A COMPARATIVE EVALUATION OF FIVE OBTURATION TECHNIQUES IN THE MANAGEMENT OF SIMULATED INTERNAL RESORPTIVE CAVITIES – AN EX VIVO STUDY

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CERTIFICATE

This is to certify that this dissertation titled **"A COMPARATIVE EVALUATION OF FIVE OBTURATION TECHNIQUES IN THE MANAGEMENT OF SIMULATED INTERNAL RESORPTIVE CAVITIES – AN EX VIVO STUDY"** is a bonafide record work done by **Dr. MATHEW JACOB ELENJIKAL** under our guidance during the study period between 2008-2011.

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY** in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY – CONSERVATIVE DENTISTRY AND ENDODONTICS, BRANCH IV.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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CONTENTS

INTRODUCTION

The success of root canal therapy depends upon total and complete obliteration of root canal space by a dimensionally stable and biologically compatible material.[2] Complete filling of the root canal with an inert filling material has been proposed as one of the goals of root canal treatment. [32]

Root resorption is the loss of dental hard tissues as a result of clastic activities. It might occur as a physiologic or pathologic phenomenon. Root resorption in the primary dentition is a normal physiologic process except when the resorption occurs prematurely. Root resorption in the permanent dentition is a pathologic event and if untreated, this might result in the premature loss of the affected teeth.[60]

Root resorption might be broadly classified into external or internal resorption by the location of the resorption in relation to the root surface . Internal root resorption presents as an irregular defect in the root canal, making that area inaccessible to normal method of cleaning and shaping as well as obturation. [60]

Internal resorption is a condition which is triggered by inflammatory process in vital pulp leading to sequence of events involving dentinoclastic activity which causes resorptive defect in root canal. Trauma seems to be the initiating factor in majority of cases. [2]

Compared with external root resorption, internal root resorption is a relatively rare occurrence, and its etiology and pathogenesis have not been completely elucidated . Nevertheless, internal root resorption poses diagnostic concerns to the clinician because it is often confused with external cervical resorption. [60]

Internal resorption as a destructive process may progress slowly or rapidly. If progression is rapid, it may result in a perforation of the crown or root within a few weeks . Clinically internal root resorption is usually asymptomatic and diagnosed through routine radiographs or by the sign of a ‘pink spot’ on the crown Radiographically, internal root resorption appears as a fairly uniform, radiolucent enlargement of the pulp canal and distortion of the original root canal outline. [68]

The presence of organic debris, bacteria etc in these irregularities may interfere with success of endodontic treatment. The only treatment modality is removal of the inflammatory pulp tissues followed by obturation. The complete extent of the defect cannot be determined either clinically or radiographically, which further calls for finding a perfect way of obturating these defects. [2]

It is generally accepted that root fillings should contain more gutta-percha and less sealer. This may be more important when filling root canals with resorptive lacunae. In resorptive lacunae, it is difficult to remove all bacteria and their products from the dentinal tubules. Dense compacted gutta-percha may block dentinal tubules, and this may lead to better entombment of microorganisms. [32]

According to Gencoglu , the various techniques used these days for filling internal resorption include warm condensation (Microseal),vertical condensation (SytemB), core techniques (Thermafil, Soft Core, JS Quickfil), thermoplasticised gutta percha(E and Q plus,Obtura), warm vertical compaction and cold lateral condensation. [32]

Cathro and Love concluded that System B plus Obtura II produced a homogenous obturation of gutta percha with minimal sealer and no voids.[12] Goldberg et al also concluded that the Obtura II system performed statistically better in obturating resorptive defects than cold lateral condensation,thermafil and a hybrid technique.[60]

The aim of the present study was to compare the quality of root fillings in artificially created internal resorption cavities, filled with Warm vertical compaction, Lateral condensation, Obtura II along with System B, E and Q plus along with System B and Thermafil.

The objective of this study was to calculate the percentage of gutta-percha , sealer and voids in the internal resorptive cavities using stereomicroscope with an Image J software.

REVIEW OF LITERATURE

Gartner et al[29](1976) studied the differential diagnosis of internal and external root resorption and concluded that these can be differentially diagnosed by radiographs in most cases.

Brothman et al[10](1981) compared the efficiency of the vertical condensation of warmed gutta-percha and the lateral condensation of gutta percha and concluded that the vertical condensation technique, on radiographic examination, shows nearly double the number of lateral and accessory canals, compared with lateral condensation.

Ahlberg et al[3] (1983) studied long-term evaluation of autotransplanted maxillary canines with completed root formation and concluded that external and internal resorption of inflammatory type were the most frequent forms of resorption and were also found to be the most hazardous factors for the prognosis of the transplanted tooth.

Hopkins et al[38] (1986) studied the extent of apical microleakage between McSpadden and lateral condensation and

concluded that lateral condensation with sealer produced a better seal than thermoplastic obturation with or without sealer.

Peters et al[63] (1986) did a Two-year In Vitro Solubility Evaluation of lateral,vertical, thermomechanical and chloroform dip condensation and concluded that sealer loss was demonstrated in a significant apico-occlusal manner only with the lateral technique and was statistically different from the other techniques and minimal changes were demonstrated by the chloroform dip and thermomechanical techniques.

Wedenberg et al[83] (1987) studied internal resorption in both permanent and primary human teeth with light microscopy, scanning electron microscopy, and enzyme histochemistry. They found no differences between primary and permanent teeth, either clinically or morphologically, except that the resorption process progressed more rapidly in the primary teeth and the cells responsibile for the resorption process were found to have a strong tartrate-resistant acid phosphatase activity and they concluded that internal resorption cannot develop unless the normal pulp tissue is replaced by a periodontal-like connective tissue.

Michanowicz et al[54](1989) compared the Clinical Evaluation of Low-Temperature Thermoplasticized Injectable Gutta-percha(Ultrafil) and lateral condensation and concluded that there was a significant amount of repair irrespective of obturation procedure.

Lares et al[46] (1990) studied the sealing ability of the Thermafil Obturation Technique in straight canals of maxillary canines and curved canals in mesial roots of mandibular molars.The Linear dye leakage measurements showed that canines obturated with the lateral condensation technique leaked significantly less than those obturated using the Thermafil technique but the difference was not statistically significant in the molar roots.

Sjogren et al [74] (1991) studied the antimicrobial effect of calcium hydroxide as a short term intracanal dressing.They concluded that seven day dressing efficiently eliminated bacteria which survived biomechanical instrumentation of the canal ,while ten minute application was ineffective.

Scott et al[71](1992) compared the Thermafil endodontic obturation technique with laterally condensed gutta-percha in

maxillary central incisors.They concluded that there was not much difference between the amount of leakage in either obturation method or in the total time to complete root canal filling process.

Saw et al[69] (1995) studied the influence of lateral condensation, Obtura, and Thermafil on root strains in upper central incisors using strain gauges mounted on the coronal and apical one-thirds of the root surface.They concluded that Obtura generated the highest strain while Thermafil showed the least strain.

McRobert et al[52] (1997) compared the backfilling capabilities of System B,Obtura II,alphaseal with lateral condensation as standard and concluded that both System B and Obtura II leaked significantly less than alphaseal and lateral condensation.

Taylor et al[77] (1997) studied the effect of obturation technique, sealer, and the presence of smear layer on coronal microleakage and concluded that removal of the smear layer, the use of AH-26, and vertical compaction have cumulative effects in reducing coronal leakage.

Ricucci et al[65] (1998) studied the apical limit of root canal instrumentation and obturation.He concluded that location of the apical foramen related to root canal treatment, most frequently ends short of the apex,often by several millimetres.

Davalou et al[16] (1999) evaluated the sealing ability of two contemporary endodontic obturation and restorative techniques namely System B and Obtura, restored coronally with Core paste using Tenure as bonding agent and other obturated using microseal and restored coronally with Panavia 21 as bonding agent and concluded that these contemporary techniques and materials provide equally good results.

Ne et al [58] (1999) studied the types of tooth resorption and concluded that there are two types of internal resorption: root canal (internal) replacement resorption and internal inflammatory resorption and classified external resorption into four categories by its clinical and histologic manifestations: external surface resorption, external inflammatory root resorption, replacement resorption, and ankylosis.

Silver et al[73] (1999) compared the area of canal occupied by gutta percha ,sealer or void using the System B heating device and that obtained by modified vertical condensation using the Touch n Heat and also compared the temperature changes at the root canal wall and external root surface during obturation.He concluded that System B produced an acceptable obturation whereas Touch n Heat source during vertical condensation may result in damage to the peridontium.

Dewani et al[21] (2000) compared the radiographic quality and sealability of root fillings in extracted human single rooted teeth using lateral condensation of gutta-percha or low-temperature thermoplasticized gutta-percha (Ultrafil).This study concluded that under laboratory conditions the low-temperature thermoplasticized gutta- percha had better sealability but poorer radiographic quality than lateral condensation.

F Goldberg et al[26](2000) compared lateral compaction , hybrid technique , Obtura II , and Thermafil in internal resorptive cavities and found obtura II to give the best results and resorptive cavities were mainly filled with gutta percha.

Nelson et al[57] (2000) compared quantitatively the density of standard cold lateral gutta percha condensation and warm lateral gutta percha condensation using System B heat instrument in a low –heat warm lateral condensation technique, in an artificial root canal in vitro.He concluded that warm lateral gutta percha condensation using System B instrument results in denser gutta percha fills by weight when compared with lateral condensation.

Smith et al[75] (2000) compared the adaptability of gutta-percha after varying the depth of heat application in the obturation of a set of standard root canals with a split-tooth model in human maxillary central incisors.This study was performed without sealer for each technique thermoplasticized injectable (TI), lateral condensation, and warm vertical compaction with heat applications at 3, 4, 5, and 7 mm from the working length. This study concluded that the thermoplasticized injectable technique was ranked best followed by the warm vertical compaction with heat applications at 3, 4, 5, and 7 mm whereas the lateral condensation technique received the lowest ranking.

Abarca et al[1] (2001) compared Thermafil and lateral condensation techniques with regard to apical sealing and extrusion in curved mesial roots of extracted human mandibular molars.This study concluded that Linear dye leakage and apical extrusion between the techniques were not statistically different

Behnia et al[7] (2001) studied root surface temperatures generated by the Thermafil Plus system using infrared thermography in extracted human maxillary central incisors and maxillary first molars. This study concluded that Thermafil Plus obturation system does not cause damage to the periodontal ligament and the surrounding attachment apparatus as a consequence of temperature rise on the external root surface.

Clinton et al[14] (2001) Compared warm gutta-percha obturation technique, Thermafil Plus , with lateral condensation for the ability to adapt gutta-percha to the walls of a root canal system in an extracted sectioned and mounted maxillary central incisor. This study concluded that Gutta-percha using Thermafil was better able to flow into lateral spaces, had fewer voids, and replicated the surface of

the root better but there was more extrusion out the apical foramen than in the lateral condensation group

Friedland et al[28] (2001) described the use of tomography, a relatively simple and well-established radiographic technique, for determining the buccolingual extent of internal resorptive lesions. They concluded that this may be a useful adjunct in selected cases to determine whether root canal therapy for the treatment of internal resorption followed by restoration of the tooth is likely to be successful.

Wu et al[84] (2001) compared the quality of cold and warm gutta percha filling in oval canals and concluded that gutta pecha filled canal area using warm gutta percha was greater than that of the cold gutta percha in oval canals.

Deitch et al[17] (2002) compared quantitatively the density of gutta-percha root canal fillings produced by cold lateral condensation with those produced by an ultrasonically energized spreader in a warm lateral condensation technique in artificial root canals.The results indicate that warm lateral condensation using a ultrasonically

energized spreader results in denser gutta-percha fills by weight than cold lateral condensation

Gencoglu et al[30] (2002) studied the core/sealer ratio and sealing ability of Thermafil,JS Quick Fill,System B and lateral condensation.He concluded that Thermafil and JS Quick Fill with carrier and System B were found to be superior to the lateral condensation in terms of core/sealer ratio whereas Thermafil and JS Quick Fill superior to the lateral condensation in terms of dye leakage.

