"COMPARATIVE EVALUATION OF THE APICAL SEALING ABILITY OF MATCHED TAPER SINGLE CONE TECHNIQUE WITH OTHER OBTURATION TECHNIQUES" - AN IN VITRO STUDY.

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BRANCH - IV

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CERTIFICATE

This is to certify that **DR.YOUSEF RISHAL P.T,** *post graduate student (2008-2011) in the Department Of Conservative Dentistry And Endodontics, J.K.K.Nataraja Dental College, Komarapalayam , Namakkal District –*

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"**COMPARATIVE EVALUATION OF THE APICAL SEALING ABILITY OF MATCHED TAPER SINGLE CONE TECHNIQUE WITH OTHER OBTURATION TECHNIQUES " - AN IN VITRO STUDY**. *Under my direct guidance and supervision in the partial fulfillment of the regulations laid down by* THE TAMIL NADU **DR.M.G.R MEDICAL UNIVERSITY, CHENNAI**, FOR M.D.S BRANCH – IV CONSERVATIVE DENTISTRY AND ENDODONTICS DEGREE EXAMINATION.

It has not been submitted (partial or full) for the award of any other degree or diploma**.**

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CONTENTS

The primary objective of root canal therapy is disinfection of the root canal space, to eliminate bacterial pathogens and to achieve a three dimensional obturation of the root canal system with a bio-compatible filling material achieving a hermetic seal, thereby preventing bacterial growth and penetration of fluid and antigenic agents between the canal and periapical tissues.

Microorganisms present inside the root canal remain active in the dentinal tubules even after vigorous chemo-mechanical preparation. Apical leakage continues to be a topic of great interest because in spite of advances in endodontics, clinical failures still occur. Total apical seal is desirable to prevent the remaining bacteria and endotoxins form reaching the root apex and beyond. Apical leakage is considered to be a common cause for endodontic therapy failure and is influenced by many variables such as filling techniques, sealer properties etc. Leakage can also be from the coronal end of the root canal restoration.

The most common cause of apparent failure in endodontically treated teeth is apical percolation resulting in incomplete canal obturation. (John Ingle, 1976)[34].

The advent of Nickel – Titanium makes predictably more efficient preparation of the root canal and makes apical cone fit a possibility in many cases. (Buchanan et al 2001)[9]. They are far superior to stainless steel instruments, more elastic and have good torsional fracture resistance. (Clifford J Ruddle, 2005)[12].

Rotary Ni-Ti instruments improve the working safety, shorten working times and cause fewer canal transportations.

Protaper (Dentsply Maillefer, Ballaigues, Switzerland) is a recent new file design of rotary nickel titanium instruments and designed to provide superior flexibility, efficiency and safety. The Protaper system features a group of 6 instruments - SX shaper, 2 shaper files – S1, S2, and three finishing files - F1, F2, F3.

Although numerous materials have been used for root canal obturation, the most commonly used material is gutta-percha in conjunction with a sealer (Carrotte.P et al 2004)[15]. The physical properties of gutta-percha have made it widely popular and have made possible different obturation techniques.

The cold lateral condensation technique is still one of the most frequently used technique. It's ability to adapt to the internal surface of root canal has been questioned. There are also other disadvantages in this technique like voids, incomplete fusion of gutta-percha cones and lack of surface adaptation (Tamer Tasdemir et al 2009)[61].

Single cone obturation came to the fore in the 1960s with the development of ISO standards for endodontic instruments and filling points. After reaming a circular stop in the apical 2mm of the canal, a single gutta-percha, sectional silver or titanium point was selected to fit with "tug-back" to demonstrate inlay-like snugness of fit. The cone was then cemented in place with thin uniform layer of traditional sealer at least at the apical portion of the canal. Concerns about the single cone technique were compounded by the realization that canal transportation is common and that damaged roots are difficult to seal. (John Whitworth, 2005)[36.]

Recently matched taper gutta-percha points for Protaper system (Dentsply, Maillefer) have been introduced, for simple time efficient obturation. In this system the canals prepared with the protaper instruments are filled with the point that matches the size of the finisher file. The system is simple and time efficient.

The matched taper single cone technique uses gutta-percha cones that closely matches the geometry of the nickel-titanium instrumentation systems. This technique minimizes the sealer component and ensures three dimensional obturation of the root canal space without accessory cones and saves time spent on lateral condensation. (Gordon M.P et al , 2005)[27].

The thermoplasticized gutta-percha technique (Yee et al, 1977)[26] introduced in the late seventies has since evolved into various types of thermoplastic gutta-percha techniques. The thermoplasticized gutta-percha injection system is used by many practitioners to back-fill the root canal system after the downpack phase of the master cone. The high temperature generated can be dissipated through the canal and periodontal ligament (Timothy L. Sweatman et al 2001)[63].

In this study we have used a high temperature Obtura-II system, which has been experimentally superior to lateral condensation technique for obturation of the root canals.

The aim of the present study is to compare the apical sealing ability of matched taper single cone technique of obturation, the cold lateral condensation technique and the Obtura-II thermoplasticized gutta-percha injection technique in teeth which have been prepared using Protaper instruments. (Dentsply, Maillefer) under laboratory conditions.

The dye penetration method used for measuring leakage uses India ink which was done under high vacuum conditions to eliminate the entrapped air within the canals. The apical seal was then evaluated after clearing the specimens and the samples observed under a Binocular stereomicroscope with a digital measurement software and the results analyzed.

Green & David in 1960[28] found that in 50% of posterior teeth the apical foramen was on the root surface and not on the anatomic apex.

John Ingle in 1976[34] describes 58.66% of failures of root canal therapy could be attributed to incomplete obturation and 9.6% were attributed to root perforations. He stresses the importance of the knowledge of root canal morphology and achievement of a hermetic seal for successful outcome of endodontic therapy.

Fulton.S.Yee et al in 1977[26] first applied the technique of thermoplasticized gutta-percha injection in vitro and found that the injection moulding technique leads to a seal comparable to that of conventional approach and suggested that this technique held great promise for in vivo use.

Mahmoud Torabinejad et al in 1978[44] compared thermoplasticized gutta- percha with lateral condensation, warm gutta-percha with vertical condensation and chloropercha respectively and found that the injection moulding technique resulted in the observation of root canal system which was comparable to other conventional approaches.

Don Robertson et al in 1980[21] described a simple and inexpensive technique for in vitro examination of endodontically treated or untreated root canal systems which clears the teeth and renders the canal contents visible.

J. Marlin et al in 1981[32] performed a preliminary study on the clinical use of thermoplasticized gutta-percha for root canal system obturation and found that this method shows promise because the success rate seems comparable to the rate achieved with conventional gutta-percha obturation procedures.

