

**A Comparative Evaluation of Fill Density Obtained by Lateral
Condensation and Ultrasonic Condensation in Curved Root
Canals of Distal Roots of Mandibular Molars Prepared with Three
Different Nickel-Titanium Rotary Instruments using
Computerized Imaging Method
– An In-Vitro Study**

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CERTIFICATE

Certified that the dissertation on **A COMPARATIVE EVALUATION OF FILL DENSITY OBTAINED BY LATERAL CONDENSATION AND ULTRASONIC CONDENSATION IN CURVED ROOT CANALS OF DISTAL ROOTS OF MANDIBULAR MOLARS PREPARED WITH THREE DIFFERENT NICKEL-TITANIUM ROTARY INSTRUMENTS USING COMPUTERIZED IMAGING METHOD - AN IN-VITRO STUDY** done by **Dr. PARMINDER PAL SINGH ISHER** Part II Post Graduate student (MDS), Branch III - Conservative Dentistry & Endodontics, Saveetha Dental College and Hospitals, Chennai submitted to The Tamil Nadu Dr. M.G.R. Medical University in partial fulfillment for the M.D.S. degree examination in February 2005, is a bonafide research work done under my guidance and supervision.

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INTRODUCTION

Predictable, successful endodontic therapy depends on correct diagnosis, effective cleaning and shaping, disinfection of root canals, and an adequate obturation. The amount of root canal dentin removed during therapy should optimally clean and shape the canals, and subsequent obturation should ensure a tight apical and coronal seal¹.

The advent of Ni-Ti rotary instrumentation has revolutionized root canal treatment by reducing operator fatigue, time required to finish the preparation, and procedural errors associated with root canal instrumentation^(2-6). Procedural errors such as transportation and loss of working length were mainly associated with stainless steel files that had insufficient flexibility⁷. The files made from nickel-titanium (Ni-Ti) had two or three times more elasticity in bending and torsion as compared with equivalent designs manufactured from stainless steel. Ni-Ti also more resilient than stainless steel can retain its shape after loading⁸.

Endodontic therapy consists of a triad of debridement, disinfection, and obturation of the root canal system. It is demonstrated that bacteria remain in the deep portions of the root canals even after application of chemical disinfectants⁹. Inability to completely obliterate the irregularities of root canal space with a filling material and adequately seal the apical foramen has been reported to account for nearly 60% of root canal failures¹⁰. So, obturation can be regarded as one of the most important criteria for the success of endodontic therapy and a well done obturation depends on shaping of the canals. Good shaping results in good obturation.

Currently gutta-percha is the most widely used and accepted obturation material, due to its inertness, biocompatibility, dimensional

stability, compactibility, plasticity when warmed and ease of removal for post placement and retreatment¹¹.

Three popular techniques that utilize these physical properties to obturate the root canal system are lateral condensation, vertical condensation, and warm lateral condensation. Lateral condensation offers the advantage of controlled placement of gutta-percha into the root canal. However, the final root canal filling may lack homogeneity and must rely on sealer to fill the voids between the individual cones¹². Vertical condensation uses heat to produce a homogenous and dimensionally stable gutta-percha mass for obturation of the root canal system¹¹. However, the improved flow of gutta-percha can result in overextension of gutta-percha into periapical tissues and can be very time consuming¹³. Warm lateral condensation using an ultrasonically energized spreader (UES) retains the length control of cold lateral condensation while adding the superior ability of a thermoplasticized technique to replicate the three-dimensional form of root canal¹⁴. All the rotary Ni-Ti files available today come with a complementary obturating system. But, in the clinical practice owing to the cost effectiveness, we are unable to use them and still follow the conventional obturating techniques, even when canals are prepared using Ni-Ti rotary files. So, it becomes essential to evaluate our obturation techniques in these well prepared canals.

The purpose of the present study was to evaluate the fill density obtained by lateral condensation and ultrasonic condensation in curved canals of distal roots of mandibular molars prepared with three different Ni-Ti rotary instruments using Computerized Imaging method.

REVIEW OF LITERATURE

Ronald R. Wollard et al¹ (1976) compared the adhesion and adaptation of filling materials to the walls of the root canals by SEM examination. Root canals of 130 freshly extracted anterior teeth were prepared and filled with various root canal fillings by various techniques. They concluded that, in general, zinc-oxide eugenol cement adhered well, whereas greater variability occurred with polycarboxylate cements. Silver and gutta-percha cones had no adhesion and required a sealer to fill the interface between cones and dentin. None of the techniques for inserting gutta-percha into the root canal was effective in obliterating the root canal space.