Hembrough et al[37] (2002) evaluated the use of three different master cones an ISO-standardized gutta-percha cone (group A), a Dia-ISOGT.06 gutta-percha cone (group B), and a size medium gutta-percha cone (group C) used in Lateral Condensation of Canals prepared with Nickel Titanium Rotary Instruments .The results showed that obturation efficiency was significantly greater in groups B and C than in group A. There was no significant difference in obturation quality between any of the three groups.

Kleoniki et al[45] (2002) studied Internal root resorption by radiography, stereomicroscope, scanning electron microscope and

computerized 3D reconstructive method and concluded that Internal root resorption is a rare remodeling process that can be studied using different experimental methods.

M Agarwal et al[2] (2002) compared the obturation of internal resorption cavities with four different techniques, Lateral compaction, Ultrasonic condensation,Thermafil and Obtura II in extracted maxillary incissors .He concluded that ultrasonic condensation and Obtura II gave good results and was mainly filled with gutta percha

Silva et al[72] (2002) compared the quality of root fillings done by lateral condensation ,thermafil,and a new technique using thermafil for backfilling with special emphasis on control of overfilling.He concluded that lateral condensation and the backfilling techniques resulted in fewer overfills than thermafil and voids were absent in thermafil while small voids were present in lateral condensation and backfilling group.

Venturi et al[81] (2002) evaluated the temperature change within gutta percha during the vertical compaction technique performed with a System B Heat source.He concluded that the increase of

temperature of the gutta percha at the apical third of the canal was negligible and that the compaction of the mass of gutta percha close to the apex was performed at room temperature

Boussetta et al[8] (2003) compared the sealing ability of a coated carrier system (Herofill) with lateral and thermomechanical condensation using dye penetration in extracted human teeth.He concluded that Herofill soft core system was a reliable obturation system in the apical portion and compared favourably with other filling techniques.

Cathro et al[12](2003) compared the proportion of gutta percha,sealer and voids following the filling of simulated root canals in plastic blocks using Microseal and System B/Obtura 11 techniques.He concluded that microseal technique produced a heterogenous fill where as System B/Obtura 11 produced a homogenous fill at all levels.

Gencoglu et al[31] (2003) compared the core to sealer ratio for six obturation techniques;Thermafil,JS Quick fill,Soft core,Microseal,System B,and lateral condensation.He concluded that Thermafil,JS Quick fill,Soft core were found to be superior to the

Microseal,System B,and lateral condensation in terms of gutta percha to sealer ratio

Levitan et al[48] (2003) determine the effect of the insertion rate of a thermoplasticized gutta-percha obturation technique (Thermafil Plus) on the quality of the root canal obturation. This study concluded that the replication of induced irregularities decreased as the rate of insertion was decreased.

Bailey et al[5] (2004) compared the quality of root canal obturation using ultrasonic and cold condensation of gutta percha and to determine the effect of power setting and activation time on the quality of obturation.He concluded that power setting 5 and activation of 10s and 15s consistently produced ultrasonically thermocompacted root canal fillings with fewer voids than cold lateral condensation without sealer.

Lipski et al[49] (2004) studied the temperature rise on the outer root surfaces of teeth with four different obturation techniques-Thermafil obturators or Soft-Core obturators using Ultrafil or Trifecta low-temperature thermoplasticized gutta-percha techniques in human maxillary and mandibular premolars with a single canal . This study

concluded that solid core gutta-percha combined with low-temperature injectable gutta-percha obturation techniques may impose less risk for thermal damage to the surrounding periradicular tissues.

Robinson et al[66] (2004) compared the extrusion of thermoplacticized gutta-percha in teeth instrumented with Profile 0.06 or Profile GT, and obturated with Thermafil Plus and Thermafil GT, respectively in extracted human maxillary central incissors. The results suggested that,in vitro, Thermafil GT may be more prone to extruding gutta-percha past the apical foramen than Thermafil Plus.

Venturi et al[80](2004) evaluated the quality of endodontic sealing in the apical 4 mm of narrow and curved canals using different filling Techniques; group A, Schilder's warm vertical condensation; group B, Schilder's technique modified by using an electric heater; group C, Schilder's technique modified by compaction of the apical tract at body temperature; and group D, a modified vertical compaction with apical back-filling.Group D showed increased apical sealing and reduced extension of voids.

Basheer et al[6] (2005) studied the Radiographic and microscopic evaluation of the efficacy of Lateral compaction and ultrasonic condensation and recommended ultrasonic condensation to obturate the internal resorption defects in clinical practice

Chu et al[13] (2005) evaluated the outcome of root canal treatment using either Thermafil or lateral condensation as filling technique and compared the time required for the treatment when either filling technique was used.He concluded that the use of Thermafil or lateral condensation in the filling of root canal did not result in significant difference in the clinical treatment outcome and thermafil consumed significantly less time lateral condensation.

Jung et al[39] (2005) examined the potential and accuracy of micro computed tomography for imaging of filled root canals.He concluded that micro –CT technique was highly accurate and non destructive method for evaluation of root canal fillings and its constituents.

Kececi et al[44](2005) compared cold lateral compaction and continuous wave of obturation techniques following manual or rotary instrumentation.He concluded that distribution of filling materials

was similar in all combinations of instrumentation and obturation techniques whereas the continuous wave technique was faster than lateral compaction and it extruded more sealer

Lea et al[47] (2005) compared the density of standard cold lateral gutta- percha compaction and warm vertical compaction by using the continuous wave of condensation technique.He concluded that the continuous wave of condensation technique resulted in a significantly greater density compared with cold lateral compaction and warm vertical compaction using the continuous wave of condensation technique in acrylic blocks resulted in a greater gutta-percha fill by weight compared with standard cold lateral compaction.

Lipski et al[51] (2005) evaluated increases in root surface temperature during the continuous wave of condensation technique using a System B Heat Source. He concluded that the continuous wave of condensation technique using the System B Heat Source produces temperature changes on the outer root surfaces, which, in the case of teeth with relatively thin dentinal walls, can reach relatively high values.

Villegas et al[82] (2005) evaluated the intracanal temperature rises at 2 and 4 mm from the working length necessary to obtain proper replication of intracanal anatomy with gutta percha using the System B heat source during vertical condensation.He concluded that positioning the plugger close to working length and a temperature rise of 6 degree Celsius were necessary to obtain replication of intracanal anatomy.

Collins et al[15] (2006) compared three gutta-percha (GP) obturation technique; cold lateral, warm lateral, and warm vertical techniques to replicate canal irregularities. There was a statistically significantly better result with both warm techniques compared to cold lateral obturation, while there was no significant difference between the warm obturation techniques.

Deus et al[19] (2006) compared the percentage of gutta percha filled area in the apical third of root canals filled with Thermafil, System B and lateral condensation.He concluded that coated carrier gutta percha system Thermafil produced significantly higher gutta percha filled area than lateral condensation and System B.

Epley et al [23](2006) compared epiphany techniques with traditional gutta-percha techniques in its ability to fill the prepared root canal space. The root canals were instrumented with hand and rotary files and divided into four groups. Gutta-percha and the new resin based material was used with lateral condensation or continuous wave obturation. The roots were sectioned at 1, 3, and 5 mm from the apex and examined under magnification.The gutta-percha, lateral condensation method was the only group that demonstrated significantly more voids. There were no statistically significant differences among any of the other three group.

Gurgel Filho et al[33] (2006) compared the ability of five different commercially available gutta percha points to fill simulated lateral canals when subjected to warm vertical compaction.He concluded that brand of gutta percha had an influence on the length of filling within lateral canals and this may be a reflection of the chemical formulations of the gutta percha points.

Lipski et al[50] (2006) measured the temperature rises on the outer surface of roots of maxillary and mandibular central incisors produced by high-temperature thermoplasticized injectable gutta-

percha technique.He concluded that the injection of the gutta-percha heated to 160°C into the root canal of maxillary central incisors produces temperature on the outer root surfaces below the theoretical critical level and, therefore, should not cause damage to supporting periradicular tissues and the injection of gutta-percha into the root canal space of the mandibular central incisors in vitro, resulted in an elevation of the root surface temperature by more than 10°C.

Sari et al[68] (2006) studied the repair of a mandibular second-primary molar tooth with an inflammatory resorptive defect in the coronal third of the root canal with MTA. They concluded that MTA may be a suitable material for use in the treatment of internal resorption in the coronal third of the root canal in primary teeth.

Schilder et al[70](2006) did a review on filling of root canals in three dimension.

Venturi et al [79](2006) evaluated the quality of root canal filling compairing two warm gutta percha filling techniques ;one a traditional warm vertical compaction technique performed using Touch n Heat and back filling with Obtura II and second a modified warm vertical compaction technique in which small amounts of gutta

percha were removed and the most apical 3 mm were compacted with a 1mm movement,then thermomechanical back filling was performed.He concluded that modified warm vertical compaction technique with apical back filling produced a more effective and precise three dimensional filling.

Burleson et al[11](2007) studied The In Vivo Evaluation of Hand/Rotary/Ultrasound Instrumentation in Necrotic, Human Mandibular Molars and found mean percent canal and isthmus cleanliness values to be significantly higher for hand/rotary/ultrasound technique at all levels evaluated.

Deus et al[18] (2007) compared the sealing ability of oval-shaped canals filled using the System B heat source with either gutta-percha/sealer or Resilon/Epiphany.The results demonstrated that Resilon/Epiphany combination do not improve the bacterial leakage resistance compared with traditional gutta-percha/sealer fillings.

Er Ozgur et al[24] (2007) studied the distribution and level of temperature, in a model of a maxillary canine, the surrounding periodontal tissues, and the bones, during a System B heat obturation technique simulation.He concluded that that the simulation of System

B technique created no potentially harmful levels of temperature throughout the maxillary canine model.

Hammad et al[34] (2007) compared vertical forces at fracture of teeth obturated with different materials in single-rooted teeth.The different materials used in this study were one negative control, second obturated with gutta percha and a zinc oxide sealer,third obturated with EndoRez points and EndoRez sealer , the fourth group was obturated with Resilon, fifth group was obturated with Guttaflow. They concluded that obturation of roots with resin-based obturation materials (Resilon and EndoRez) increased the resistance of root canal filled teeth to vertical root fracture.

Karr Alicia et al[42] (2007) compared the flow of gutta-percha and Resilon into lateral grooves and depressions in the apical 7 mm of a root canal by using warm vertical compaction. He concluded that Gutta-percha and Resilon showed similar movement into lateral grooves and dentin depressions, with a significant difference found only with increased flow of gutta-percha into depressions at the 1-mm level when the System B plugger was placed 3 mm or 4 mm from WL.

Kaya et al[43] (2007) compared the sealing ability of gutta-percha and thermoplastic synthetic polymer-based systems along the root canals using a recently introduced glucose penetration model. He concluded that all material/technique combinations allowed glucose penetration and Gutta-percha/AH Plus combinations allowed similar patterns of glucose penetration to Resilon/Epiphany combinations.

Mente et al[53] (2007) assessed the apical leakage of ultrasonically condensed root fillings in extremely large canals, compared to cold lateral condensation and thermoplastic compaction.The results showed that apical leakage associated with ultrasonically condensed root fillings was less than that with cold lateral condensation.

Peng et al[62] (2007) evaluated clinical outcome differences of root canal obturation by warm gutta-percha (GP) or cold lateral condensation (CLC) through a systematic review and meta-analysis.They concluded that warm GP obturation demonstrated a higher rate of overextension than cold lateral condensation and postoperative pain prevalence, long-term outcomes, and obturation quality were similar between the two groups.

Royzenbalt et al[67] (2007) compared the time required for removal of small Thermafil plastic carriers in moderately curved MB roots of mandibular molars using the ProFile rotary system at 300 and 1,500 rpm.They concluded that trend for greater separation of instruments was found with the higher rpm group.