David A Allison et al in 1981[17] in their study of the influence of master cone adaptation on the quality of the apical seal, showed that the microleakage of the canals obturated with lateral condensation technique using gutta-percha and sealer was directly proportional, to the shape of the prepared canal. There was little or no microleakage if the canal had sufficient taper to permit spreader penetration to within 1mm of the prepared length. The techniques evaluated were standardized or step-back instrumentation techniques.

Yee RDJ in 1984[55] studied the effect of canal preparation on the formation and leakage characteristics of apical dentin plug and found that

1. Dentin plugs occurred during instrumentation and can produce a seal that resist penetration by the isotope
2. Formation of this seal in a dentin plug is not reliable, even after instrumentation with five file series.
3. Leakage resistance varied according to the density of the plug
4. The proportion of hard to soft tissue components of each plug increases with increased instrumentation and irrigation.

Andrew Michanowicz et al in 1984[2] investigated the apical sealing properties of a low temperature thermoplasticized gutta-percha with or without sealer and compared it with the lateral condensation technique with sealer and found that the low temperature gutta-percha creates a low seal especially if used in conjunction with a sealer. Several advantages of low temperature injection gutta-percha technique is that it creates a good seal, especially if used in conjunction with a sealer. Radiographic observations showed that a uniform mass was achieved when low temperature gutta-percha was used.

Mahmoud. E Eldeeb et al in 1985[43] evaluated the sealing ability of injection moulded thermoplasticized gutta-percha with and without sealer and compared it with laterally condensed gutta-percha with sealer and found that leakage increase significantly when the injection technique was used without sealer and overfilling occurred 75% of time with vertical condensation of thermoplasticized gutta-percha. There was no significant difference in leakage between the lateral condensation and injection techniques providing sealer was used.

Kimberly Swanson et al in 1987[38] evaluated coronal microleakage overtime when the obturation material was exposed to fluids in his study of evaluation of microleakage in endodontically treated teeth. They observe that coronal microleakage following exposure of root canal obturation material to oral fluids caused considerable dye penetration while the group not exposed to saliva exhibited no dye penetration. No significant differences were found between the groups exposed to artificial saliva. They concluded that a significant amount of coronal microleakage was evident after 3 days of exposure to artificial saliva.

Budd et al in 1991[13] in their study compared the quality of obturation of high and low thermoplasticized gutta-percha injection technique with standard lateral condensation. Statistical analysis of the results indicated both the technique were significantly better than lateral condensation. There was no significant difference between either of the obturation techniques. Although

High and low temperature thermoplasticized gutta-percha techniques produced superior obturations within the parameters of the in vitro study, further investigation is needed to evaluate an acceptable clinical technique which allows these materials to be predictably condensed and confined within the root canal.

Scott. S. Dickson et al in 1993[59] evaluated leakage with or without vacuum with two gutta-percha filled techniques and found there was no significant difference between vacuumed and non-vacuumed for degree of ink penetration.

Dilek M. Dalat et al in 1994[20] compared the apical leakage in root canals obturated with various gutta-percha techniques using a dye vacuum tracing method and found that there was no statistically significant difference between the gutta-percha obturation methods. He also observed that radiographically detected voids resulted in an increased failure rate. This study concentrated in detecting microlumina in obturated root canal spaces in the apical region using this dye tracer technique.

P. Portman et al in 1994[51] evaluated a new vacuum obturation technique and compared it with lateral condensation technique and found that obturation with the new vacuum technique resulted in significantly less leakage than lateral condensation and is also less time consuming.

John Masters et al in 1995[35] compared dye leakage pattern of prepared root canal with that of glass tubes with or without vacuuming. The results showed that filled and unfilled, prepared root canals leaked significantly more than their glass tube counterparts and vacuuming may not be necessary in dye leakage studies in filled root canals. The findings of this study questioned the importance of the entrapped air dye leakage studies in obturated root canals. The use of vacuum may not be necessary for dye leakage studies in filled root canals.

Norman Weller et al in 1997[50] compared the ability of three types of Thermafil obturators, Obtura II Thermoplasticized gutta-percha injection technique and the lateral condensation technique to obturate a standardized root canal. Obtura-II technique demonstrated the best in adaptation to canal walls. No root canal sealer was used in this study. However a sealer is always indicated in any obturation technique, to reduce the clinical microleakage into the root canal system.

Zmener O et al in 1997[71] evaluated the sealing properties of a new epoxy resin based root canal sealer (AH-plus) in vitro for apical leakage and compared it with AH-26 and found that neither material produced an effective apical seal and that most leakage occurred between the wall of the root canal and the sealer. He also observed that failures observed in both materials were unlikely the result of problems inherent in the sealers or observation technique per se. Other factors such as the presence of smear layer, entrapped air at the interface, accessory canals, fins, or oval shaped canals that are difficult to prepare or fill may also be responsible for failure.

Larz. S.W. Spangberg et al in 1998[41] studied the influence of entrapped air on the accuracy of leakage studies using dye penetration methods. A new approach to study dye penetration was developed in which the entrapped air was evacuated before the dye was introduced. This was compared with a passive dye infusion technique. And the results suggests that the sample should be evacuated prior to dye introduction inorder to demonstrate the full extent of voids. This study also found that passive soaking in dye solutions does not reveal void and therefore is unreliable.

A. Katz et al in 1998[37] – In their in vitro study to assess the root apex position on leakage to dye under reduced pressure (560mm Hg) found that the tooth positioning has a significant effect on linear dye penetration or reduced pressure and emphasized the need for standardized factors that influence penetration when assessing leakage study methodology.

Blaire T. Johnson et al in 1999[6] in their in vitro study compared the dye leakage in canals backfilled with single increment and canals backfilled with multiple increment with Obtura-II with two different sealers. The results of the study suggests that it may be clinically acceptable to backfill canals upto 10mm in a single increment using sealer and the Obtura-II gutta-percha system.

Kytridou.V. et al in 1999[40] in this in vitro study, evaluated the adaptation and short and long term sealability of two different thermoplastic technique, a core carrier technique – Thermafil, and a warm vertical continuous wave of compaction technique – system B. They concluded that Thermafil demonstrated the more filling material extrusion beyond the apex and significantly more long – term apical leakage. They concluded that

1. Both Thermafil and system B obturation techniques demonstrated acceptable root canal fillings in the coronal, middle and apical thirds
2. There was significantly more filling material extrusion beyond the apex with the Thermafil technique.
3. The 67 day Thermafil group showed significantly more leakage than the 67 day system B group. No difference in leakage was noted in the 10 day and 24 hr groups of teeth obturated with the two techniques.
4. Both thermoplastic obturation techniques demonstrated good adaptation of gutta-percha and sealer to the canal irregularities.

Von Fraunhaufer et al in 2000[67] in the study on the effect of root canal preparation on microleakage in an in vitro setting observed that smear layer removal is beneficial to root canal sealing. Obturation with thermoplasticized gutta-percha provides a superior seal whilst canal instrumentation with engine-driven NiTi files reduces the extent of microleakage in root canals.

