal. Retroplast is a good choice for root end restorations.

Conclusion

Within the limitations of this in-vitro study, it can be concluded that the Retroplast has better bonding to resected root surface followed by Ketac-N100 and Heat burnished gutta-percha showed maximum apical microleakage compared to Retroplast and Ketac-N100. Post space preparation done with peeso-reamers had significant effect on the apical leakage of Retroplast, Ketac-N100 and Heat burnished gutta-percha, when apical 5mm. of remaining gutta-percha was present. Post space preparations followed by apicoectomy and root end restorations exhibited significant reduction in apical microleakage. Further, long term in-vivo studies will also be necessary to evaluate the effect of post space preparation on the apical seal of root end filling materials like Retroplast and Ketac-N100.

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