Xu et al[85] (2007) compared the sealing ability of 4 different obturation techniques ; Warm vertical compaction, Thermafil, E & Q Plus system and cold lateral compaction of gutta-percha by using a glucose leakage test. He concluded that warm vertical compaction, Thermafil, and the E & Q Plus system showed a better sealing result than cold lateral compaction of gutta-percha at extended observation periods

Altundasar et al[4] (2008) studied the sealing properties of cold laterally compacted gutta percha and Thermafil applied over different apically fractured ProTaper and ProFile rotary nickel-titanium files in extracted human premolars.They concluded that roots with fractured ProTaper instruments displayed significantly less leakage than those filled without ProTaper fragments, regardless of the obturation technique used whereas intracanal separation of ProFile

instruments increased the leakage, but the obturation method did not influence fluid conduction.

Deus et al[20] (2008) compared the percentage of gutta-percha–filled area achieved in oval-shaped canals after filling with 3 thermoplasticized techniques; thermomechanical compaction , wave of condensation, and Thermafil system with lateral condensation. He concluded that Thermafil system, wave of condensation, and thermomechanical compaction produced significantly higher PGFAs than lateral condensation.

Gencoglu et al[32] (2008) studied the quality of root fillings in teeth with artificial internal resorptive cavities filled with Thermafil, JS Quick-Fill, Soft Core, System B and Microseal, and by cold lateral compaction (LC) technique in extracted maxillary incissors . He concluded that warm gutta techniques filled artificial resorption cavities significantly better than the other gutta-percha techniques.

Hammad et al[35](2008) studied the remaining filling volume of different obturation materials from root-filled extracted teeth by using 2 removal techniques in single-rooted teeth. The teeth were randomly allocated into 4 groups, and each group was obturated by

using a different material. Group 1 was filled with gutta-percha and TubliSeal sealer, group 2 was filled with EndoRez points and EndoRez sealer, group 3 was filled with RealSeal points and RealSeal sealer, and Group 4 was filled with a gutta-percha point and GuttaFlow sealer.The root fillings were removed by using ProTaper retreatment files or hand K-files. This study showed that all tested filling materials were not completely removed during retreatment by using hand or rotary files.

Karabucak et al[41] (2008*)* evaluated the ability of Obtura II and Calamus to fill artificially created lateral canals in simulated plastic teeth using standard guttapercha, Flow 150 gutta-percha and Resilon. He concluded that the flow of the filling material into lateral canals is a function of the viscoelastic properties of the filling material rather than the mechanical properties of the delivery systems and that Resilon filling material flows better into lateral canals when a single backfill technique is used.

Nagas et al[56] (2008*)* compared the sealing ability of a resin- and polymer-based root canal obturation system used in conjunction with different light-curing units and obturation techniques . The

obturation technique used were (1) single cone, (2) cold lateral compaction, and (3) System B plus Obtura II.He concluded that the tested obturation techniques had no significant effect on the leakage values.

Zielinski et al[88] (2008) compared the flow of GuttaFlow and gutta-percha into lateral grooves and depressions in the apical 7 mm of the root canal system. This study fabricated a split-tooth model with depressions and lateral grooves placed in the canal walls at 1 mm, 3 mm, 5 mm, and 7 mm from the working length in maxillary canines. This study showed extrusion of GuttaFlow beyond the apex but completely obturated the grooves and depressions at all levels from the working length.

Duggan et al[22] (2009) studied the Periapical Inflammation and Bacterial Penetration After Coronal Inoculation of Dog Roots Filled With RealSeal 1 and Thermafil. Teeth were aseptically prepared and then filled with carrier-based Resilon or with carrier-based gutta-percha Thermafil, and were left exposed for 4 months. The first control group received a coronal seal over either Resilon -1 or Thermafil root fillings and second control group was instrumented

and left completely empty. They concluded that Resilon 1 appeared to resist bacterial penetration more effectively than Thermafil under the conditions of this study.

Estrela et al[25] (2009) studied a method to measure inflammatory root resorption (IRR) by using cone beam computed tomography (CBCT) scans.They concluded that cone beam computed tomography was useful in the evaluation of inflammatory root resorption, and its diagnostic performance was better than that of periapical radiograph.

Hammad et al[36](2009) studied the percentage of volume of voids and gaps in root canals obturated with different obturation materials by using micro–computed tomography in singler rooted teeth , The roots were randomly allocated into 4 groups, and each group was obturated by using cold lateral compaction with a different material gutta-percha and TubliSeal sealer, EndoRez points and EndoRez sealer, RealSeal points and RealSeal sealer, and a gutta-percha point and GuttaFlow sealer. This study concluded that none of the root canal filled teeth were gap-free and roots filled with gutta-

percha showed less voids and gaps than roots filled with the remaining filling materials.

Kandaswami et al[40] (2009) compared laterally condensed, vertically compacted thermoplasticized and cold free-flow GP obturations using spiral CT.He concluded that cold free-flow obturation technique showed the highest volume of obturation, followed by the vertically condensed thermoplasticized technique and the least volume of obturation was observed in cold lateral condensation technique.

Mirfendereski et al[55](2009) assessed two simplified root filling methods; ProTaper Obturators and System-B/Calamus for adequacy and expediency when performed by inexperienced students.He concluded that the ProTaper Obturators root filling method was particularly suitable for teaching when endodontic experiences available for students are limited.

Patel et al[59](2009) studied the etiology, predisposing factors, diagnosis, and management of external cervical resorption and also the role of cone beam computed tomography as a diagnostic adjunct .

Pinheiro et al[61] (2009) evaluated the sealing ability of AH Plus, Epiphany, Acroseal, Endofill, and Polifil after active lateral condensation technique, by using a bacterial test, during 64 days.He concluded that AH Plus and Endofill had the worst sealing ability when compared with Polifil, which showed the least leakage whereas Acroseal and Epiphany showed a tendency toward having an intermediate behaviour and there was no significant difference among Acroseal, Epiphany, and the other sealers.

Pirani et al[64] (2009) studied the root canal wall morphology under scanning electron microscopy magnification after removal of 2 types of root canal fillings - AH Plus as a sealer with Thermafil or warm vertically condensed gutta-percha using ultrasonic tips, nickel-titanium (NiTi) rotary instruments, and hand K-files. They concluded that all retreatment techniques showed similar performances in terms of smear layer morphology, debris, and surface profile and none of them completely removed filling debris from dentinal tubules of apical third.

Tasdemir et al[76] (2009) compared the sealing ability of 3 current filling techniques; tapered single-cone technique, lateral

condensation and warm vertical compaction in root canals shaped with ProTaper and Mtwo rotary systems.He concluded that filling with tapered single-cone technique, lateral condensation and warm vertical compaction techniques treated with ProTaper or Mtwo rotary instruments showed similar levels of sealing efficacy

Yilmaz et al[86](2009) investigated the sealing properties of 2 warm vertical compaction techniques (BeeFill 2in1, System B/Obtura II) in comparison with single-cone and cold laterally compacted gutta-percha.He concluded that the apical sealing efficiency of System B/Obtura II and BeeFill were inferior to the other obturation techniques after 2-week fluid conductance testing in vitro.

Zhang et al[87] (2009) investigated the apical sealing ability of a newly introduced root canal sealer: iRoot SP Root Canal Sealer. Group A specimens were filled with iRoot SP using the continuous wave condensation technique; Group B specimens were obturated with iRoot SP using a single cone technique; Group C specimens were filled with AH plus by means of the continuous wave condensation technique.He concluded that iRoot SP was equivalent to AH Plus sealer in apical sealing ability.

Brosco et al[9](2010) studied the presence of dentin infection in root canals, obturated with 4 techniques; lateral condensation, MicroSeal system, Touch ’n Heat and Ultrafil, and Tagger’s hybrid technique with bacterial leakage test.He concluded that lateral condensation technique allowed lower penetration of bacteria in the root canals and dentinal tubules, followed by Touch ’n Heat and Ultrafil, MicroSeal, and Tagger’s hybrid technique, which allowed significantly greater penetration of bacteria.

Fleming et al[27] (2010) compared classic techniques (eg, instrumentation with stainless steel hand files, alternating 5.25% NaOCl and 3% hydrogen peroxide irrigation, mostly multiple treatment visits, and so on) with those performed using more contemporary techniques (eg, instrumentation with hand and rotary nickel-titanium files, frequent single-visit treatment, NaOCl, EDTA, chlorhexidine, H2O2 irrigation, warm vertical or lateral condensation obturation, use of surgical microscopes, electronic apex locators, and so on).He found no statistically significant difference was noted between the two technique groups or between single or multiple visits in terms of survival.

- **Patel et al[60] (2010)**studied the etiology and pathogenesis of internal root resorption as well as the problems encountered in the diagnosis and treatment planning.He also studied the epidemiology ,classification,and histological features of internal root resorption.This study showed that the advent of cone beam computed tomography has considerably enhanced the clinicians capability of diagnosing internal resorption and that root canal treatment remains the treatment of choice .

Tzanetakis et al[78] (2010) studied the influence of smear layer removal on through-and-through fluid movement along root canal fillings obturated using 3 different root canal sealers, namely AH26, Pulp Canal Sealer, and Gutta-Flow and 3 different obturation techniques; lateral compaction, System B plus Obtura II and gutta flow technique.He concluded that smear layer removal improves the ability of the filling materials to prevent the fluid movement, at least after the use of warm obturation techniques and on the contrary, smear layer removal does not seem to improve the same ability after the use of cold lateral compaction technique.

MATERIALS AND METHODS

Materials used

1. Freshly extracted maxillary central incisors approximately 21 mm length.
2. Glyde (Denstply)
3. 3% NaOCl
4. Saline
5. Gutta-percha points(2% taper) (Dentsply)
6. AH Plus sealer (Dentsply)
7. GIC cement(Type 2) (GC)
8. Putty (rubber based impression material)
9. Fevi –Quik

Armamentarium

1. Endo access bur
2. No.6 round bur
3. Hand K- files (21mm length -10,15,20,25 size) (Mani)
4. Fine diamond disc
5. Hu –Friedy 30 #,40 # and 50# pluggers

6. Pluggers and spreaders (Mani)
7. Thermafil obturator(Thermaprep plus)
8. Sytem B heat source(Analytical technology,Orange,CA,USA)
9. Obtura II(Obtura corporation) ,Fenton,MO,USA.
10. E andQ plus (Meta Dental Corp)
11. Stereo microscope
12. Nickon cool pix 885 digital camera

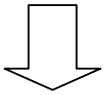
METHODOLOGY

Thirty five freshly extracted human intact maxillary central incisor teeth with fully formed root apices were taken.The selection criteria were teeth with no calcification,no internal resorption and no previous root canal filling were used in this study. The collected teeth were almost of 21 mm length and teeth were ultrasonically cleaned for removing calculus and debris and stored in saline . A conventional endodontic access was prepared in each tooth and a size 10-K file was inserted to determine the location of the apical foramen. The teeth were instrumented to master apical file size 40 and the step-back technique till 80 size and then irrigated with saline and 2.5% sodium hypochlorite solution.

To create artificial internal resorptive cavities, the roots were sectioned horizontally 7 mm from the apex with a fine diamond disc. Semi-circular cavities of 2 mm were created using a low speed No. 6 round bur around the periphery of the opening of the root canal of each section . Then the sections were repositioned together using feviquik glue on the dentine surface around the cavities. Care was taken to maintain the patency of the canal by using minimal amount

of glue and a master apical cone of 40 size was placed to prevent the glue from flowing into the resorptive cavity and then radiographs were taken both in buccolingual and mesiodistal view.Each tooth was embedded in putty (rubber based impression material). Then, thirty five teeth were randomly assigned to five groups of seven samples each.

35 samples



Group I Warm vertical compaction	Group II Lateral condensation	Group III ObturaII with System B	Group IV E and Q plus with System B	Group V Thermafil

Group I ; Warm vertical compaction

Seven teeth were obturated with this group.A gutta-percha master cone 40 size was fitted within 1.5 mm short of the working length. Freshly mixed AH plus sealer was applied to the root canal walls using a file in a counter clockwise rotation. The master cone of 40 size was lightly coated with sealer and placed into the root canal and then the coronal porotion of the master cone is removed with a heating instrument.A heated Hu-Friedy 30 # plugger is used for

initial compaction in the apical portion and a Hu-Friedy 40 # plugger is used for compaction of remaining portion of root canal which is filled with 3 mm of small segmants of gutta percha. In this technique heated pluggers are used and pressure is applied in vertical direction to heat softened gutta percha which causes it to flow and and fill the canal spaces.