Rajeshwari et al in 2000[53] performed an in vitro evaluation of apical microleakage and compared Thermafil and Obtura with cold lateral condensation using a fluid filtration system and found that cold lateral condensation had the most apical leakage followed by Obtura and Thermafil presented the least.

Lyroudia et al in 2000[34] deviced a new method for analysis of apical microleakage and they found that this 3-dimensional reconstruction method proved to be a useful tool. India ink was used as a passive stain in this study. This method enables the accurate evaluation of total volume of microleakage from different viewpoints. This method used high magnification microscopic images of cross sections thus allowing histological study of microleakage.

Yuichi Kimura et al in 2001[69] studied the effect of laser preparation on the root canals and found that root canal preparation by laser does not affect the apical leakage after obturation compared with leakage in canals prepared using conventional method. Laser irradiation allows successful endodontic treatment because of imparted acid resistance, sterilization of the contaminated root walls, haemostatic effect, and the removal of debris and smear layer from the root canals.

E.G. Kontakiotis et al in 2001[39] studied the penetration of dye in dry and water filled gaps along root canal filling and found that methylene blue dye penetrated along the root canal more easily in dry gaps than in water-filled gaps.

Timothy L. Sweatman et al in 2001[63] evaluated the radicular temperature associated with thermoplasticized guta-percha injection and found that at no time did the system B, Obtura-II or ultrasonic delivery of warm gutta-percha exceed an increase of 10^{0}C at any thermocouple level at the external root surface.

Ralph M.P. Gilhooly et al in 2001[54] evaluated and compared the sealability of lateral condensation gutta-percha technique with a single gutta-percha cone technique and concluded thermomechanically condensed gutta-percha used in conjunction with a single gutta-percha cone had poor radiographic quality than laterally condensed gutta-percha.

Aneet S. Bhal et al in 2001[3] compared the quality of seal in canals prepared in a standardized manner and obturated with 0.06 and 0.02 gutta-percha cones using lateral condensation. The difference between the two groups was not significant. They also observed that most posterior teeth had complex anatomy with curves, isthmuses, cul-de-sacs and fins. Further studies are needed to determine whether filling these more complex teeth with matched gutta-percha cone will result in an acceptable seal. They also found that the depth of spreader penetration does not seem to affect the coronal microleakage.

Ludovic Pommel et al in 2001[42] compared in vitro the apical sealing ability of System B with other techniques and found that the samples obturated with the single-cone technique showed the highest leakage.

CobanKara et al in 2002[25] in their quantitative evaluation of apical leakage of four sealers found that root fillings with Roeko sealer in combination with cold lateral condensation technique showed better sealing when compared with other sealers (Ketac-endo, AH-plus and Sultan)

Bousetta et al in 2003[7] did an in vitro evaluation of apical microleakage and concluded that the Herofill soft core system was a reliable obturation system in the apical portion and compared favourably with other gutta-percha filling techniques. In this study, a softcore thermoplasticized gutta-percha obturation system produced a better seal than conventional lateral condensation obturation system.

Tani Ishii et al in 2003[62] evaluated clinical and radiographic healing of 236 root canal treatments, in 131 cases obturated with Obtura II system. They reported a 96% success rate with the Obtura II system and root filling excess had no impact on the healing process of periapical lesions. The treatment outcome for roots with apical periodontitis was not dependent on the level of root filling in relation to root apex. Post operative sizes of the periapical lesions were smaller in the over filled cases after 12 months.

P.R. Cathro et al in 2003[10] compared the proportion of gutta-pecha, sealer and voids in fillings of simulated root canals using two warm gutta-percha techniques and concluded that the Microseal technique produced heterogeneous filling and the system B / Obtura II produced a homogenous obturation of gutta-percha with minimal sealer with no voids at all levels.

Wu et al in 2003[47] in their study on the fluid movement along the coronal two thirds of gutta-percha root fillings placed by three different techniques found that the coronal two-thirds of the warm vertical compaction technique did not prevent fluid movement when Roeko automix sealer was used.

Wilson & Baumgartner et al in 2003[8] compared the initial penetration depth of fine Ni-Ti and fine stainless steel spreaders during lateral compaction of 0.02 or 0.04 taper master gutta-percha cones, and evaluated the effect of increasing canal curvature on penetration depth and found no significant difference in both the groups for varying canal curvatures.

E.Schafer Vlassis et al in 2004[58] compared the cleaning effectiveness and shaping ability of Protaper and RaCe Ni-Ti rotary instruments during the preparation of curved root canals in an in vitro setting and observed that under the conditions of the study, RaCe instruments resulted in relatively good cleaning and maintained the original curvature significantly better than Protaper.

Schoop et al in 2004[9] compared four different lasers within the root canal and achieved an apical seal in in vitro conditions. This would make the apex impermeable to bacteria and their toxins. However, there was a very high temperature rise associated with the use of lasers though a satisfactory seal was achieved.

Clifford J.Ruddle et al in 2005[12] in his description of Protaper instruments suggest that it is safe for use by both experienced and inexperienced users. The Protaper instruments provide unique geometrics that when sequenced and used correctly offers extra ordinary flexibility, efficiency, safety and simplicity. The Protaper sequence is always the same regardless of the tooth or anatomical configuration of the canal being treated. The Protaper instruments relocate the canal orifices away from the furcation, produced a centered preparation and contact a significant portion of the internal canal walls.

John Whitworth in 2005[36] in his review of root canal filling methods observes that laboratory evidence suggests comparable cross sectional area occupied by gutta percha using single matched - taper cones with lateral condensation and in significantly less time under in vitro conditions.

But clinical trial data are as such unavailable. He also observes that cold lateral condensation is probably the most commonly taught and practiced filling technique world wide and is regarded as the bench mark against which others must be evaluated.

Markus Haapasalo et al in 2005[45] states that cleaning and shaping of the root canal is the single most important factor in the prevention and treatment of endodontic diseases, and the effects of instrumentation and irrigation on intracanal infection have been a focus of increased activity in endodontics. Although sterility of the rootcanal can occasionally be achieved by instrumentation and irrigation with antibacterial solutions, the protocols used today cannot predictably provide sterile canals. As none of the elements of endodontic therapy (Host defence system, systemic antibiotic therapy, instrumentation and irrigation, intracanal medicaments, permanent root filling, and coronal restoration) can alone guarantee complete disinfection.

Gordon M.P.J et al in 2005[27] compared the area occupied by gutta percha, sealer or voids in standardized 0.06 taper, prepared, simulated curved canals and in mesio-buccal canals of extracted maxillary first molars, filled with single 0.06 gutta-percha and sealer or lateral condensation of multiple 0.02 gutta-percha and sealer. They found that the 0.06 taper single cone technique was comparable to lateral condensation in the amount of gutta-percha occupying the prepared 0.06 tapered canal and that the 0.06 single cone technique was faster.