Dorothy McComb et al² (1976) evaluated several physical properties of nine commercial root canal sealers in-vitro and compared these with those of two experimental endodontic sealers based on polycarboxylate formulations. Flow, setting time, compressive strength, radiopacity, adhesion to rot dentin and solubility were evaluated. They concluded that, zinc-oxide eugenol sealers were typically of low strength and high solubility. These sealers and polyvinyl resin sealer, Diaket, showed no adhesion to dentin. The epoxy resin AH26 showed superior properties with respect to strength, flow, radiopacity and adhesion.

Alfonso Moreno³ (1977) developed a method for modifying the root canal filling techniques of lateral condensation and vertical condensation of warm gutta-percha. The method used a source of heat desired from an ultrasonic unit. 20 freshly extracted human teeth were used in the study .the teeth were randomly divided into 2 groups of 10 each .The 10 teeth in

control group were filled by lateral condensation and the remaining 10 teeth had their canals filled by thermomechanically softened gutta percha using an ultrasonic unit (PR 30 Insert).The effectiveness of the seal obtained by the new method was demonstrated by autoradiography of longitudinally sectioned specimen. It was concluded that teeth treated with lateral condensation showed a mean leakage of 2 mm whereas those treated with ultrasonic compaction, only 3 teeth showed apical leakage with a mean of 0.6mm.Photographs of root canal fillings showed a more homogenous filling when the thermomechanical technique was used.

Eva M. Beyer-Olsen et al⁴ (1983) evaluated radiographic voids and leakage along root fillings in vitro. Ninety single-rooted human lower premolars with completely formed roots were selected for the study .The canals were prepared and covered by two layers of protective varnish before filling. Various endodontic materials were employed in obturation of root canals. Chloropercha was used in combination with gutta percha whereas all other materials were used alone and in combination with gutta-percha. Thus a total of 9 different groups each of 10 teeth were studied by radiographic examination and dye leakage .The teeth were sectioned transversely at 1 mm interval corresponding to points of observation on radiographs .It was concluded that radiographic voids were frequent in all treatment groups except N2/GP .KP/GP, AH and AH/GP showed incidence of leakage, while very little leakage was seen in N2 and Procosol either with or without gutta percha points.

Richard G. Beatty and Kenneth L. Zakariasen⁵ (1984) evaluated the apical leakage associated with three methods of root canal obturation: These were laterally condensed gutta-percha with and without custom fitted master cones and a single silver point technique .Two different sized canals

were used— 45 for maxillary central incisors and 30 for mesial roots of mandibular first molars, a total of seventy five extracted human teeth. After instrumentation the teeth were randomly assigned to one of the three above groups .An analysis of linear dye leakage was performed for the large canals and a technique of dye recovery and spectrophotometric analysis was used to examine the volume of leakage in both large and small canals. It was concluded that laterally condensed gutta percha with custom fitted master cones (group 2) resulted in less volume of apical leakage than did non – custom fitted laterally condensed gutta percha (group 1) or silver points (group3).

Mahmoud E. El Deeb and Kenneth J. Zudcer⁶ (1985) studied the relation between apical leakage and radiographic density obtained with the McSpadden warm gutta percha, and the lateral condensation techniques in 60 extracted central incisors. By using 2% methylene blue dye as a tracer, the quality of the apical seals were assessed by measuring dye leakage linearly and volumetrically .The density of the fillings was assessed at two levels by scanning pre and post obturation radiographs on scanning microdensitometer . It was concluded that there were no significant differences among the groups regarding the mean densities at apical level .At the middle third of the root, the McSpadden technique showed significantly lower density than did the other techniques. Linear and volumetric measurement of apical dye leakage showed that the warm gutta percha technique allowed less leakage than the other techniques. A definite correlation between radiographic density and leakage was found, especially at middle third of the root.

H.W. Kersten et al⁷ (1986) evaluated the quality of root canal filling by thermomechanical compaction of gutta percha in teeth with moderately

intricate anatomic features and the influence of several aspects of filling procedures, such as: The size of compactor, size of master cone and the amount of gutta percha inserted into the root canal prior to compaction .114 teeth were used for the study and randomly divided into six groups with above three combinations .These were evaluated by radiographic and dye leakage method using stereomicroscope. It was concluded that group 6 (medium condenser, medium master cone and 1-3 auxillary cones) showed best obturation quality and differed significantly from group 2(large condenser, large master cone and no auxillary cones). Group 2 and group 6 showed least dye leakage and group 5 the maximum (large condenser, large master cone and many auxillary cones), which was statistically significant. There was no difference for adaptation and compaction between group means taking all groups together.