Group II ; Lateral condensation

A gutta-percha master cone of 40 size was fitted within 0.5 mm of the working length. Freshly mixed AH plus sealer was applied to the root canal walls using a file in a counterclockwise rotation. The master cone of 40 size was lightly coated with sealer and placed into the root canal. Lateral condensation was achieved using standardized finger spreaders . When the points prevented the spreader penetrating beyond the coronal third of the canal, the canal was considered to be adequately filled and excess gutta-percha was removed with a hot instrument.

Group III ; Obtura II along with System B

Seven teeth were obturated with this technique. A gutta-percha master cone 40 size was fitted within 0.5 mm short of the working length.A fine System B plugger is selected with a rubber stop placed

3mm short of the maximum depth of the plugger reached in root canal. The master cone of 40 size was lightly coated with AH plus sealer at the tip and was placed in the canal.The master cone is then severed at the orifice with an heated instrument.The system B was set to 200ºC and gutta percha was sheared off at 5 mm from apex with a fine System B plugger and then compacted slightly.Radiograph is taken to confirm the apical stop.Back filling was done with Obtura II set at 200 ºC and the 20 guage needle placed in into the root canal against the apical gutta percha for 5 seconds before extruding gutta percha. It consist of a an electric control unit with pistol grip syringe and specially designed gutta percha pellets which are heated for obturation. The mass of gutta percha was allowed to force the needle coronally to the canal orifice and the needle was removed after a pause of 1 second.A Hu –Friedy 50# plugger was used to firmly compact the mass of gutta percha at the orifice level.

Group IV; E and Q plus along with Sytem B

Seven teeth were obturated with this technique. A gutta-percha master cone 40 size was fitted within 0.5 mm short of the working length.A fine System B plugger is selected with a rubber stop placed 3mm short of the maximum depth of the plugger reached in root

canal. The master cone of 40 size was lightly coated with AH plus sealer at the tip and was placed in the canal.The master cone is then severed at the orifice with an heated instrument. The system B was set to 200ºC and gutta percha was sheared off at 5 mm from apex with a fine System B plugger and then compacted slightly.Radiograph is taken to confirm the apical stop. The System B should not be set at high temperature because it may burn the gutta percha and while down packing apply a constant firm pressure .

Back filling is done with an E and Q plus gun. After inserting the 20 guage needle into the root canal, wait for 5 seconds .Pull the trigger slowly and backfill with warm gutta percha and then allow the flow of warm gutta percha to bring the needle up from the canal. A Hu –Friedy 50# plugger was used to firmly compact the mass of gutta percha at the orifice level.

Group V; Thermafil

The canals were filled using the plastic carrier Thermafil system and AH plus sealer was applied to the canal walls with a file and a size 40 Thermafil obturator was warmed in a Thermaprep oven for a minimum of 10 s in accordance with the manufacturer's recommendations. The heated obturator was slowly inserted into the

canal within 0.5 mm of the working length. An inverted cone bur was used to cut through the shank of each carrier. The technique was described as a single penetration, compacted, warm gutta-percha technique and was commercialized under the name of Thermafil Endodontic Obturators. The manufacturer recommends that the carriers be heated in a special oven, the ThermaPrep Oven , before being inserted in a canal previously lined with sealer.

After this coronal access was sealed with Type 2 glass ionomer cement .Following filling, the teeth were stored for 7 days at room temperature to ensure all materials had set. The teeth were removed from putty (rubber based impression material) and radiographs of the teeth were taken both in buccolingual and mesiodistal view. Then, each tooth was sectioned with a rotary saw 7 mm from the apex at the level of the previous cut, and under cold water to minimize gutta-percha smearing. Photographs of both surfaces of the sectioned area were taken by using a Nikon Coolpix 885 digital camera, which was mounted on a Stereomicroscope(16x) ocular eye.

The photographs were transferred to a computer and an image analysis program (ImageJ software) was used to calculate the percentage of gutta-percha, sealer and voids. ImageJ is a Java image

processing and analysis program which can calculate area and pixel value statistics of user-defined selections. It can measure distances and angles. It can create density histograms and line profile plots. It supports standard image processing functions such as contrast manipulation, sharpening, smoothing, edge detection and median filtering. It does geometric transformations such as scaling, rotation and flips. Image can be zoomed up to 32 : 1 and down to 1 : 32. All analysis and processing functions are available at any magnification factor. The program supports any number of windows (images) simultaneously.

The results of the present study were subjected to statistical analysis to interpret the mean , standard deviation and mean difference.One way ANOVA and POST HOC TUKEY test were used for statistical analysis.One way analysis of variance (ANOVA)was used to study the overall variance within groups. POST HOC TUKEY was done inorder to determine which groups differ from each other.

METHODOLOGY

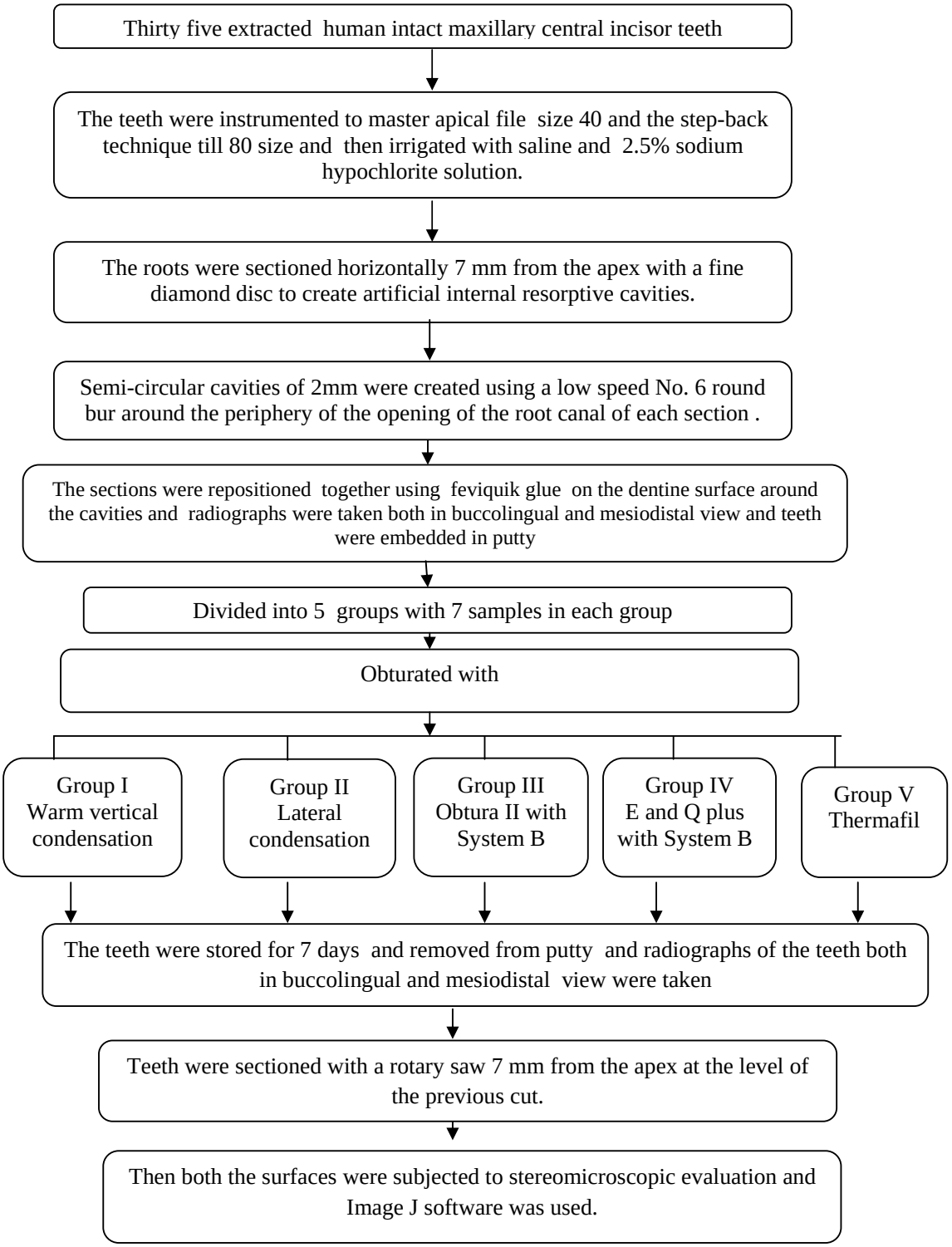


Fig. 1 : Armamentarium

Fig. 2: Teeth Specimens

Fig.3: Horizontally cut 7 mm from apex

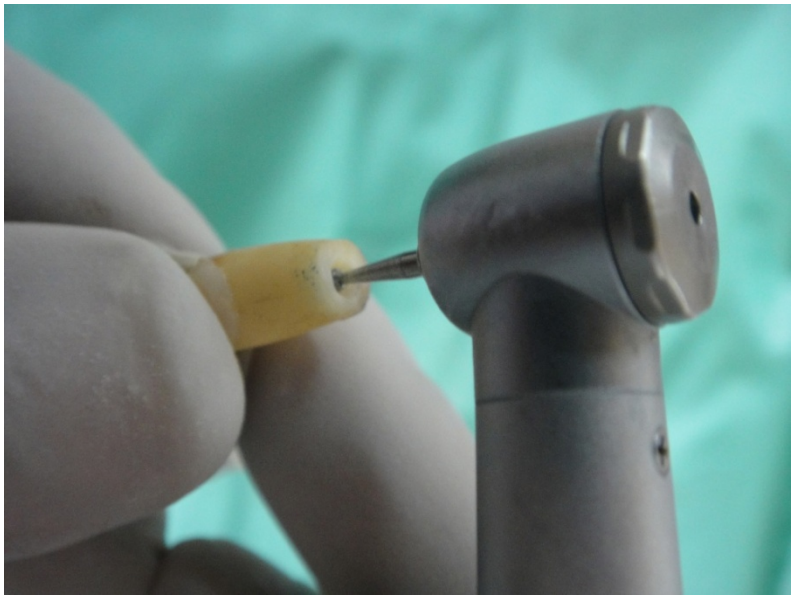


Fig. 4: Preparation of resorptive cavity

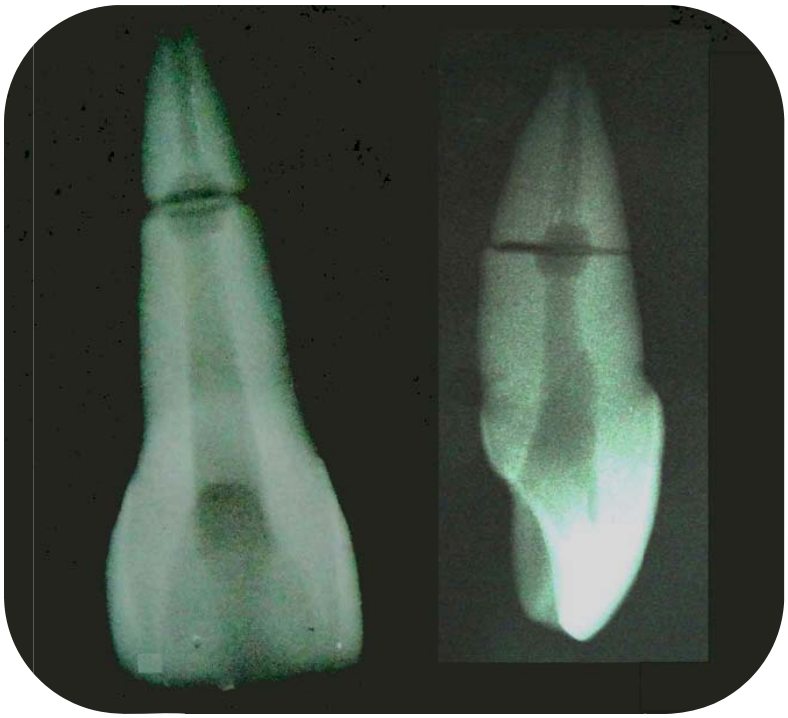


Fig5:Radiograph revealing resorptive cavity in buccolingual and mesiodistal view.