Gregory T Engel et al in 2005[29] studied to determine if a final rinse with either 70% isopropyl alcohol or peridex (chlorhexidine) in instrumented, smear free canals, would affect apical microleakage or Rothes 801 sealer penetration into dentinal tubules. He found that these tensioactive agents may alter dentinal wettability allowing increased sealer penetration into dentinal tubules which enhances the apical seal and better entombing of remaining bacteria. No significant difference was found compared to NaOCl. The clinical significance of this study is that both agents can be safely used as a final rinse in non-surgical root canal therapy without adversely affecting the microleakage.

Allen Aptekar et al in 2006[1] in their study of comparative analysis of microleakage, compared Resilon /Epiphany and gutta-percha and concluded that the R/E system provides a better option than gutta-percha which creates a chemical bond with the internal tooth structure or entire root area that is maintained over time compared to gutta-percha. He also observed that R/E has the potential to replace gutta-percha in the setting.

Denusa Moreira et al in 2006[19] in the review of methodologies for assessment of apical leakage, recommended the standardization of various methodologies used for assessing leakage.

Shemesh.H et al in 2006[60] in their longitudinal ex vivo study of apical leakage with or without smear layer found that glucose penetration model is a sensitive method to detect leakage along root fillings and canals filled with Resilon had more glucose penetration than gutta-percha and AH – 26, while

No statistical difference was found between the Resilon and gutta-percha filled teeth in the fluid transportation model either at 1 or 8 weeks.

Min-Kai et al in 2006[47] evaluated the leakage of single cone fillings with Roeko-RSA sealer and concluded that in wide and straight canals single cone fillings with Roeko-RSA sealer prevented fluid – transport for 1 year.

Johannes Mente et al in 2007[33] in their in vitro study on leakage associated with three root filling techniques in large and extremely large root canals found that ultrasonic lateral condensation might be a valuable root filling technique in such teeth, in that it appears to afford better apical seal and can be achieved using the cold lateral condensation technique. In addition, injury to periradicular tissues caused by ultrasonically generated heat can be avoided if activation time does not exceed 15 seconds.

Prashanth B.R et al in 2007[52] evaluated the efficacy of 4 different technique to obturate the root canal prepared to a constant taper of 0.06. 40 extracted human maxillary central incisors were prepared using K3 NiTi rotary system to a constant taper of 0.06 upto size 40 and were obturated with 4 different techniques. Teeth were horizontally sectioned at 2 & 4mm from the apical foramen and percentage of gutta filled area (PGFA) was calculated. They concluded that quality of fillings was compromised in irregularly shaped canals. Thermo plasticized gutta-percha techniques could be the material of choice to achieve a 3 dimensional obturation.

David Sonntag et al in 2007[18] examined the results of rotary root canal preparation with NiTi systems - the K3, Protaper and Mtwo and found no significant difference in the preparation length, transportation or taper. All the three system achieved good preparation results.

Ugur Inal et al in 2007[66] compared the apical sealing ability of three different root canal obturation techniques and found that under the conditions of the study the thermoplastic gutta-percha technique (Thermafil and system B) created a better apical seal than cold lateral condensation. The dye penetration and electrochemical technique ranked the 3 obturation technique in the same order and gave similar results.

Mercedes Perez Heredia et al in 2007[46] compared the apical sealing ability in mesiobuccal canals of extracted molars obturated with low-temperature thermoplasticized gutta-percha or cold lateral condensation techniques using a 0.06 or a 0.02 mm/mm tapered gutta-percha master cone. They also evaluated the depth of spreader penetration in root canals using a 0.06 or a 0.02 mm/mm tapered gutta-percha master cone. They concluded that the Ultrafil 3D system and cold lateral condensation techniques with 0.06 or 0.02 tapered master cones were equally effective in the apical sealing of curved canals. The spreader penetrated deeper using a 0.02mm/mm tapered gutta-percha master cone.

Chris Yelton et al in 2007[11] measured the ability of Thermoplasticized injectable gutta-percha delivery system to fill up prepared root canal to working length and replicate intracanal defects as a function of root canal preparation with varying lateral dimensions.. Within the limitations of this in vitro study, the results suggests a 0.4mm apical gauge preparation might yield better intracanal effect and working length replication when using Thermoplasticized injectable gutta-percha in the clinical situations.

Monticelli et al in 2007[48] in their in vitro study evaluated the sealing efficiency of three root filling systems nanely warm vertical compaction with gutta-percha/AH Plus, single cone technique with active G.P, single cone technique with gutta flow and found that warm vertical compaction technique using thermoplasticized gutta-percha and AH Plus to be most effective.

Bhavana Gaikwad et al 2008[5] evaluated the coronal and apical sealing ability of gutta-percha root filling used with either Mineral trioxide Aggregate (MTA), calcium hydroxide based sealers, and zinc-oxide eugenol as sealer. It was concluded that the single cone technique with MTA can provide favorable coronal and apical seal.

Ugur Inan et al in 2009[65] in their study of apical sealing ability of matched - taper single-cone obturation technique found that the apical sealing ability of this technique was comparable to that of Thermafil and lateral condensation. Since the study was done in straight canals, he recommends the use and evaluation of this technique in posterior teeth which have curved canals and complex anatomy.

Zeleha Yilmaz et al in 2009[70] in their study on the micro leakage evaluation of roots filled with different obturation techniques and sealers found that single-cone Protaper gutta-percha and lateral compaction techniques showed a similar sealing effect, though other studies on root filled with the single cone method have shown different results. The tapered single cone may be used with a sealer that adapts well to the dentinal walls.

Tamer Tasdemir et al in 2009[61] in their in vitro study compared the sealing ability of three filling techniques - the tapered single-cone techniques, lateral condensation, or warm vertical compaction in extracted mandibular premolar teeth prepared with either Protaper or Mtwo rotary systems. AH-plus was used as the sealer. They concluded that filling with lateral condensation, single-cone or warm vertical compaction in canals prepared with Protaper or Mtwo rotary instruments showed similar levels of sealing efficacy.

Toshiko – Ozawa et al in 2009[64] evaluated techniques for obturating oval-shaped root canals. They compared 3 obturation techniques namely

1. Protaper canal preparation with single cone obturation with matching gutta-percha point,
2. Protaper preparation plus thermoplastic obturation (Thermafil)
3. Profile 0.06 taper and matching master cone with lateral condensation.

They found that in single straight root canals prepared with Protaper instruments, obturation with a single Protaper gutta percha point is as effective as lateral condensation, laterally compacted Protaper gutta-percha and combination of system B and thermoplasticized gutta-percha. The leakage was increased in all obturation techniques within a 3 month period.