Stephen B. Haas et al⁸ (1989) compared the apical seals by four obturation techniques. Sixty four extracted human permanent teeth were selected for the study .The canals were prepared and obturated using lateral condensation of gutta percha that was either unmodified (1) or dipped in chloroform (2), eucalyptol (3) or Eucapercha paste (4). Dye leakage study was done using India ink. It was concluded that there was significant apical leakage in eucapercha group than in the other three groups. The results suggested that modification of gutta percha master cone with solvent does not improve apical seal in vitro. If modification is desired, then dipping the master cone in either Eucalyptol or Chloroform produces an apical seal superior to that achieved with Eucapercha.

Kisk. R. Baumgardner & Keith V. Kisell⁹ (1990) compared lateral condensation of gutta-percha with and without Ultrasonic activation of the spreader by using dye penetration analysis acid scanning electron

photomicrographs of gutta-percha fills in extracted human incisors and canines. Thirty-two extracted human incisors and canines were taken for the study. These were randomly divided into three groups of 10 teeth each according to the method of obturation. One tooth served as positive and one as negative control. Sealability was assessed by dye leakage after decalcifying the teeth and homogeneity by longitudinal splitting of teeth and viewing under SEM. It was concluded that there was statistically significant difference in apical dye penetration among three groups: Group I (Ultrasonic Energized Spreader), Group II (Fine finger spreader) and Group III (Non-activated Ultrasonic Spreader). Ultrasonically activated spreader group showed least leakage but the Groups II & III, the manual condensation groups were not different from each other. The scanning electron photomicrograph showed a more consistent, homogenous fill in Group I than Groups II & III.

Constantine Amditis et al¹⁰ (1992) assessed four root canal filling techniques— Lateral condensation, McSpadden Compaction, Ultra sonic activation and thermoplastic injection (Ultrafil) for adaptation of filling materials to the canal wall. Forty human extracted incisors and canines and mandibular premolars were taken for the study. These were randomly divided into four groups of ten teeth: Group I— Lateral condensation, Group-II- McSpadden Compaction, Group III— Ultrasonic activation, Group IV— Thermoplasticized injection— Ultrafil. The assessment of adaptation was done by electrochemical leakage, linear dye penetration and radiographic evaluation. The electrochemical method showed relatively small differences among obturation technique, although a greater proportion tooth that had been filled by lateral condensation exhibited no leakage. Radiographically; the techniques appeared to exhibit similar adaptation in apical 6mm. The

techniques of lateral condensation and ultrasonic activation showed control of length of the root canal filling.

Frederick R Lieweir et al¹¹ (1993) compared obturation techniques to determine whether use of the endodontic instrument resulted in a quantitatively dense filling of gutta-percha in an artificial root canal in vitro and to determine whether a second insertion of the instrument would result in a further increase in density. Simulated straight root canals in 30 transparent acrylic blocks were taken for the study. These were instrumented and obturated with gutta-percha without sealer using lateral condensation (group A); Zap and Tap method of warm lateral condensation was used on same 30 canals (group B). A second treatment of warm condensation was then applied to these same canals (Group C). The acrylic blocks were weighed after initial canal preparation and after subsequent obturation. A 14.63% increase in weight of gutta-percha occurred in group B compared with group A, and a 2.43% increase in weight occurred in-group C compared with group B. Both differences were statistically significant. ($P < 0.001$).

Claudia R. Barthel et al¹² (1994) compared dye preparation in root canals filled with AH26 sealer in different consistencies. In this study, the effectiveness of the powder to liquid ratio and temperature was assessed using 60 root canals of maxillary central incisors, randomly divided into 4 groups after cleaning and shaping. The teeth were obturated either by lateral condensation or single cone technique using AH26 warmed or at room temperature. After exposure to basic fuchsin, teeth were embedded and cross-sectioned using a diamond saw. The dye penetration was measured microscopically and reported as percentage of total circumference of the filling of each slice using a goniometric eyepiece.

It was concluded that AH26 in combination with lateral condensation leads to less leakage when used at room temperature. It was statistically significant from single cone obturation and AH sealer when warmed at a temperature ($50^{\circ}\text{C} \pm 3^{\circ}\text{C}$).