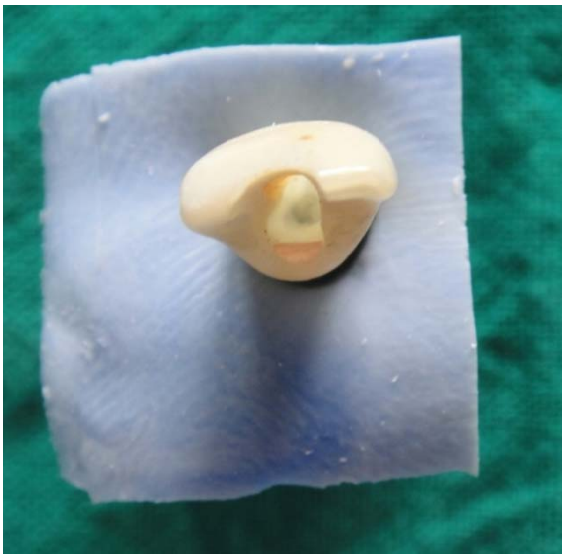


Fig.6: Tooth embedded in putty (rubber based impression material)

Fig.7: E and Q plus

Fig.8:Thermafil

Fig.9: System B

Fig.10: Obtura II

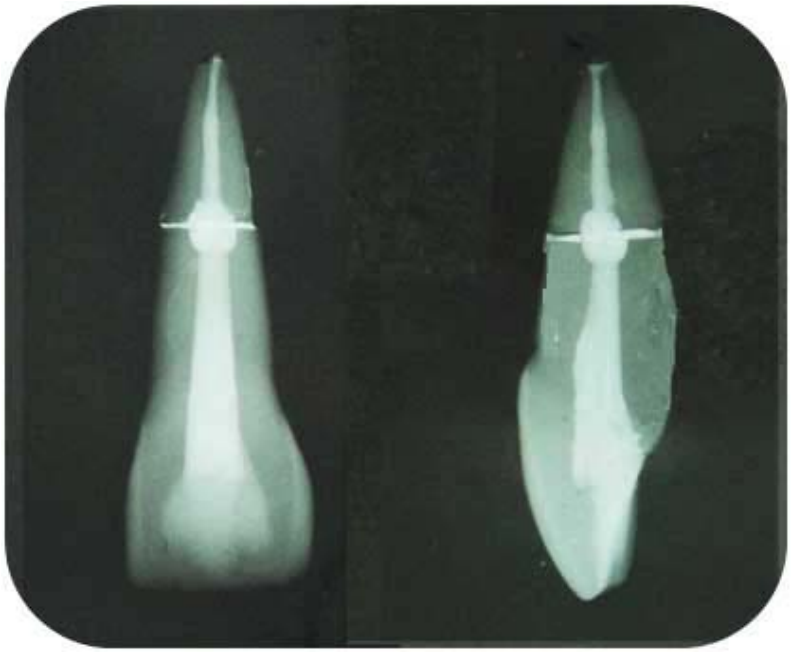


Fig.11: Radiograph taken in buccolingual and mesiodistal view after obturation

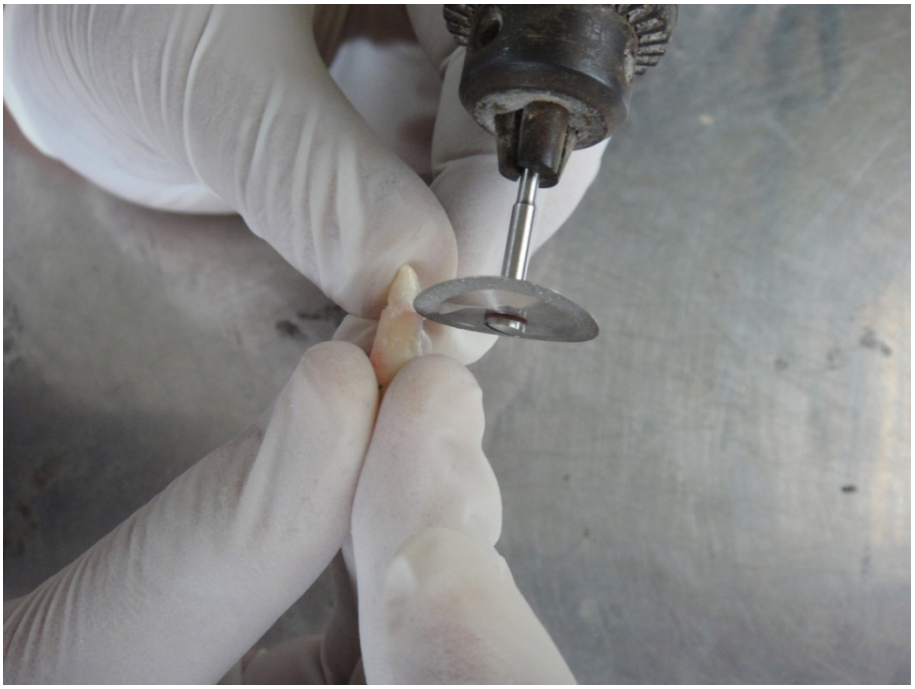
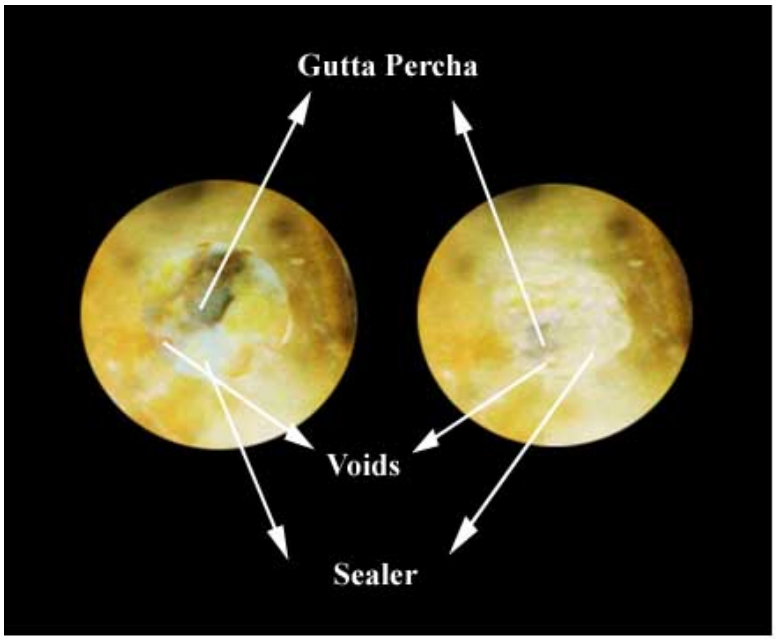


Fig. 12: Sectioned at the previous cut

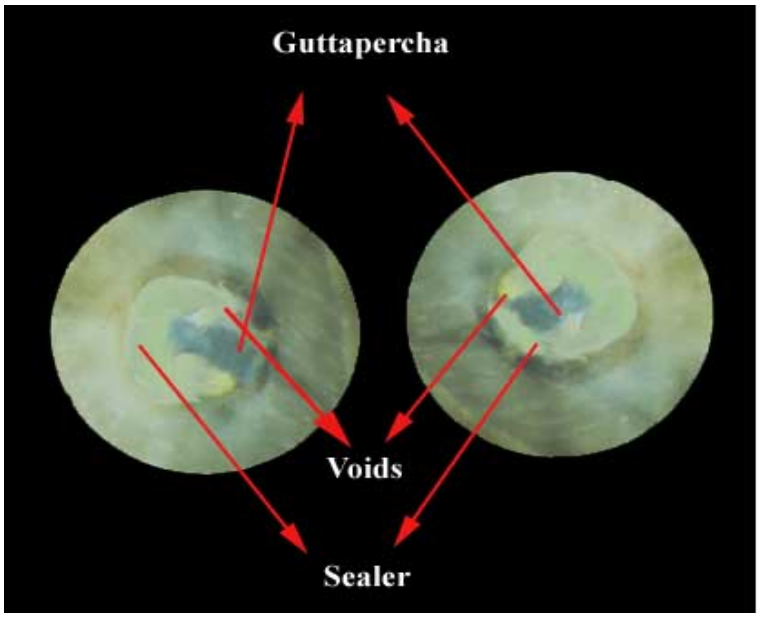
Fig.13: Stereo Microscope

Stereomicroscopic pictures



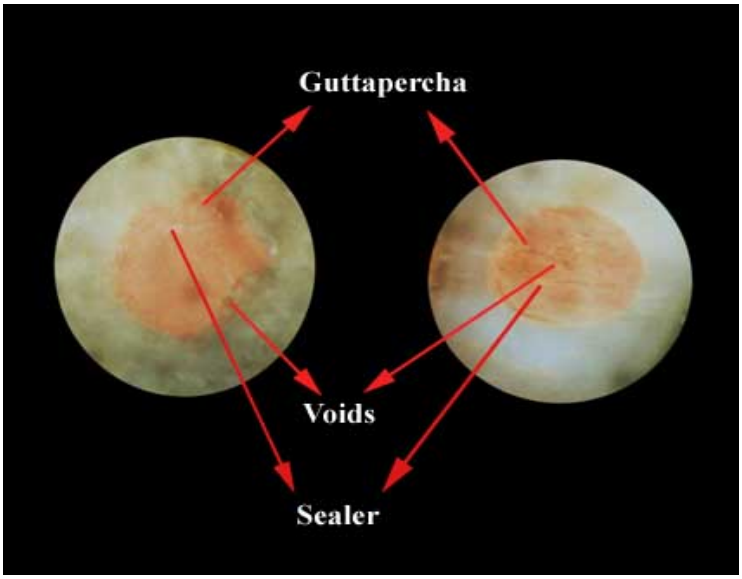
Coronal part Apical part

Fig. 14: Warm Vertical compaction (Group I)



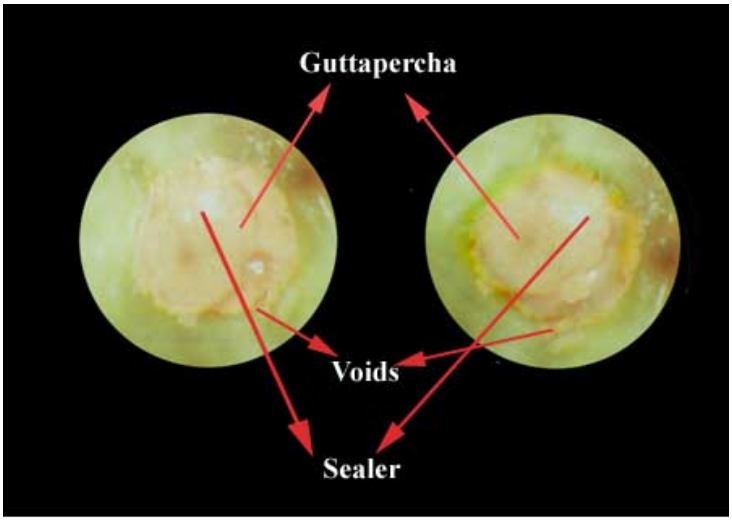
Coronal part Apical part

Fig.15: Lateral condensation (Group II)