Mahera Fani et al 2009[49] studied the microleakage of four obturation techniques –lateral condensation, lateral condensation of protaper gutta-percha, single protaper gutta-percha and warm vertical condensation over a 3 month period and found no statistically significant difference between the four groups. However the leakage was increased in all obturation techniques over a period of 3 months.

Bahareh Dadresanfar et al in 2010[49], in his in vitro study compared the sealing ability of lateral condensation technique and the Beefill system after canal preparation with the Mtwo rotary system. They concluded that the mean dye leakage in the Beefill thermoplasticized injection group was less than the lateral condensation group but there was no significant difference between the experimental groups on the parametric independent test.

ARMAMENTARIUM

PREPARATION OF SAMPLES

1. Normal saline (Nirlife Health Care, Nirma Products, India)
2. 3% hydrogen peroxide(Nice chemicals Pvt Ltd, India)
3. 3% sodium hypochlorite(Nice chemicals Pvt Ltd, India)
4. No. #8 and #10 K-file (K-endo, VDW,GmBH,Munich,Germany)
5. Water cooled diamond saw.
6. Distilled water.

ROOTCANAL PREPARATION

1. Protaper system (Dentsply Maillefer, Ballaigues, Switzerland)
2. X-smart (Dentsply Maillefer,Ballaigues,Switzerland)
3. 3% sodium hypochlorite(Nice chemicals Pvt Ltd, India)
4. 17% EDTA solution(Nice chemicals Pvt Ltd, India)
5. Distilled water
6. Digital ultrasonic cleaner.

OBTURATION

1. Matched taper single cone (gutta-percha - ProTaper, size –F3).
2. .02 taper gutta-percha cone (Dentsply Maillefer, Ballaigues, Switzerland)
3. Thermoplasticized gutta-percha injection system (Obtura-II, Spartan, Fenton, U.S.A)

DYE PENETRATION

1. India ink (Nice chemicals Pvt Ltd, India)
2. High volume suction vacuum device
3. Nail varnish, colours - violet, pink and red
4. Nail varnish remover

CLEARING OF TEETH SAMPLES

1. 5% Nitric acid(Nice chemicals Pvt Ltd, India)
2. Methyl salicylate solution (Nice chemicals Pvt Ltd, India)
3. Distilled water
4. Ethyl Alcohol 99.99% (Qualigens)

VISUALISATION OF APICAL DYE PENETRATION

1. Leica stereomicroscope(S8APO, Leica Microsystems, Switzerland)
2. Leica application suite –Version 2.5.0 R_1 ,Build:975

PREPARATION OF SAMPLES

One- hundred and twenty human mandibular premolar teeth extracted for periodontal and orthodontic reasons were selected and immediately stored in normal saline after extraction. All the teeth had mature apices and a single root. The samples were subsequently cleansed with 3% hydrogen peroxide solution for 24 hrs and debrided with 3% sodium hypochlorite for 24 hrs. The teeth were washed continuously for 2 hrs in running water and placed in distilled water for 24 hrs. The crowns were removed at the cemento-enamel junction using a diamond disc with water coolant. After sectioning, the specimens were washed with water and stored in 3% sodium hypochlorite for 24 hrs, and then were placed in distilled water for further processing.

Assessment of the roots were done and a size #8 k-file (K-endo, VDW,GmBH,Munich,Germany) was inserted into the canal to assess the patency of the canal and establish the glide path. Samples with non-single canal configurations were discarded and a total of seventy specimens were singled out for the study .Working length was determined by inserting a size #10 K-file (Dentsply Maillefer) until it was visible at the apical foramen. The working length of each canal was calculated to be 1 mm short of that position.

ROOTCANAL PREPARATION

All teeth were prepared using NiTi rotary instruments of the Protaper system to size F3. A total of 6 instruments were used with the X-Smart Device (Dentsply Maillefer) with a gear reduction of 16:1; the speed of rotation was maintained at 250 rpm. A new set of Protaper instruments were used for every 5 teeth. 2 ml of 3% sodium hypochlorite solution was used for irrigation between each file size. Protaper files were used in the following sequence, according to the manufacturer’s recommendations:

1. The rootcanal was filled with 3% sodium hypochlorite solution and the S1 file was used to enlarge the coronal two-thirds of the canal.
2. The canal was re-irrigated and the SX file was inserted into the canal until it encountered light resistance. Shaping with the SX

was continued with a brushing motion until two-thirds of its cutting blades were below the orifice.

3. The canal was irrigated and a # 10 K-file was used for recapitulation.
4. Shaping continued with the S1 file to the working length.
5. Then the S2 file was taken to the working length.
6. The F1 file was taken to the full working length and immediately withdrawn.
7. The F2 file was taken to the full working length.
8. The F3 file was taken to the full working length.

The prepared teeth were then irrigated with and then placed in 17% EDTA solution in an ultrasonic bath for 1 minute. The teeth were subsequently rinsed and cleansed in distilled water in an ultrasonic bath. The teeth were randomly divided into 3 groups, each consisting of 20 specimens . The remaining 10 teeth were used as positive and negative controls. AH-Plus (Dentsply DeTrey, Konstanz, Germany) was used as a sealer and the root canals were obturated as follows:

Group 1	:	With a matched taper single cone (gutta-percha - ProTaper, size F3) technique
Group 2	:	With the cold lateral condensation technique (.02 taper gutta-percha cone)
Group 3	:	Thermoplasticized gutta-percha system.(Obtura-II, Spartan)

Group 4 : The negative control group was obturated with either of the above techniques and all the root surfaces were covered with 3 layers of nail varnish, with sufficient dry time to ensure no leakage.

Group 5 : The positive control group in which the rootcanals were left unobturated.

OBTURATION TECHNIQUES

Matched Taper Single Cone Obturation

The 20 specimens in group-1 were obturated with a size F3 gutta-percha cone (Dentsply Maillefer) at the working length. First the canal was dried with paper points (Dentsply Maillefer) and AH-Plus (Dentsply DeTrey Konstantz, Germany)sealer was applied to the root canal walls with a size 25 reamer rotated anti-clockwise. Then the gutta-percha cone (Protaper F3 size) cone was lightly coated with the sealer and placed into the canal to the working length.

Cold Lateral Condensation Obturation

The 20 specimens in group-2 were obturated with size #30 .02 taper gutta-percha cone (Dentsply Maillefer) at the working length. First the canal was dried, and AH - Plus (Dentsply, DeTrey, Konstantz, Germany) was applied to the canal walls. The master cone was coated with the sealer and placed into the canal at the working length. Lateral condensation was done with finger spreaders and accessory cones. Lateral condensation was completed until the spreader could no longer penetrate more than 3mm into the canal.

Obtura II -Thermoplasticized Guttapercha System

The 20 specimens in-group-3 were obturated with the Obtura-II heated gutta-percha system. The canals were coated with very little quantity of AH-Plus sealer, because excessive sealer causes pooling. The gutta-percha pellets (Regular flow gutta-percha) were loaded into the obtura handpiece and the temperature control on the unit was adjusted to 190 degrees. The 25 gauge-injection needle was placed within 3 to 5 mm of the working length and the canal was totally filled as the needle was withdrawn. Finger pluggers were used to vertically condense the filling.