Gin-ichiro Hata et al¹³ (1995) compared the sealing ability of thermo-plastized gutta-percha fill techniques as assessed by apical leakage using Resorcinol-formaldehyde resin. One hundred fifty nine extracted single rooted maxillary human teeth were instrumented and randomly divided into nine groups of 17 teeth each and 6 control teeth. Experimental groups were obturated with Thermafil, Obtura II, Ultrafil regular set gutta-percha, and Ultrafil firm set gutta-percha, each with or without a sealer. A control group was obturated using a lateral condensation and sealer. Teeth were immersed in a resorcinol-formaldehyde for 5 days at 4°C and resin was allowed to polymerize completely for 4 days at room temperature. Teeth were then sectioned horizontally at 1.5, 2.5, and 3.5 mm from anatomical apex, and examined under a stereomicroscope at x 25 magnifications. The resin filled the spaces in the gap between the canal walls and the gutta-percha and this was measured at each of three levels. The ratio of area of resin to the total area of canal was obtained as mean leakage area. The results showed no significant difference in mean leakage area at the same level for different obturation materials. However leakage was significantly less when root canal sealer was used in all materials.

O. Zmener et al¹⁴ (1997) evaluated the sealing properties of a new epoxy resin based root canal sealer. In this study, epoxy based resin endodontic sealer AH plus was tested in vitro for apical leakage. The conventional sealer AH 26 was used as a control. The root canals of 72 single rooted teeth were prepared biomechanically using a step back

technique before lateral condensation of gutta-percha with one of the 2 sealers. Teeth were immersed in 5% methylene blue dye for 2, 4, or 10 days. The roots were split longitudinally so that extent of dye can be measured with stereomicroscope. The mean extent was 0.4 mm for AH 26 and 1.4 mm for AH plus. Neither material produced a complete apical seal and leakage increased with the duration of immersion in dye. The difference between materials with respect to dye penetration were statistically significant ANOVA ($P < 0.005$)

S. T. Bryant et al¹⁵ (1998) evaluated the shaping ability of profile 0.04 taper rotary Ni-Ti instruments in 40 simulated root canals with 20° and 40° curvature. Instrumentation was done using Crown down methodology. Canal preparation was assessed for preparation time, instrument failure, and canal blockage, loss of working length and canal form. Results that time taken for canal preparation was 5.2 minutes on average which was not influenced by canal shape, 3 instruments fractured (2# 35 and 25 size) with no canal blockage, no significant change in the WL and canals had smooth walls, good flow, taper with apical stops. They concluded that profile .04 taper rotary Ni-Ti instruments with ISO sized tips prepared simulated canals rapidly and created good 3 D flow.

Zmener O, Banegas G.¹⁶ (1999) evaluated the root canal filling by ultrasonic condensation of gutta-percha clinically and radiographically. Ninety human teeth with a total of 18 prepared root canals were filled with the use of ultrasonically energized spreaders as an aid for lateral condensation of gutta-percha of gutta-percha cones .It was concluded that adequate fillings were found in 93% of canals up to the working length. Underfill was recorded in 3% and 2% of them were flush filled, 2% of the

canals showed extrusion of material beyond apical foramen. The overall success rate was 93%.

R. J. G. De Moor and J. G. De Boever¹⁷ (2000) evaluated the sealing ability of an epoxy resin root canal sealer AH 26 used with fine obturation techniques in 237 straight single rooted human teeth. The teeth were prepared with crown down / step back technique and randomly divided into 5 groups of 45 teeth each and one group of 12 teeth as control. Obturation was done using cold lateral condensation, warm vertical condensation, hybrid condensation, Thermafil and Soft-Core Obturators. After the filling, 15 teeth of each group were kept for 1 day, another 15 for 1 week, and another 15 for 4 months at 37 °C in vacutainers in 80 % relative humidity. The 237 teeth were immersed in India ink for 90 hrs, each root was split and sectioned longitudinally and leakage was measured using stereomicroscope. It was concluded that leakage occurred whatever the technique was combined with AH 26 and leakage increased with time. It was highest in soft-core obturators and least in hybrid condensation technique.