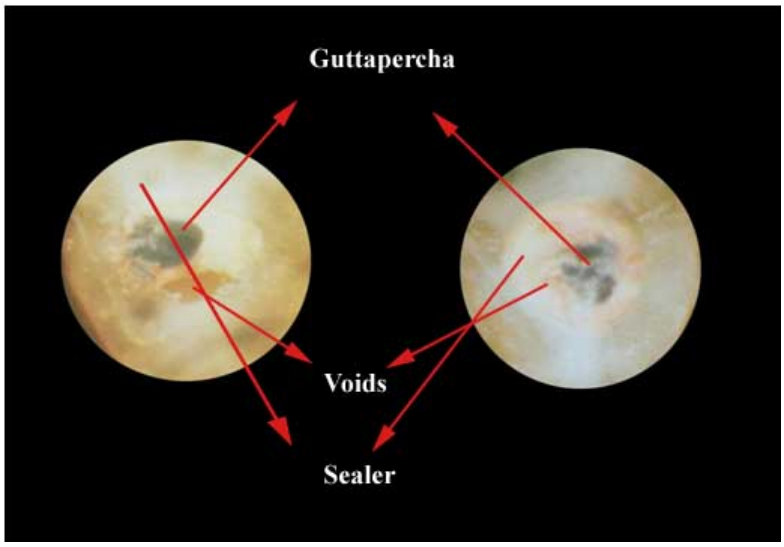
Coronal part Apical part

Fig.16: Obtura II along with System B(Group III)



Coronal part Apical part

Fig.17: E and Q along with System B(Group IV))



Coronal part Apical part

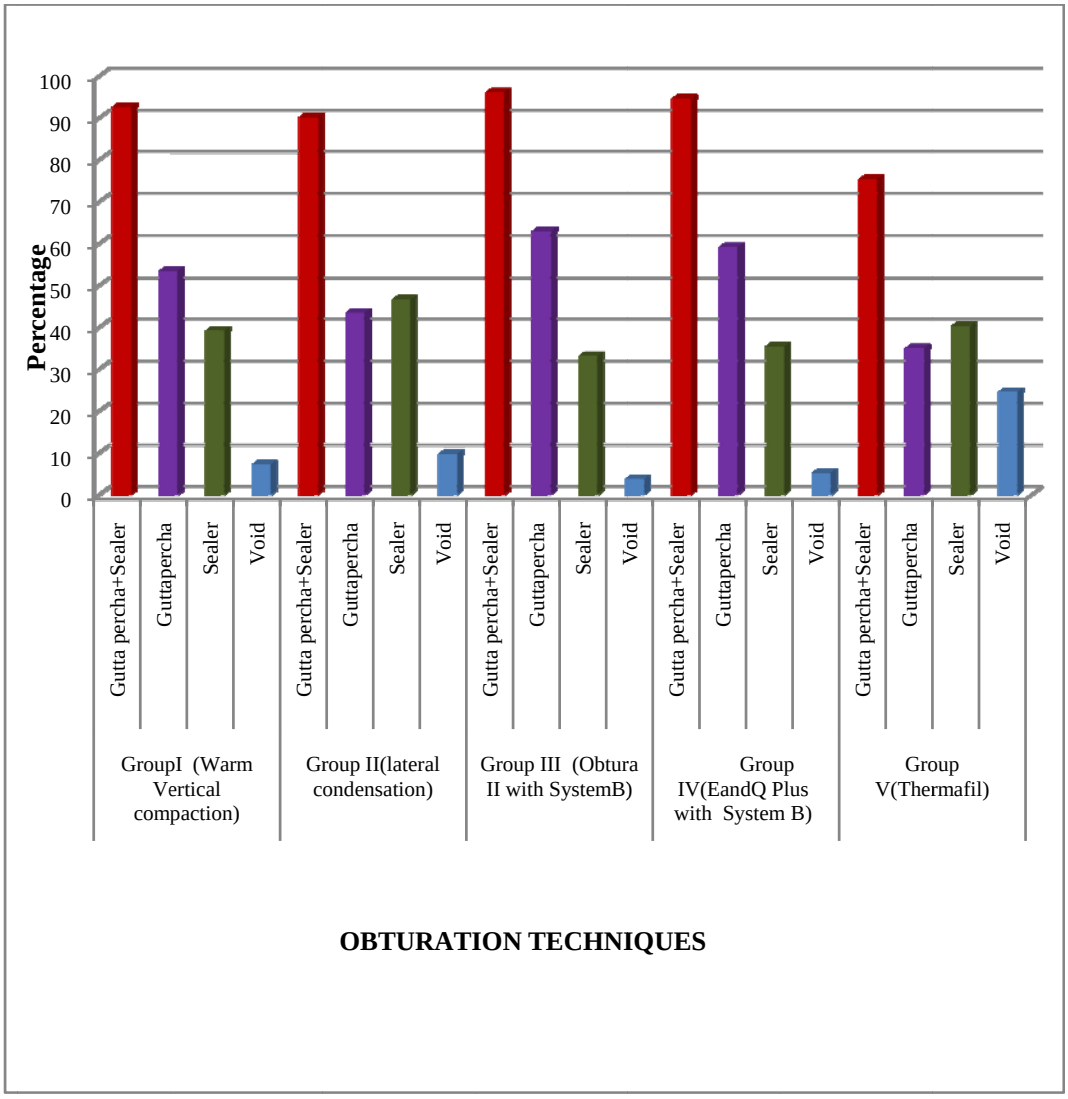
Fig.18 : Thermafil (Group V)

RESULTS

1. Figure 14 to 18 shows the stereomicroscopic pictures of different obturation techniques showing gutta percha, sealer and voids.
2. Table 1 shows mean and standard deviation of the ratios of percentage of gutta percha and sealer,gutta percha,sealer and voids.Between the warm vertical compaction(groupI) , lateral condensation (group II) ,Obtura II with System B(group III),E and Q plus with System B(group IV) and thermafil (group V), group III showed the highest percentage of gutta percha plus sealer,gutta percha and least number of voids which was statistically significant ($p<0.000$).The Table 1 also shows that the highest percentage of sealer was seen in group II which was statistically significant ($p<0.000$). The Table 1 also shows that the highest percentage of voids was seen in group V which was statistically significant ($p<0.000$).
3. Table 2 shows the ratios of mean diference and significance of gutta percha and sealer(multiple comparison) within the groups.The mean difference is significant at the .05 level.

4. Table 3 shows the ratios of mean diference and significance of gutta percha (multiple comparisons) within the groups. The mean difference is significant at the .05 level ($p < .05$).
5. Table 4 shows the ratios of mean diference and significance of sealer (multiple comparison) within the groups. The mean difference is significant at the .05 level ($p < .05$).
6. Table 5 shows the ratios of mean diference and significance of voids (multiple comparison) within the groups. The mean difference is significant at the .05 level ($p < .05$).

GRAPH –1 Percentage of gutta-percha plus sealer, gutta percha, sealer, and voids in five obturation techniques.



Results

The results of stereomicroscope analysis of gutta percha plus sealer,gutta percha,sealer and void are summarised in Tables 1 to Table 5.

Oneway Anova

Table 1: Estimated least square mean (mean %) and standard deviation of the ratios evaluated in stereo microscope. (Percentage of gutta-percha and sealer,gutta percha,sealer and void) between group.

Mean% ± standard deviation

	Gutta percha plus Sealer	**Gutta percha**	**Sealer**	**Void**
Warm vertical compaction (GroupI)	92.67±1.14	53.49±1.73	39.22±.8191	7.28±1.15
Lateral condensation (GroupII)	90.19±1.87	43.48±.872	46.64±1.47	9.78±1.85
Obtura II with SystemB (Group III)	96.12±.886	62.99±.927	33.16±.715	3.77±.826
E and Q plus with System B (Group IV)	94.63±1.46	59.15±1.59	35.47±1.79	5.27±1.42
Thermafil (Group V)	75.38±1.63	35.01±.943	40.35±1.44	24.59±1.63

The mean difference is significant at the .000 level

Table2: Estimated ratios of mean difference and significance evaluated in stereomicroscope(percentage of gutta percha and sealer) between 5 groups.

Multiple comparison

POST HOC TEST

Gutta percha plus sealer

Gutta percha plus sealer			**Mean difference**	**Significance**
Warm vertical compaction (I)	vs	Lateral condensation(II)	2.467*	.000
		Obtura II with System B(III)	-3.462*	.000
		Eand Q with System B(IV)	-1.965*	.005
		Thermafil(V)	17.285*	.000
Lateral condensation(II	vs	Warm vertical compaction (I)	-2.467*	.000
		Obtura II with SystemB(III)	- 5.930*	.000
		E and Q withSystemB(IV)	- 4.432*	.000
		Thermafil(V)	-14.817*	.000
Obtura II with System B(III)	vs	Warm vertical compaction (I)	3.462*	.000
		Lateral condensation(II)	5.930*	.000
		E and Q and System B(IV)	1.497	.058
		Thermafil(V)	20.747*	.000
E and Q plus with System B(IV)	vs	Warm vertical compaction (I)	1.965*	.000
		Lateral condensation(II)	4.432*	.000
		Obtura IIwith SystemB(III)	- 1.497	.058
		Thermafil(V)	19.250*	.000
Thermafil(V)	vs	Warm vertical compaction (I)	-17.285*	.000
		Lateral condensation(II)	-14.817*	.000
		Obtura II with System B(III)	-20.747*	.000
		E and Q with System B(IV)	-19.250*	.000

***The mean difference is significant at the .05 level.**

Table 3:. Estimated ratios of mean difference and significance evaluated in stereomicroscope(percentage of gutta percha) between 5 groups.

Multiple comparison

POST HOC TEST

Gutta percha

Gutta percha			Mean difference	Significance
Warm vertical compaction(I)	vs	Lateral condensation(II) Obtura II with System B(III) Eand Q with System B(IV) Thermafil(V)	10.013* - 9.501* - 5.654* 18.477*	.000 .000 .000 .000
Lateral condensation (II)	vs	Warm vertical compaction (I) Obtura II with SystemB(III) E and Q withSystemB(IV) Thermafil(V)	-10.013* -19.515* -15.667* 8.464*	.000 .000 .000 .000
Obtura II withSystem B(III)	vs	Warm vertical compaction (I) Lateral condensation(II) E and Q and System B(IV) Thermafil(V)	9.501* 19.515* 3.847* 27.979*	.000 .000 .000 .000
E and Q plus with System B(IV)	vs	Warm vertical compaction (I) Lateral condensation(II) Obtura IIwith SystemB(III) Thermafil(V)	5.654* 15.667* -3.847* 27.132*	.000 .000 .000 .000
Thermafil(V)	vs	Warm vertical compaction (I) Lateral condensation(II) Obtura II with System B(III) E and Q with System B(IV)	-18.477* - 8.464* -27.979* - 24.132*	.000 .000 .000 .000

***The mean difference is significant at the .05 level.**

Table 4: Estimated ratios of mean difference and significance evaluated in stereomicroscope(percentage of sealer) between 5 groups

Multiple comparison

POST HOC TEST

Sealer

Sealer			Mean difference	Significance
Warm vertical compaction(I)	vs	Lateral condensation(II) Obtura II with System B(III) Eand Q with System B(IV) Thermafil(V)	-7.420* 6.060* 3.744* -1.135	.000 .000 .000 .163
Lateral condensation (II)	vs	Warm vertical compaction (I) Obtura II with SystemB(III) E and Q withSystemB(IV) Thermafil(V)	7.420* 13.480* 11.165* 6.285*	.000 .000 .000 .000
Obtura II withSystem B(III)	vs	Warm vertical compaction (I) Lateral condensation(II) E and Q and System B(IV) Thermafil(V)	-6.060* -13.480* -2.315* -7.195*	.000 .000 .000 .000
E and Q plus WithSystem B(IV)	vs	Warm vertical compaction (I) Lateral condensation(II) Obtura IIwith SystemB(III) Thermafil(V)	-3.744* -11.165* 2.315* -4.880*	.000 .000 .000 .000
Thermafil(V)	vs	Warm vertical compaction (I) Lateral condensation(II) Obtura II with System B(III) E and Q with System B(IV)	1.135 -6.285* 7.195* 4.880*	.163 .000 .000 .000

***The mean difference is significant at the .05 level**.

Table 5: Estimated ratios of mean difference and significance evaluated in stereomicroscope(percentage of voids) between 5 groups