After Obturation , the excess gutta-percha was removed with a heated instrument and the cavities sealed with composite resin after the application of a bonding agent(Adper single bond 2, 3M ESPE, St. Paul, U.S.A). The teeth were stored at 37 degrees for 24 hours in 100% humidity to allow the complete setting of the sealer. In the experimental groups, all root surfaces except the apical 3 mm were covered with 3 coats of nail varnish. For each of the experimental group a different colour nail varnish was used. Specimens selected for positive (n = 5) and negative (n = 5) control groups were instrumented in the same way as the specimens for the experimental groups, but the root canals were not obturated in the positive control group to allow 100% leakage. The teeth in the negative control group were obturated with either the lateral condensation, single cone or obtura techniques, and the whole root surface were covered with 3 layers of nail varnish to ensure there was no leakage.

DYE PENETRATION TECHNIQUE

The samples in each group was immersed in an India ink container and placed in a specially designed vacuum chamber connected to a high suction vacuum device (760 mm Hg) and the vacuum was maintained for 30 minutes. After removing the specimens from the chamber, they were allowed to remain in the dye solution for 24 hrs. They were subsequently washed in water and the nail varnish coating was removed using a nail varnish remover and were then subjected to a clearing technique for visualization of the apical leakage.

CLEARING TECHNIQUE FOR THE VISUALISATION OF THE ROOTCANAL FILLING

The samples of individual experimental groups were stored in separate containers and decalcified with 5% nitric acid at room temperature. The nitric acid solution was changed in every 6 hrs and agitated with hand in every 2 hrs. After completion of the procedure, the samples were rinsed in distilled water, dehydrated and placed in methyl salicylate solution, which rendered the samples transparent.

The samples were then observed, photographed and sent for analysis using a stereomicroscope (Leica stereomicroscope S8APO, Leica Microsystems, Switzerland) at 10X magnification , and the depth of dye penetration in each sample was measured digitally using an inbuilt software

(Leica Application Suite –Version 2.5.0 R_1 , Build:975), and the data was recorded and stored in a computer for further analysis.

Apical leakage was measured as the distance from the anatomic apex to the maximum extent of dye penetration in a coronal direction.

Observer reliability was assessed by re-measuring 10 specimens from each group on a separate occasion without the knowledge of the first readings.

The results were subsequently analyzed.

DYE LEAKAGE MEASUREMENT

MATCHED TAPER SINGLE CONE TECHNIQUE (GROUP – 1)

Tabular Column: 1

Sample No.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***
Dye Leakage (mm)	5.20	3.84	2.78	3.19	4.07	2.68	2.52	2.99	1.93	3.40	2.39	1.72	3.22	1.83	2.45	1.60	1.80	3.02	3.21	3.11

COLD LATERAL CONDENSATION TECHNIQUE (GROUP – 2)

Tabular Column: 2

Sample No.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***
Dye Leakage (mm)	1.29	1.61	1.69	1.58	1.65	2.10	1.25	1.02	1.39	1.31	1.53	1.15	1.49	1.67	1.58	1.76	2.10	1.02	1.21	1.59

THERMOPLASTICIZED GUTTA-PERCHA TECHNIQUE (GROUP - 3)

(OBTURA - II)

Tabular Column: 3

Sample No.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***
Dye Leakage (mm)	1.39	1.14	1.09	0.88	0.94	0.89	1.26	0.87	1.36	1.06	0.96	1.04	0.97	1.27	0.98	1.38	1.15	1.40	1.25	1.13

DYE LEAKAGE MEASUREMENT

CONTROL GROUPS

Tabular Column: 4

Group 4 (Negative Control)						***Group 5 (Positive Control)***					
Sample No.	***1***	***2***	***3***	***4***	***5***	***Sample No.***	***1***	***2***	***3***	***4***	***5***
Dye Leakage	0	0	0	0	0	Dye Leakage	All samples showed complete dye penetration				

The primary objective of rootcanal therapy is to obturate the debrided canals with a biocompatible filling material, inorder to eliminate the source of infection from the residual organic material or from apical percolation. The most common cause of apparent failure in endodontically treated teeth is apical percolation resulting from incomplete canal obturation (John Ingle, 1976)[34].

The successful outcome of endodontic treatment is dependant on the efficient cleaning, shaping and 3-dimensional obturation of the root canal system, with the aim of achieving a hermetic seal. The apical 3rd of the root presents a unique anatomical configuration in that the majority of the ramifications and accessory canals are more likely to be found in this region. The incidence of accessory canals in the apical one-third has been reported to be as high as 73.5% (Vertucci F.J 1984)[68].

Micro organisms present inside root canals may remain viable in dentinal tubules even after efficient chemo - mechanical preparation of the canals. Thus achieving a perfect apical seal is vital to prevent the remaining bacteria and their endotoxins from reaching the apex and the periradicular tissues.

Apical leakage is considered to be a common cause for failure of endodontic therapy. It is influenced by various factors such as the anatomy of the apex, the chemo - mechanical preparation of the apical one-third, the presence or absence of smear layer, different types of obturation techniques, the selection of a sealer, the properties of sealers and the ability of the sealer to bond to dentin as well as gutta-percha. (John Whitworth 2005)[36].

Although apical seal of root canal system has received a lot of attention, achieving a good coronal seal is equally important.

Coronal leakage can also be responsible for contamination of the canal with microorganisms and is most often the result of the loss of the temporary filling or inadequate endodontic filling or crown sealing.

Endodontic sealers play a very important role preventing microleakage. They seal the interface between gutta-percha and dentinal walls. Leakage may however occur at the interfaces between the sealer and dentin, sealer and gutta-percha, or the spaces in the sealer itself. Therefore, the quality of the rootcanal filling to a large extent depends upon the sealing capacity or the efficiency of sealers (Cobankara et al 2002)[25]

Ideally, the development of sealers should focus on materials that

1. Penetrate the patent dentinal tubules.
2. Bind closely to both the organic and inorganic phases of dentin
3. Neutralize or destroy microorganisms and their products.
4. Predictably induce a regenerative cement response on the apical foramen.
5. Strengthen the root system
6. Biocompatible (Guttmann JL, Witherspoon DE, 2002)[30]

A method often used to create an apical stop or matrix for obtaining a biological apical seal supports the placement of dentinal chips or artificial barriers ie. Calcium hydroxide, demineralised dentin, lyophilised bone, tricalcium phosphate, hydroxyapatite, collagen, MTA etc before canal obturation. This is not a new technique and favourable results were obtained 60 years ago using dentin chips . These barriers in addition to creating biological apical seal may help to confine the irrigating solutions within the canal. However, they may or may not enhance the seal of the canal apically (Yee RDJ, et al 1984)[55].