Tom G. Gound et al¹⁸ (2000) described an alternative method of lateral condensation and compared the ability to obturate canals using mechanical and traditional lateral condensation in 80 simulated canals one straight 40 and with 30° curvature and 16 mm in length. Instrumentation was done using step back technique. The teeth were divided into 48 groups of 20 teeth each. 20 straight canals were obturated by lateral condensation technique and 20 by mechanical lateral condensation, 20 curved canals were obturated by lateral condensation and 20 by mechanical condensation, 10 canals by each of the two obturators. The compact mass obtained by mechanical lateral condensation was removed in toto and compared with lateral condensation by sectioning and weighing the group mass. The results

showed that experimental obturation were quite heavier than lateral condensation. One operator's obturation was significantly heavier than the others. They concluded that mechanical lateral condensation was found to be superior in ability to produce a heavier fill, regardless of whether canal is straight or curved or whether the operator tends to produce heavier or lighter fill.

Edward A. Nelson et al¹⁹ (2002) compared quantitatively the density of slanted cold lateral condensation of gutta-percha and warm lateral gutta-percha condensation using the system B heating instrument in a low heat warm lateral condensation technique in an artificial root canal in vitro. Thirty – degree simulated root canals in 30 transparent acrylic blocks were instrumented using Gates-Glidden burs and Quantec rotary files. Canals were obturated with gutta-percha using cold lateral condensation technique without sealer. Warm lateral condensation was performed in the same canals twice. The blocks were weighed after initial canal preparation and after each obturation. The results showed that warm lateral condensation of gutta-percha using system B significantly increased the weight by 23.97% and further weight increase of 2.59 % after second heat application over that second heat application .It was concluded that warm lateral condensation using System B instrument results in denser gutta-percha fills by weight when compared with standard cold lateral condensation.

R. M. P. Gilhooly et al²⁰ (2000) compared cold lateral condensation and a warm multiphase gutta-percha (Alphaseal) technique for obturating curved root canals and evaluated the radiographic quality and sealability of root fillings in 108 extracted teeth. These were divided into two groups of 54 teeth each depending on the group. After preparation the canals of one group were obturated using cold lateral condensation of gutta-percha and canals of

other group were filled using warm multiphase gutta-percha technique. The extrusion of sealer was observed. The sealability was assessed by dye leakage. The results showed that the roots filled with multiphase obturation had significantly more extrusion of sealer and gutta-percha, less apical leakage but poor obturation quality in bucco- lingual view radiographically than lateral condensation. It was concluded that, under laboratory conditions multiphase gutta-percha had better sealability but poor radiographic quality than lateral condensation.

Kenan Clinton and Van T. Himmel²¹ (2001) compared warm gutta-percha obturation technique, Thermafil Plus (Tulsa Dental, Tulsa OK) with lateral condensation for the ability to adapt gutta-percha to the walls of root canal system. An extracted, sectioned and mounted maxillary central incisor had canal irregularities replicated, quality of replications, number of voids and general appearance of obturation were all evaluated using standardized criteria. The results showed significant differences between both techniques in all categories. Gutta-percha using the Thermafil technique was better to flow into lateral spaces, had fewer voids and replicated the surface of root better. It also showed more apical extrusion than did lateral condensation.

Pia Deplazes et al²² (2001) compared the apical preparation of root canals shaped by Nickel-Titanium rotary and hand instruments. Eleven maxillary or mandibular with fully formed apices were selected for the study. Roots were embedded in Teflon molds and three serial cross- sections were obtained at a distance of 1.25, 3.25 and 5.25 mm from the apices. The sections were photographed and then repositioned in the molds for instrumentation with light speed and Nitiflex files. The cross- sections were removed and photographed. The pre and post- instrumentation photographs

were superimposed and analyzed for displacement of root canals along X and Y- axis, and increase in cross-sectional areas of files used. It was concluded that both types of instruments used produced similar displacement of canal centers after preparation.

Michael W. Hembrough et al²³ (2002) evaluated the lateral condensation technique in obturating canals prepared with 0.006 tapered Ni-Ti rotary files and what effect, if any, the use of 0.06 or near 0.06 mm/mm tapered ISO-Standardized master cones. Forty-five single rooted teeth were instrumented with profile ISO 0.06 Ni-Ti rotary instruments and obturated with lateral condensation using three different master cones: An ISO standardized gutta-percha cone, and a size medium gutta-percha cone. Obturating efficiency in each group was evaluated by recording the number of accessory cones. The obturation quality was evaluated by the cross sectional observation of the ability of the gutta-percha to obliterate the root canal. The results showed that the obturation efficiency in groups using Dia ISO_{GT} 0.06 and size medium gutta-percha was better than that with ISO standardized gutta-percha. The obturation quality was not significant in either of the group, at any cross sectional level or overall.