Multiple comparison

POST HOC TEST

Voids

Voids			Mean difference	Significance
Warm vertical compaction(I)	vs	Lateral condensation(II)	-2.497*	.000
		Obtura II with System B(III)	3.505*	.000
		Eand Q with System B(IV)	2.010*	.004
		Thermafil(V)	-17.311*	.000
Lateral condensation (II)	vs	Warm vertical compaction (I)	2.497*	.000
		Obtura II with SystemB(III)	6.003*	.000
		E and Q withSystemB(IV)	4.507*	.000
		Thermafil(V)	-14.813*	.000
Obtura II withSystem B(III)	vs	Warm vertical compaction (I)	-3.505*	.000
		Lateral condensation(II)	-6.003*	.000
		E and Q and System B(IV)	-1.495	.054
		Thermafil(V)	-20.817*	.000
E and Q plus withSystem B(IV)	vs	Warm vertical compaction (I)	-2.010*	.004
		Lateral condensation(II)	-4.507*	.000
		Obtura IIwith SystemB(III)	1.495	.054
		Thermafil(V)	-19.321*	.000
Thermafil(V)	vs	Warm vertical compaction (I)	17.311*	.000
		Lateral condensation(II)	14.813*	.000
		Obtura II with System B(III)	20.817*	.000
		E and Q with System B(IV)	19.321*	.000

***The mean difference is significant at the .05 level.**

DISCUSSION

Internal root resorption has been reported as early as 1830.[60] The most commonly affected teeth were maxillary incisors and is mostly seen in the middle third of the root.[26] Internal root resorption has been described as intraradicular or apical according to the location in which the condition is observed . Intraradicular internal resorption is an inflammatory condition that results in progressive destruction of intraradicular dentin and dentinal tubules along the middle and apical thirds of the canal walls. The condition is more frequently observed in male than female subjects. [45]

Various etiologic factors have been proposed for the loss of predentin, including trauma, caries and periodontal infections, excessive heat generated during restorative procedures on vital teeth, calcium hydroxide procedures, vital root resections, anachoresis, orthodontic treatment, cracked teeth, or simply idiopathic dystrophic changes within normal pulps. Trauma was found to be the most common predisposing factor.[60]

Resorptions were divided into treansient and progressive type resorption where progressive type requires continuous stimulation by infection.[89] Two types of internal root resorption were described by

Ne et al, internal (root canal) inflammatory resorption and internal (root canal) replacement resorption.[58]

The histological appearance of internal resorption is characterized by the presence of large multinucleated cells, similar to the dentinoclasts observed in external root resorption. It is therefore likely that internal resorption is engineered by clastic cells similar or identical to osteoclasts and numerous macrophage-like cells were also found. Clastic mononuclear cells have also been observed in internal resorption.[83]

For internal resorption to occur, the pulp tissue apical to the resorptive lesion must have a viable blood supply to provide clastic cells and their nutrients, whereas the infected necrotic coronal pulp tissue provides stimulation for those clastic cells.[60] The criterion standard for the diagnosis of internal root resorption is microscopic analysis and it may be classified as active, arrested, or repaired according to microscopic findings . The diagnosis of the condition is primarily based on radiographic examination, with supplementary information gained from history and clinical findings.[25]

As early as 1976,Gartner et al suggested an important radiographic aid that may be used to help distinguish these lesions

and was referred to as the mesial-buccal-distal (MBD) rule.[29] In endodontic therapy it is imperative that the clinician know the spatial or buccolingual relation of an object within the tooth or alveolus. The technique used to identify the spatial relation of an object is called the cone or tube shift technique, buccal object rule, clarks rule or SLOB rule.Proper application of the technique allows the dentist to locate additional canals or roots,to distinguish between objects that have been superimposed, and to distinguish between various types of resorption. [89]

Advancement in the field of radiography, rotational tomography, a relatively simple and well-established radiographic technique was used for determining the buccolingual extent of internal resorptive lesions.[28] Recently cone beam computed tomography,a non invasive technique has been used for diagnosing internal resorption and was very helpful in diagnosing the exact size and location of resorption and in the serial cross-sectional views, the size and the location of resorption were clearly determined.[25]

The differential diagnosis for tooth resorption are the normal tooth with its variations, dental caries, early pulpal death or incomplete root formation, and external resorption.[29] Traditionally,

the pink spot of Mummery has been thought to be pathognomonic of internal root resorption. However, these pink spots are more commonly associated with external cervical root resorption. In many instances, there are no clinical signs, and the teeth that exhibit internal root resorption are asymptomatic.[59]

Root canal treatment remains the only treatment of choice with teeth diagnosed with internal root resorption because the resorptive defect is the result of an inflamed pulp and the clastic precursor cells are predominantly recruited through the blood vessels.Internal root resorption lesions present the endodontist with unique difficulties in the preparation and obturation of the affected tooth. Access cavity preparation should be conservative, preserving as much tooth structure as possible, and should avoid further weakening of the already compromised tooth.[60]

The principal cause of persistent apical periodontitis might be attributed to microorganisms remaining within the canal after root canal treatment. Despite advances in endodontic techniques, instruments and irrigants fail to predictably access the restricted areas of the canal space.[65] The various irrigants used in endodontics are sodium hypochlorite, hydrogen peroxide, chlorhexidine, urea

peroxide, chelating agents and citric acid .These irrigants produce a broad spectrum antibacterial property, aid in debridement of root canal system and also in dissolving necrotic tissue or debris. [89] Because of the inaccessibility of internal root resorption lesions to chemomechanical debridement, ultrasonic activation of irrigants should be viewed as an essential step in the disinfection of the internal resorption defect.[11] The use of multiple calcium hydroxide dressings has been advocated to enhance chemomechanical debridement of the internal root resorption defect.[74]

Internal root resorption are not merely of diagnostic challenge to the clinician but also pose difficulty in cleaning,disinfecting and obturation of the resorptive defect. Hence in this study different obturation techniques has been evaluated for their efficiency in filling the resorptive cavities to simulate the clinical condition in vitro.

Internal root resorption defects can be difficult to obturate adequately. To completely seal the resorptive defect, the obturation material should be flowable. Gutta-percha is the most commonly used filling material in endodontics.Commercially pure gutta percha exists in two distinct,two different crystalline forms,alpha and beta.These forms are interchangeable depending on the temperature of the

material. Most commercially available forms are the beta structure whereas newer products have adopted the alpha crystalline structure for compatibility with the thermosoftening of the material during obturation.This change has been made because heating of the beta phase cause the crystalline structure to change to the alpha phase and ultimately into an amorphous melt.[89]

Gutta percha undergoes significant shrinkage during its phase retransformation to the beta phase thereby necessitating thorough compaction during cooling.In the alpha phase however the gutta percha undergoes less shrinkage, and compaction pressures and techniques can better compensate for any shrinkage that may occur. [89]

According to Gencoglu ,the various techniques used these days for filling internal resorption include warm condensation (Microseal),vertical condensation (SytemB),core techniques (Thermafil, Soft Core, JS Quickfil),thermoplasticised gutta percha(E and Q plus, Obtura),warm vertical condensation, cold lateral condensation.[32]

Cold lateral condensation is a commonly taught method of filling and widely accepted and practiced by dental practitioners.It has been considered as a gold standard and a basis of comparison for

new filling techniques.Lateral condensation has the advantage of low cost and ability to control the length of the fill . If there is a poor preparation of the canal,inadequate pressure being applied,or a mismatch of tapers of spreader,GP cone and canal ,there will be spaces between the GP cones,which is probably filled with sealers.[13]

Brayton et al reported voids,spreader tracts,incomplete fusion of the gutta percha cones ,and lack of surface adaptation from the lateral condensation technique.Eguchi et al reported that this technique results in excessive amounts of sealer and apical voids.Peters demonstrated that some sealer used in lateral condensation technique may resorb with time.[30]

The lateral condensation technique has been blamed as a major cause of vertical root fracture. In lateral condensation, the strain is generated by the wedging effect of the spreader, because it laterally compacts the gutta-percha and adapts it to the canal wall.[69]

Vertical compaction of warm gutta percha method of filling the root canal was introduced by Schilder with an objective of filling all the portals of exit with maximum amount of gutta percha and minimum amount of sealer and was known as Schilders technique of obturation. Vertical compaction of warm gutta percha was used in

this study because internal resorptive cavities needed to be filled more with gutta percha than sealer which was possible with this technique.[89]

This technique requires a continuous tapering funnel shape canal from orifice to apex and an apical opening as small as possible.The advantages of this technique are excellent sealing of canal apically,laterally and obturation of lateral as well as accessory canals.The disadvantages are increased risk of vertical root fractures,overfilling of canals with gutta percha or sealer from apex and it is time consuming.[89]

In a comparative study between between lateral and vertical condensation Peter Brothman found that lateral condensation appears to be better for ribbon shaped canals whereas vertical condensation for centric canals.[10] Because of the disadvantages of these techniques, several variations have been developed. Many have evolved to decrease operating time, take advantage of the benefits of the warm gutta-percha technique, and gain better apical control of the gutta-percha. [47]

Johnson demonstrated a simple method of carrying thermoplasticized gutta-percha to the extent of the prepared canal.[46]

Currently, there are three types of Thermafil obturators, with their differences based on the carrier material for the gutta-percha.Stainless steel, titanium, and plastic carriers are coated with alpha phase gutta-percha and become part of the final obturation. [49] Thermafil technique was used in this study because it was found to be very effective in filling normal root canals and was superior to the lateral condensation in terms of core sealer ratio according to Gencoglu et al.

The advantages of this technique are that it requires less chairside time,and dense three dimensional obturation is possible as gutta percha flows into canal irregularities such as fins ,anastomoses and lateral canals and there is no need to precurve obturators because of flexible carriers and less strain because minimum compaction during obturation.[89] Lip-Hean Saw found that in Thermafil technique, only minimal condensation is recommended, and the condensation is limited to the coronal aspect. This aspect, plus the ease of insertion of the carrier with heat-softened gutta-percha, was responsible for the lower load application observed during condensation.[69]

A technique called continuous wave of condensation has been introduced and is said to simplify and speed up vertical condensation

of root canal system called System B which can be heated to preset temperatures prior to vertically condensing the gutta percha within the root canal system and the remaining canal source requires backfilling otherwise coronal leakage would result. The backfilling is frequently performed with Obtura II to introduce thermoplasticized gutta percha to the root canal,which are then condensed using hand instruments.[52]

System B device was introduced by Buchanan for warming gutta percha in the canal and it monitors tempearature at the tip of heat carrier pluggers ,thereby delivering a précise amount of heat. [89] The System B was used in this study to shear off the gutta percha,for down packing and to provide an apical stop which was not produced with the backfilling techniques and found to be effective with Obtura II in previous studies by Mc Robert and Cathro et al.

The advantages are that it creates single wave of heating and compacting thereby compaction of materials can be done at same time when it has been softened and there is a thorough condensation of the main canal and lateral canals and there is excellent apical control and it is less technique sensitive and fast and predictable. [89]

Obtura II heated gutta percha system was introduced in 1977 at Harvard institute. [89] In this regular Beta phase of gutta percha is used .Obtura II was used in this study because it showed good results in the previous studies by Goldberg and Goldman et al who showed that Obtura II performed better than Thermafil and cold lateral condensation.

To get three dimensional obturation by Obtura II,there should be a continuous tapering funnel shape canal for inrestricted flow of softened gutta percha and a definite apical stop to prevent overfilling.It is indicated in roots with straight or curved canals,for backfilling of canals and for obturation of roots with internal resortion and perforations. [89]

The E & Q Plus system consists of a control unit with a pen-grip device holding a heating tip, as well as a gutta-percha injection gun. [85] E and Q plus was used in this study because this technique is very similar to Obtura II which was very effective in filling resorptive cavities and no previous studies have been reported in resorptive cavities with this technique.

The aim of the present study was to compare the quality of root fillings in artificially created internal resorption cavities, filled

with Warm vertical compaction, Lateral condensation, Obtura II along with System B, E and Q plus along with System B and Thermafil.

The objective of this study was to calculate the percentage of guttta percha , sealer and void in the internal resorptive cavities using stereomicroscope with an Image J software.