Clinical studies evaluating endodontic failures have reported that incomplete obturation in the apical region was the principle cause of microleakage. These studies agree that evaluation of apical leakage of particles or solutions between the root canal filling and the rootcanal walls is a proper method to establish the quality of endodontic obturation although achieving a hermetic seal at the apex is one of the primary objective of rootcanal therapy. The issue of the apical termination of the filling material often arises as considerable variants occurs at the apical portion of the canals. The cemento-dentinal junction is a histologic position, not a clinical position in the root canal system. It is not always found at the apical constriction. The distance from the apical foramen to the constriction depends on various factors such as increased cemental deposition or radicular resorption. The position of the foramen and the cemento-dentinal junction is highly variable and can exist anywhere from the direct radiographic apex upto 3mm or more coronal to the radiographic apex depending upon the morphology. Long term evaluation studies favour and support obturation within the confines of the root canal system in all cases, in order to attempt to prevent further challenge to the already compromised and challenged periradicular tissues.

A number of in vitro tests have been used to test the efficacy of endodontic filling techniques and materials.

The most common method for evaluation of microleakage has been the linear measurement of tracer dye penetration. Eg. Methylene blue, Eosin, India ink, Radioisotopes , fungi and even bacteria. They have also been measured by longitudinal sections, cross sections or decalcification and clearing of the root structure. Other methods that have been tried for evaluating apical leakage are the vacuum technique, the fluid filtration or transportation technique, the electrochemical technique, the dye extraction technique, the bacterial and toxin infiltration method, capillary flow pyrometry and glucose penetration technique. All the described methods have their limitations. The largest limitations are their low reproducibility and lack of standardization (De Bruyne et al 2005)[23].When using dyes, the particle size, the pH value and chemical reactivity affect the degree of penetration. India ink particles with a diameter smaller than 3 μm have been widely used as it is unlikely that bacterial invasion would occur in spaces inside the canal where this dye is unable to penetrate. It has been reported that the weight and size of India ink molecules are smaller than bacterial molecules found in the root canal (Denusa Moreira et al 2006)[19].

One of the major considerations in the dye penetration studies are the air entrapped in voids along the root canal filling which may hinder the fluid movement. Use of a vacuum while exposing the specimen to the dye and maintenance of this vacuum for a sufficient period of time removes air entrapped within the voids and helps penetration of the dye.

Passive soaking in dye solutions does not reveal the entire voids present and therefore is unreliable . When used along with vacuum, consistent results were found for dye penetration (Spangberg et al 1989)[41].

Though various methodologies are available for assessing leakage, there is a real lack of technique standardization even when the same methodology is used (Denusa Moreira et al 2006)[19].

In the present study India ink was used in conjunction with a specially designed vacuum chamber connected to a high volume vacuum pump. The level of the vacuum was maintained at 760mm Hg for 30 minutes.

Cleaning and shaping of the root canal has been the single most important factor for preventing and treatment of endodontic diseases as this removes all the etiological factors associated with endodontic diseases (Haapasalo M , 2005)[45].

In the present study, in all the sample groups canal preparation was done using the Protaper system (Dentsply, Maillefer). These are NiTi instruments which represents a new generation of instruments for shaping canals. Each of the Protaper instrument has changing percentage of taper over the length of its cutting blades. They have convex triangular section, a changing helical angle and pitch over their cutting blades and a non-cutting, modified guiding tip. The Protaper system is comprised of three shaping and three finishing instruments. Canal preparation is improved when instruments pass through the access opening, effortlessly slide down smooth axial walls and are easily inserted into the orifice. The potential to consistently shape canals and clean root canal systems is significantly enhanced when the coronal two - thirds of the canal is first pre-enlarged followed by preparing its apical one-third.

The Protaper system features six instruments namely SX shaper, two shaping files (S1and S2) and 3 finishing files (F1, F2, F3). The principles in the use of these instruments are

1. Creation of a glide path.
2. Use of S1 and S2 in sequence to the working length.
3. No pressure is applied during instrumentation and they are passively allowed to follow the glide path.
4. To optimize safety and efficiency, it is used with a brush like motion to a laterally and selectively cut dentin on the outstroke. A brush like cutting action creates a lateral space which will facilitate larger , stronger and more active cutting blades on the shaping instrument to safely and progressively more deeper into the canal.

After every instrument, recapitulation with a #10 size k-file is done. When the coronal one-third of the canal is shaped, the attention is shifted to the apical - third procedures. Now a decision has to be made whether a hand or rotary preparation of apical third is to be done. The Protaper sequence is always the same regardless of the tooth or anatomical configuration of the canals.

Although several techniques have been used for 3-dimensional obturation of the root canal system using gutta-percha, cold lateral condensation is still one of the most frequently used techniques. Filling of rootcanals traditionally uses .02 taper standard gutta-percha cones followed by accessory standard gutta-percha cones, after lateral condensation of gutta-percha with spreaders, in conjunction with a rootcanal sealer.

Gutta-percha cones are now manufactured to match the taper of the canals prepared with 0.04 or 0.06 rotary instruments. Large taper gutta-percha can be used with warm vertical compaction techniques or cold lateral compaction technique. (Wilson and Baumgartner et al 2003)[8].

With the NiTi rotary preparation of the root canals and use of the sealer, these cones may provide 3-dimensional obturation of the root canals over its entire length without the requirement of accessory cones or time spent on lateral condensation (Himbrough et al 2002)[31].

Use of excessive forces during lateral compaction can result in root fractures. Some clinicians have proposed the use of NiTi spreaders in curved canals. Stainless steel spreaders have the own advantage in that they are more stiff without buckling, a common problem with NiTi spreaders.

When the single cone obturation technique is filled at room temperature and used in conjunction with a sealer, the thickness of the sealer varies depending on the adaptation of the single cone to the canal wall. The volume of the sealer required is larger than the volume of sealer necessary to complete a compaction technique. It has been reported that single cone filled roots have more than half the canal space filled with sealer (Wu M K et al 2006)[60].

When the sealer dissolves after some time, the single cone fillings may have larger voids than lateral or vertical filling. The single cone is no longer included in current endodontic text books. Porosities in large volumes of sealer, setting contraction and dissolution of the sealer are the main disadvantages of this technique.

More recently gutta-percha cones for Protaper have been introduced for simple time efficient obturation. In this system, the rootcanals are prepared with Protaper instruments and filled with a point that fits the size of the finisher file. The manufacturer claims that the Protaper gutta-percha points perfectly fit canals that have been prepared with the Protaper files.

The matched taper single cone technique in this study was compared with a cold lateral condensation technique and a thermoplasticized – gutta-percha injection technique to evaluate the apical seal in an in vitro setting.