They concluded that under the conditions of the study, the use of either a Dia ISO_{GT} 0.06 gutta-percha cone or custom fitted size medium gutta percha cone as master cone in lateral condensation technique for obturating canals prepared with Profile ISO 0.06 Ni-Ti rotary instrument i.e. both more efficient than, and equally effective to, the use of the lateral condensation technique with an ISO standardized master gutta percha cone.

Alexander K. Deitch et al²⁴ (2002) compared fill density obtained by supplementing cold lateral condensation with ultrasonically energized spreader, in artificial root canals. Thirty –degree simulated root canals in 30

transparent acrylic blocks were instrumented using rotary files. The blocks were weighed. The canals were obturated with gutta-percha using cold lateral condensation. The same 30 canals using UES obturation treatment. The results showed that first heat application produced a 26.92% increase in weight over lateral condensation, and second application produced an additional 5.95% increase which was statistically significant. They concluded that warm lateral condensation using an ultrasonically energized spreader results in denser gutta-percha fills by weight than cold lateral.

Edgar Schafer et al²⁵ (2002) assessed the seal obtained in straight and curved root canals filled with either laterally compacted gutta-percha or Thermafil obturators used in combination with three different sealers (RSA Roekoseal, AH26, AH Plus). Thermafil obturators were used without sealer also. The study included 284 extracted teeth, 142 with straight and 142 with curved canals. These were divided into four groups of 16 teeth each. 60 teeth served as positive or negative controls. All canals were enlarged and after obturations were placed into India ink for 48 hours and rendered transparent to measure dye leakage. The results showed that canals filled with Thermafil obturators had significantly more extrusion of filling material than canals filled with lateral condensation. Thermafil without sealer exhibited higher dye penetration than compared with all groups both in straight and curved canals. The seal obturated with Thermafil and lateral condensation was equivalent when sealer was used. They concluded that under conditions of this study, Thermafil obturators achieved seals comparable to lateral condensation as long as sealer was used.

R.J.G. De Moor and G.M.G. Hommez²⁶ (2002) evaluated the long term sealing ability (both apical and coronal) of an epoxy resin (AH26) when

used with different gutta- percha obturation techniques. 790 extracted straight single rooted teeth were divided into 10 groups of 75 teeth and one group of 40 teeth as control. After preparation using crown down /step back techniques canals were obturated using cold lateral condensation, warm vertical condensation and hybrid condensation of gutta- percha, and the Thermafil and soft core obturators. AH 26 was used as sealer in all cases .Each group was again divided into five individual groups of 15 teeth each and kept for 1 day, 1 week, 4 months, 6 months and 12 months at 37° C in vacutaners in 80% relative humidity. The teeth were immersed in India ink for 90 hours and split longitudinally, and maximum extent of leakage was measured using stereomicroscope. They concluded that hybrid gutta- percha technique was superior to other four techniques in respect of apical leakage. Coronal leakage was significantly greater during first 4 months for Thermafil as compared to the three condensation techniques; coronal leakage was significantly greater at all time periods for the soft core system .There was no significant difference between Thermafil and soft-core system.

Ponti et al²⁷ (2002) had evaluated the canal centering ability of two rotary file systems. The purpose of this study was to evaluate a new split mold design as a tool for studying instrumentation procedures and compare the ability of Profile Ni-Ti .06 taper with Profile GT rotary file to maintain the canal center of natural teeth with curved canals. Ten freshly extracted mandibular first and second molar's mesial roots having two separate canals were selected. Mesial roots were sectioned, working length determined. Canal curvature determined using Schneider's method and were divided into two groups of five teeth with canal curvature less than 20°, other five greater than 20°. The teeth were mounted in resin blocks using the endodontic cube

which has 5 brass pieces assembled by means of screw. Horizontal grooves of 1mm depth and 2mm apart served as index. The specimens were sectioned and pre- instrumentation image obtained. It was reassembled and randomly chosen for instrumentation with Profile .06 taper and Profile GT series. After instrumentation each section was photographed and analyzed in software by overlying the pictures for the amount of deviation of canals. Results showed that in both the systems canal deviated minimally from the original path. It was concluded that endodontic cube was an effective tool in studying and comparing the instrumentation techniques.