It is important to stress that radiographic images only show the buccolingual view of the tooth, which is insufficient to establish the quality of the three-dimensional fill achieved. In this regard, the use of an experimental model to study the behavior of the different techniques in the obturation of internal resorptive defects would be beneficial. [26]

In the present study, maxillary central incisors with simulated internal resorptive cavities located in the middle third of the roots were used, since these are the teeth and areas in which internal resorption is most frequently seen . [26] The teeth were stored in saline and 2% hydrogen peroxide to remove debris and scaling done to remove the calculus.Then cleaning and shaping was done to master apical file size 40 and the step-back technique till 80 size and irrigated with saline and 2.5% sodium hypochlorite to remove pulp

tissue. After creation of internal resorption with low speed No. 6 round bur ,the round tip of which is 2mm is inserted fully,and this creates semicircurcular cavities on either side of 2mm,after that teeth were radiographed both in buccolingual and mesiodistal view.The teeth is placed in rubber based impression material to properly hold the teeth during obturation.

In this study AH plus sealer was used and teeth were kept in the plaster casts for 7 days to ensure the setting of the sealer and the setting time according to the manufacturer ranges between 9 and 15 h at 37ºc. The AH plus sealer comes in a paste –paste system and as a working time of 4 hours. AH plus sealer also prevents movement and distortion of the gutta percha during sectioning process. [90] This was accordance to the studies done by Goldberg et a(2000) and Gencoglu et al who also used AH plus sealer for obturation of internal resorptive cavities.

In the present study Obtura II along with System B showed the best results in filling the resorptive cavities followed by E and Q plus along with System B,Warm vertical compaction,Lateral condensation and Thermafil.

The percentage of gutta percha and sealer in Obtura II and System B was 96.16% and was found to be the highest when compared with lateral,warm vertical, thermafil and E and Q plus.The highest percentage of gutta percha was also seen with this technique which was 62.99% when compared with lateral, warm vertical, thermafil and E and Q plus. The percentage of sealer was 33.16% which was found to be the least among the techniques used whereas the percentage of voids was 3.77% which was also found to be the least among the techniques used.

The percent of gutta percha was most in Obtura plus System B and this was similar to the studies by Stamos & Stamos Wilson & Barnes who reported 2 cases of internal resorption in which the Obtura II system was used to successfully obturate the canals.Cathro and Love concluded that System B plus Obtura II produced a homogenous obturation of gutta percha with minimal sealer and no voids. [12] Goldberg et al also concluded that the Obtura II system performed statistically better in obturating resorptive defects than cold lateral condensation,thermafil and a hybrid technique.Agarwal et al also concluded high percentage of gutta percha with Obtura II technique. [2]

The result for high percentage of gutta percha was because its a thermoplasticised technique in which regular beta phase of gutta percha pellets are heated for obturation. The reason for lesser voids is because it involves placing of small aliquots of thermosoftened gutta percha within the root canal and condensing them individually[52]

The second best obturation technique in filling resorptive cavities was seen in E and Q plus and System B.The percentage of gutta percha plus sealer was 94.63% which was found to be lesser than Obtura II but greater than E and Q plus, warm vertical and thermafil .The percentage of gutta percha was 59.15% which was found to be lesser than Obtura II but greater than E and Q plus, warm vertical and thermafil .The percentage of sealer was 35.47% which was found to be greater than Obtura II but lesser than E and Q plus, warm vertical and thermafil and the percentage of voids was 5.27% . which was found to be greater than Obtura II but lesser than E and Q plus, warm vertical and thermafil.

The higher percentage of gutta percha found in in E and Q plus and System B which is very close to Obtura ,can be supported by the fact that both being similar thermoplasicised technique and beta phase technique used in both.There are no previous studies in

literature where E and Q plus and System B has been done in internal resorptive cavities.

The third best obturation technique in filling resorptive cavities in this study was seen in warm vertical compaction.The percentage of gutta percha plus sealer was 92.67% which was found to be lesser than Obtura II and E and Q plus but greater than lateral condensation and thermafil.The percentage of gutta percha was 53.49% which was found to be lesser than Obtura II and E and Q plus but greater than lateral condensation and thermafil.The percentage of sealer was 39.22 which was found to be greater than Obtura II and E and Q plus but lesser than lateral condensation and thermafil % and the percentage of voids was 7.28% which was found to be greater than Obtura II and E and Q plus but lesser than lateral condensation and thermafil.

There was not much difference in the results obtained with warm vertical and other two thermoplasticised techniques because it is similar to these techniques and the only difference in this technique is that heated hand pluggers are used wheras in other technique heated devices were used. Collins et al (2006) suggested the use of

warm lateral and warm vertical condensation gutta-percha techniques for internal resorption and have got similar results.

The fourth best obturation technique in filling resorptive cavity in this study was seen in lateral condensation.The percentage of gutta percha plus sealer was 90.19% which was found to be lesser than Obtura II,E and Q plus and warm vertical but greater than thermafil. The percentage of gutta percha was 43.48% which was found to be lesser than Obtura II,E and Q plus and warm vertical but greater than thermafil. The percentage of sealer was 46.64 % which was found to be greater than all the other four techniques. The percentage of voids was 9.78% found to be greater than Obtura II,E and Q plus and warm vertical but lesser than thermafil.

The highest percentage of sealer was seen in lateral condensation. The results obtained in this study were similar to Gencoglu et al who found high percentage of sealer with lateral condensation.Similar results were obtained by Goldberg et al who found lateral condensation less effective in filling resorptive cavities.[26] Agarwal et al also found high percentage of sealer and lesser gutta percha in filling resorptive cavities when compared with ultrasonic condensation,thermafil and Obtura II. Eguchi et al reported

that this technique results in excessive amounts of sealer and apical voids

The high percentage of sealer in lateral condensationis due to inadequate pressure being applied,or a mismatch of tapers of spreader, gutta percha cone and canal ,which will result in spaces between the gutta percha cones, which is probably filled with sealers[13] . This high sealer proportion in lateral condensation is associated with inability of cold gutta-percha cones to be compacted into the cavities and the diffusion of the sealer into the resorption area during condensation. [32]

The obturation technique which filled the resorptive cavity the least in this study was seen with the Thermafil technique.The percentage of gutta percha plus sealer was 75.38% which was found to be least among all the other techniques.The percentage of gutta percha was 35.01% which was also also found to be least among all the other techniques. The percentage of sealer was 40.35% which was found to be lesser than lateral condensation but higher than the other three techniques and the percentage of voids was 24.59% which was found to be higher than all the other techniques

Thermafil technique had the maximum percentage of voids than all the techniques used in this study.The results obtained in this study were similar to those done by Gencoglu et al who also found greater percentage of voids in the thermafil group when filling resorptive cavities when compared with lateral,System B,microseal,JS Quickfill and soft core.[32] Goldberg et al also found thermafil with increased number of voids.Agarwal et al also found thermafil not effective in filling resorptive cavities as it was filled with more of voids.[2]

The reason for more voids may be because the warmed gutta-percha around the core material was not adequate in filling the hollow space in the resorptive area. In each core technique, the amount of gutta-percha surrounding the core material and the characteristics of fluidity is different and this may affect the filling quality of the core techniques in resorptive area.[32]

Many techniques and materials have been studied ex vivo as possibilities to fill internal resorptive defects. Gutmann et al suggested the use of the Thermafil obturation technique; while Agarwal et al. reported that the use of ultrasonics to condense the

gutta-percha and the Obtura II system were superior to the Thermafil and lateral compaction (LC) techniques.

Goldberg et al (2000) and Agarwal et al. (2002) also reported that the Thermafil technique did not fill resorptive cavities . Gutmann et al concluded that the use of Thermafil obturation technique ex vivo was acceptable .Collins et al (2006) suggested the use of warm lateral and warm vertical condensation gutta-percha techniques for internal resorption. Wilson & Barnes reported that thermoplasticized gutta-percha techniques were acceptable for filling of internal resorption cavities in a case report.

Gencoglu (2002) found that core techniques contained more gutta-percha than warm condensation (Microseal), vertical condensation (System B) and cold lateral condensation techniques when filling regular root canals. Gencoglu (2008) found all core techniques (Thermafil, Quick-Fill, Soft-Core) were less effective for filling resorptive cavities, whereas both Microseal and System B filled the resorptive cavities to a greater extent than core techniques, mainly with gutta-percha. In addition, all core techniques had more voids than the condensation techniques.

Goldman et al also concluded that the Obtura II system performed statistically better in obturating resorptive defects than cold lateral condensation, Thermafil, and a hybrid technique. Stamos and Stamos reported 2 cases of internal root resorption in which the Obtura II system was used to successfully obturate the canals.[60]

Ragheed M Basheer et al (2005) compared lateral condensation and ultrasonic condensation in filling internal resorption and found ultrasonic condensation better than lateral condensation .[6]

The success of treatment depends, on the size of the resorptive lesion . If, there is communication between the pulp and surrounding tissues, prognosis is less favorable. Even in situations where endodontic therapy could be successfully conducted, the ultimate outcome could nevertheless be failure if the area of resorption is so large that too little tooth structure remains for the tooth to be able to withstand the normal strains and stresses associated with daily function.[28]

SUMMARY

An ideal obturation of the root canal should be a three dimensional filling of the entire root canal system. In conjunction with root canal sealers ,the core filling material should establish an adequate coronal and apical seal. It is generally accepted that root fillings should contain more gutta percha and less sealer and this is more important when filling root canals in resorptive lacunae.

The aim of the present study was to compare the quality of root fillings in artificially created internal resorption cavities,filled with Warm vertical compaction, Lateral condensation ,Obtura II along with System B, E and Q plus along with System B and Thermafil.

Thirty five freshly extracted human intact maxillary central incisors were selected.The teeth were instrumented till size 40 with K files and irrigated with saline and sodium hypochlorite solution.The teeth were horizontally sectioned at 7 mm from the apex. Internal resorptive cavities were then created and the sections repositioned.Radiographs were taken in buccolingual and mesiodistal view and the teeth were embedded in rubber based impression material.The teeth were then divided into five groups with seven teeth

in each group based on different obturation techniques.AH plus sealer was used as the sealer in all the techniques.

Group I: Warm vertical compaction .

Group II : Lateral condensation .

Group III: Obtura II along with System B.

Group IV: E and Q plus along with System B.

Group V: Thermafil

All the obturated teeth were stored for seven days at room temperature.The teeth were removed from the rubber based impression material and radiographs were exposed from both buccolingual and mesiodistal view.Teeth were sectioned again at the level of the previous cut.

Photographs of the surface of the resorptive lacunae created in both the sections were taken by using a Nikon Coolpix 885 digital camera, which was mounted on a stereomicroscope ocular eye .The photographs were transferred to a computer and an image analysis program was used to calculate the percentage of , gutta-percha,sealer and voids.The values were tabulated and statistically analysed.

CONCLUSION

Within the limitations of this present study it can be inferred that ,

1. The percentage of gutta percha plus sealer in resorptive cavities in the obturation techniques were in the following order:

   Obtura II along with System B - 96.12%

   E and Q plus along with System B - 94.63%

   Warm vertical compaction - 92.66%

   Lateral condensation - 90.19%

   Thermafil - 75.38%

2. The percentage of gutta percha in the resorptive cavities in the obturation techniques were in the following order:

   Obtura II along with System B – 62.99%

   E and Q plus along with System B – 59.15%

   Warm vertical compaction - 53.49%

   Lateral condensation – 43.48%

   Thermafil – 35.01%

3. The percentage of sealer in the resorptive cavities in the obturation techniques were in the following order:

   Obtura II along with System B – 33.16%

   E and Q plus along with System B – 35.47%

   Warm vertical compaction - 39.22%

   Lateral condensation – 46.64%

   Thermafil – 40.35%

4. The percentage of voids in the resorptive cavities in the obturation techniques were in the following order:

   Obtura II along with System B – 3.77%

   E and Q plus along with System B – 5.27%

   Warm vertical compaction - 7.28%

   Lateral condensation – 9.78%

   Thermafil – 24.59%

According to the present study , Obtura II along with System B was found to be the most suitable obturation technique for the management of teeth exhibiting internal resorption. Thermafil was found to give the poorest obturation quality when used to fill the teeth with internal resorption. Similarly lateral condensation technique was observed to show maximum sealer and hence not ideal for the management of internal resorptive cavities.

Results of this study has to be extrapolated with different techniques in invivo situations.

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