The thermoplasticized gutta percha injection technique has been developed which helps flow of gutta-percha efficiently into the ramifications of the rootcanal space. They are used in conjunction with a sealer. Both high temperature (200^0C) and low temperature (70^0C) are available. Obtura-II system has been found to be significantly superior to lateral condensation methods and has demonstrated the best adaptation to the 3-dimensional rootcanal system (Budd CS et al 1991)[13].

Obtura-II system is also commonly used for Backfilling and it has been suggested that it might be clinically acceptable to backfill canals upto 10mm in a single increment using sealer and Obtura-II system. The high temperature generated in the root canal can be dissipated through the root surface and the periodontal ligament. It is generally accepted that a temperature rise of approximately 10^0C above normal body temperature is most critical. Studies have proved that the maximum temperature change on the external root surface with the Obtura-II system is 6.2^oC (Timothy L Sweatman et al 2001)[63]. This rise in temperature produced by the system on the external surface of the root was well less than 10^0C which is potentially harmless to the surrounding periodontal ligament .

Apical extrusion of gutta-percha has been a common problem with injection technique. The advent of NiTi makes predictably centered preparation more realistic than ever in curved canals, and may make accurate apical cone fit a possibility in many cases. Contemporary advertising on ergonomic, matched file and cone systems may serve to promote single cone cementation techniques. Laboratory evidence in fact suggests comparable cross-sectional area of canal occupied by gutta-percha using single matched taper cones compared with lateral condensation, and in significantly less time ,but clinical trial data is unavailable (Gordon et al 2005)[27].

With the widespread use of NiTi instruments it has brought about the adaptation of single cone technique to the NiTi system, where the tapers of the gutta-percha cone are matched to the tapers of the last instrument used.

The most important objectives of endodontic therapy are total debridement of the pulp space, development of a fluid tight seal at the apical foramen and total obturation of the root canal. Therefore leakage tests are a relevant way to evaluate the apical seal.

In this study, the sealer was lightly coated within the canal using a 25 size reamer rotated anti-clockwise and the cones were also lightly coated with the sealer before placement to the working length.

In the present study we have used an AH- plus sealer because of its low solubility (Schafer et al 2003)[24]. Ideally sealers should have very low solubility because, leaching of components from the root canal filling would have undesirable biological effects on the surrounding tissues. Degradation of the sealer also may result in percolation at the sealer / dentin or sealer / gutta-percha interface (Dag Orstavik et al 2001)[16].

Dimensional stability has been introduced as a requirement in the Draft International Standard (DIS) for root sealing materials. The requirements for compliance with the standard have been set at a linear expansion of not more than 0.1%, shrinkage of not more than 1% (Draft International Standard – DIS)[22].

Among the three groups tested for apical leakage in this study, the Group-3 (thermoplasticized gutta-percha injection technique-obtura-II) showed the least amount of apical penetration of the dye with a mean value of 1.223 and was statistically significant when compared with other groups ($p<0.05$).

The results showed that Group-1 (matched taper single cone technique) showed the highest values for the dye penetration under vacuum with a mean value of 2.8475.

In the single cone technique the volume of the sealer required is larger than the volume required to complete a compaction technique. The larger volume of sealer used is inherently prone to more changes than the small volume used for compaction techniques.

Some studies on the comparison of the matched taper single cone technique with the lateral condensation technique have found no significant difference in the sealing ability and the cross-sectional area of gutta-percha was comparable (Mahera Fani et al 2009)[49]. The matched taper single cone technique was also faster.

The same sealer AH-Plus was used for all the three techniques. It is very important to avoid void formation while loading the sealer into the canal. The matched taper single cone technique matches the taper of gutta-percha cones to the taper of the last instrument used to prepare the canal, and has been advocated for obturation of curved canals.

This technique has got certain inherent advantages like safe coronal extrusion of cement with minimal apical extrusion, more uniform gutta-percha, lesser obturation time, elimination of lateral stresses during obturation, avoids potential damage of radicular tissues due to increase in temperature, no obturation material shrinkage and comparatively lower cost.

In a study of comparison of two single cone techniques (Activ GP and Gutta-flow) with warm vertical compaction technique, the single cone techniques did not ensure a durable apical seal. (Monticelli et al 2007)[48].

The Group-2 (cold lateral condensation technique) had higher apical leakage than Group-3 (thermoplasticized gutta-percha injection technique – obtura-II) with a mean of 1.4995.

There was significant difference between the three groups when statistically analysed ($p<0.05$).

The teeth used in this in vitro study had straight canals. The posterior teeth have curved canals with complex anatomical presentation, which might pose greater challenges to these techniques. The cross-sectional shape of the canals also contribute to the long-term efficacy of the seal achieved. In the single cone and cold lateral condensation techniques, the comparatively larger amount of sealer used can possibly cause more shrinkage and apical leakage in the long term.

In the matched taper single cone technique, the use of a matched taper gutta-percha for cold obturation relies on the original canal shape and ability to create a tapered circular preparation. A smaller diameter canal would more suit this technique. Oval or longer diameter canals would necessitate excessive preparation for this technique to be effective.

A slight deviation from the manufacturer’s recommeneded technique of use could result in the mis-match between the canal geometry and the size of the last instrument used thereby leading to an ill-fitting protaper gutta-percha cone. Therefore the operator must ensure an optimum match between the geometry of the gutta-percha cone and the rotary instrument used.

Seventy single-rooted mandibular premolar teeth were selected, cleaned and stored in normal saline solution. They were sectioned at the level of the cementoenamel junction and the rootcanal preparation was done as per the manufacturer's recommendations. The teeth were then divided into five groups, two of which were used as positive and negative control groups. The other three groups were obturated with matched taper single cone technique, cold lateral condensation technique and thermoplasticized gutta-percha injection technique (obtura-II) respectively. The teeth were then subjected to a dye penetration technique using high vacuum and left in the dye solution for 24 hrs. They were then cleaned and subjected to a technique for clearing the roots. Subsequently the dye penetration at the apex was measured in all the three groups using a binocular stereomicroscope and analysed using a Leica application suite. The results were tabulated and statistically analysed.

Matched taper single cone obturation technique was evaluated for the apical seal in comparison with the cold lateral condensation technique and thermoplasticized gutta-percha injection technique(obtura-II) of obturation and the following conclusions were made.

- The thermoplasticized gutta-percha injection technique of obturation, obtura-II (Group-3) showed the least amount of apical percolation of dye and was better than other two techniques in the apical sealing ability.
- There was statistically significant difference between all the three groups ($p<0.05$).
- Matched-taper single-cone technique of obturation (Group-1) showed the highest amount of apical percolation of the dye.
- The cold lateral condensation method of obturation (Group-2) was also efficient in terms of apical sealing ability though it could not match Group-3,($p<0.05$).

The matched taper single cone technique needs to be further studied and evaluated with regards to the limitations of this technique.