Gin- Ichiro et al²⁸ (2002) have compared the shaping ability of Profile GT file and Flex-R file in simulated canals. 160 simulated resin blocks with 20° to 30° curvature were divided into four groups of 40 canals each. Each group of 40 was subdivided into 20 each based on degree of curvature. The canals were instrumented with .04 taper Profiles, Profile .04 and .06 taper, Profile GT file and balanced force technique with Flex-R file. The canals were evaluated for amount of resin removed at 5 levels in apical 5mm of canal by superimposing the pre-operative and post-operative images. At 1mm from apical end all the instruments showed canal transportation towards outer aspect of curvature except in balanced force technique where more resin was removed from inner aspect. It was concluded that balanced force technique required more preparation time than rotary instrumentation.

Rodig et al²⁹ (2002) had evaluated the quality of preparation of oval distal canals in mandibular molars using Nickel-Titanium instruments. 60 extracted mandibular molars were used. Access cavities were prepared. Only teeth with bucco-lingual distance twice as long as mesio- distal distance and root canal curvature of less than 20° were selected. All the teeth were

shortened to a length of 19mm and mounted in resin. It was then sectioned horizontally at 3, 6, 9mm from the apex and the pre- operative shape were photographed. Canals were prepared with Profiles, Light speed and Quantec. After preparation, cross-sections were photographed and divergence of root canal diameter was evaluated by superimposing pre and post- operative outlines. Roots were freed from resin and viewed under SEM for analysis of debris and smear layer. Results showed that all three instruments left uninstrumented canals in the coronal third. Best results were obtained in apical third. Root canals were not homogenous and some amount of debris was left behind. The Profile preparation was found to be safe without any procedural errors and fractures. It was concluded that Ni-Ti instruments did not prepare the buccal and lingual extensions of oval canals. Prepared root canals had remaining debris on the smear layer in unprepared extensions.

C. N. Ardila, M- K. Woo and P. R. Wesselink³⁰ (2003) compared the percentage of filled canal area in mandibular molar roots after conventional root canal hand instrumentation or after non- instrumentation technique (NIT). 40 mandibular molars were taken for the study. Root canals of 20 were prepared with conventional hand instruments and obturated with warm vertical condensation of gutta- percha. The 20 teeth in second group were claimed and obturated by NIT, entire tooth being embedded in an acrylic resin cylinder before NIT. Horizontal sections were cut at 2, 4, 6 and 8 mm from apex and images were taken using a stereomicroscope and digital camera. The cross-sectional area of canal with filling materials was measured using image analysis programme. The percentage of filled canal was calculated .The results showed 93-100 %of canal area was filled in both groups at all levels. They concluded that, following the cleaning and filling of root canals using NIT, the percentage of filled root canal was similar to

that using warm vertical condensation of gutta- percha after conventional root canal therapy.

Calvin B. Suffridge³¹ (2003) evaluated the cleaning efficiency of Nickel- Titanium GT and .04 Rotary files using a torque controlled rotary handpiece. The objective of this study was to compare two torque modes- torque setting of 1 Ncm to no-torque control at same speed of 300 rpm. Fifty extracted human anterior teeth with straight canals were selected and sectioned at CEJ. They were randomly divided into two groups with 20 specimens each based on torque control. Positive and negative controls had 5 specimens each. After instrumentation canals were irrigated, cleansed, sealed and then sectioned longitudinally. Canal cleansing was determined by projecting a grid over the photograph of apical 6 mm of canal and counting the number of squares containing debris. It was concluded that no difference was found between the two groups which may be because of larger sizes of canals and operator familiarity with the technique.

Mian K. Iqbal et al³² (2003) compared the apical transportation in four Nickel-Titanium rotary instrumentation techniques. A new radiographic technique which consists of Plexiglass jig to hold the X- ray tube and turntable to hold the specimen was used for this study. Sixty mesio-buccal canals of mandibular molars were randomly divided into four groups and were instrumented by four techniques- Profile 0.06 series using Crown- Down technique, Profile 0.06 series with Step-back technique, GT followed by Profile 0.06 series using Crown Down technique and GT followed by Profile in Step-back technique. The pre and post instrumentation radiographs were taken, superimposed and analyzed for loss of working length and transportation at different levels. It was concluded that operational sequence

of Profiles or preinstrumentation with GT files has no effect on degree of transportation and loss of working length.

Peters et al³³ (2003) evaluated the effect of canal anatomy on the final shape obtained by ProTaper root canal preparation analyzed by Micro CT. the results showed no errors like perforation, ledges, and zips. Overall the mean canal volume and surface area increased significantly after the preparation. Canal transportation occurred more in the apical area. Large untreated areas were found in the mid- root of the convex side of curvature. It was concluded that Protaper prepared canals in a smooth tapered shape with no procedural errors. Some apical canal transportation was evident on. Canal anatomy had an insignificant effect on preparation indicating Protaper instruments were able to shape constricted canals than wide ones.

O. A. Peters et al³⁴ (2003) assessed the root canal preparation with Protaper with the effect of canal anatomy over torque and force. Results showed that that a distinct relationship between torque, force and instrument insertion depth, that is, for each advancement of Protaper instrument in the canal, a paralleling increase in apically directed force and torque was noted. It was concluded that Protaper instruments generated lower torque value than rotary U-file design. It was also found that a positive correlation exists between canal geometry and physical parameters during shaping.

E. Schafer and M. Vlassis³⁵ (2004) compared the shaping ability, in simulated canals, of two rotary Nickel-Titanium instruments: ProTaper and RaCe. The canals were prepared by crown-down technique. Pre- and post-instrumentation images were recorded and assessment of canal shape was done with a computer image analysis program. The results indicated, on the average, canals prepared with RaCe instruments remained better centered compared with those enlarged with ProTaper files. It was concluded that

both instruments were relatively safe. RaCe respected original canal curvature better than ProTaper, which tended to transport towards the outer aspect of the curve.

E. Schafer and M. Vlassis³⁶ (2004) compared two rotary Nickel-Titanium instruments, ProTaper and RaCe, in cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. The canals were prepared using crown-down technique. The pre- and post-instrumentation radiographs straightening of the canal curvature was determined with a computer image analysis program. After longitudinally splitting the roots, the amount of debris and smear layer were quantified on the basis of a numerical evaluation scale, using an SEM. The results showed that RaCe files removed debris slightly better than ProTaper. It was concluded that under the conditions of the study, RaCe instruments resulted in relatively good cleaning and maintained the original curvature slightly better than ProTaper did.

G. C. Bailey et al³⁷ (2004) evaluated the effect of power setting and duration of activation on the temperature rise at the root surface during root canal obturation by ultrasonic condensation of gutta-percha. Combinations of power settings (1, 3, 5) and durations of activation (4, 10, 15 s) were used to test their effect on temperature rise at the root surface using eight K-type thermocouple at the mid-root and apical levels. The results showed, only one combination of power setting (5) and duration of activation (15 s) resulted in temperature rise in excess of 10°C. The maximum temperature rise at the mid-root level was greater than that recorded apically. It was concluded that, temperature rises at the root surface during ultrasonic condensation of gutta-percha in excess of 10°C were evident in only one combination of power (5) and time (15 s) settings at the mid-root level.

SUMMARY

The aim of this study was to compare and evaluate the fill density obtained by lateral condensation and ultrasonic condensation in curved root canals of distal roots of mandibular molars prepared with three different Nickel-Titanium rotary instruments using Computerized Imaging method in-vitro.

60 freshly extracted human mandibular molars with patent distal canals and canal curvatures ranging between 20°- 40° were selected. Crowns were sectioned 14 mm from the apex and embedded in plaster blocks with apex sealed with modeling wax to prevent the plaster from entering the canal. The specimens were divided into three groups of 20 teeth each depending on the instruments used.

Group I: Profiles

Group II: ProTaper

Group III: RaCe

After the preparation the groups were further divided into two subgroups of 10 teeth each depending upon the method of obturation.

Subgroup A: Lateral Condensation

Subgroup B: Ultrasonic Condensation

After the obturation, the roots were separated from the plaster blocks and sectioned at 3 levels- apical, middle and coronal. The sections were photographed and image was displayed on the computer screen using Schick's CDR system. The obturation quality for each section was evaluated

by observing the space or spaces, in each section that contained sealer, more than 0.1mm in size using linear measurement device.

Optimal obturation was achieved in canals prepared with Profiles and RaCe when compared to ProTaper and ultrasonic compaction produced a more homogenous and three-dimensional obturation when compared to lateral condensation.

CONCLUSION

Under the conditions of study it can be concluded that;

- 1) Ultrasonic compaction (Warm Lateral Condensation) produced a more homogenous, three-dimensional obturation when compared to cold lateral condensation.
- 2) Optimal obturation was obtained in canals prepared with Profile and RaCe when compared to Protaper.
- 3) It is not necessary to use the complementary obturation systems of corresponding Ni-Ti instruments for achieving good obturation.

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