THE INFLUENCE OF USING ULTRASOUNDS FOR IMPROVING THE SEALING ABILITY OF THE PERMANENT ROOT CANAL FILLING

Cristian Levente Giuroiu*, Horia Aldea, Raluca Dragomir, Galina Pancu, Cătălina Dănilă, Silvia Teslaru, Sorin Andrian

"Gr. T. Popa" U.M.Ph. - Iași, Romania, Faculty of Dental Medicine, Department of Odontology, Periodontology, and Fixed Prosthesis

*Corresponding author: Cristian Levente Giuroiu, Assistant Professor, DMD, Stud. PHD
"Gr. T. Popa" University of Medicine and Pharmacy
- Iași, Romania
e-mail: giuroiu.cristian@umfiasi.ro

ABSTRACT

This paper aims to evaluate ,,in vitro'' the tightness of root fillings in monoradicular teeth using distinct techniques: monocone classic technique, cold lateral condensation technique and warm vertical condensation ultrasound associated technique, underlining some issues of particular interest regarding clinical outcomes over time for endodontic treatment. The study group consists of 45 permanent, monoradicular maxillary and mandibular teeth. The study results showed a higher degree of dye infiltration in the teeth root, filled with monocone classic technique compared to cold lateral condensation and hot vertical condensation ultrasound associated methods; slightly higher dye infiltration in teeth filled by cold lateral condensation technique compared to the teeth group with hot vertical condensation ultrasound associated technique; the control group showed overall richest dye penetration in root canals and dentinal tubules. Warm root canal filling with fluid gutta-percha makes a more qualitative 3D sealing, especially in the medium and coronal thirds compared to other techniques used.

Key words: root canal filling, ultrasound, sealing, optical microscope

INTRODUCTION

Different ingenious clinicians developed many materials, tools and techniques in order to obtain an ideal endodontic filling.

In 1958, the father of contemporary endodontics, Prof. Dr. Louis I. Grossman remarked: „I seriously doubt that there is any other space in the human body except the root canal, where was filled over time, with such diversity of materials"[1].

Despite continuous research and development of new materials and techniques for ,,three-dimensional filling'', by now we cannot achieve perfect sealing in the complex endodontic space. However, clinical success for long term proves to be very high, when restorations performed to the highest standards available today [2, 3].

Root canal obturation is reluctance for a majority of dentists. This is because, they are evaluated and judged only after the radiographic appearance of the completed case regarding the ,,continuous and dense dental radiograph white stripes''. Often, however, a root filling apparently ,,aesthetic'' can hide many irregularities.

Technical problems raised during root fillings are often the consequences of incorrect and insufficient root preparations. A dead, unoccupied, avascular, empty, space is

the ideal site for colonization of microorganisms that are protected against immune system. Radiographs of the analyzed subjects, taken in several horizontal angulations, must show a continuous filling without holes and marks from compaction tools, uniform density throughout its length, perfectly adapted to the root canal preparations contour. Not only the main canals, but microanatomy and the endodontic details (side, accessories, furcal canals, communication isthmuses etc.) should be filled with an inert filling material, biologically tolerated and dimensionally stable over time [3, 4].

This paper aims to evaluate ,,in vitro'' the tightness of root fillings in monoradicular teeth using distinct techniques: monocone classic technique, cold lateral condensation technique and warm vertical condensation ultrasound associated technique, underlining some issues of particular interest regarding clinical outcomes over time for endodontic treatment.

MATERIAL AND METHODS

Teeth selection

The study group consists of 45 permanent, monoradicular maxillary and mandibular teeth (incisors, canines, and premolars). Gender, age or race was no selection criteria. The teeth were collected for one and a half year in the Oro-Maxillofacial Surgery Unit, ,,St. Spiridon'' Emergency Hospital. Chronic deep marginal periodontitis and deep carious lesions making any recovery prosthetic procedure impossible were reasons for extraction. These radical therapeutic decisions were taken without any connection to our study.

The 45 teeth were randomly divided into three experimental groups: ***control group*** *– to be treated by monocone classic technique (15 teeth);* ***Lot I*** *– to be treated by cold lateral condensation technique (15 teeth) and* ***Lot II*** *– to be treated by warm vertical condensation ultrasound associated technique (15 teeth).*

After extraction, teeth were cleaned out of surface soft and hard tissues using a curette. The teeth were kept in saline until the collection of the number of teeth in this study was completed. The root canal of all this teeth was then cleaned, manula shaped and then the root canal was filled using the techniques mentioned above.

Preparation of teeth

All teeth were prepared by a single dentist not to influence the study results. The crowns of the teeth are left intact to reproduce the clinical conditions encountered in practice. Making access to the coronary pulp chamber is performed with spherical and cylindrical diamond burrs of various sizes, turbine operated. The access cavity shape is consistent with the morphology of each prepared tooth. Canals location is obtained using Kerr needle files # 8 and 10. After the coronary access, the working length of 1 mm to the apical foramen is established. All canals are prepared in accordance with previously established working length (apex-locator) for every tooth. Mechanical preparation of the canal is done by Crown-Down technique using Kerr and Headstroem hand steel files. After every needle usage, the canals are abundantly irrigated (3% sodium hypochlorite and hydrogen peroxide 3%) and 17% EDTA prepared, to remove smear-layer.

Root canal obturation

a) *The control group* - the root was filled using *monocone technique*.

The canals are irrigated and dried with sterile paper points. The master cone used was one size bigger than the last file used for the apical stop preparation. The root canal

wall is coated with thin layer of sealing cement using Lentullo needle at a conventional speed. The master cone is placed on the entire length of the canal and cut with a heated fuloar. Mandatory prerequisite to achieving fair fillings by this technique is that the cone should be tightly fixed in the canal for a length of 3-4 mm to the apical stop. Teeth crowns are filled with composite material.

b) *The study group I* - the root was filled using cold lateral condensation technique.

After canal irrigation and drying, a root canal spreader is tested. A master cone one size bigger than the last needle used for the preparation of apical stop is chosen for each tooth, to stop at 0.5-1 mm distance to the apex. The canals were coated with a thin layer of cement sealing using Lentulo needle inserted with a conventional speed in the clockwise direction. Master cone was adjusted 0.5 mm to the apical constriction and is laterally condensed using a spreader, to obtain the necessary space for accessories cones. A new accessory gutta-percha cone, dressed in sealing cement is introduced into the canal space conducted by spreader. Maneuver is repeated to fill the canal with more cones until the last additional cone can't be introduced more than 2-3mm. in depth. Gutta-percha cones are sectioned at canal inlet with a heated fuloar and condensed vertically with a plugger. Last maneuver is to fill the crown of each tooth.

c) *The study group II* – the root was filled using injection techniques of *associated warm and vertical condensation ultrasound technique*.

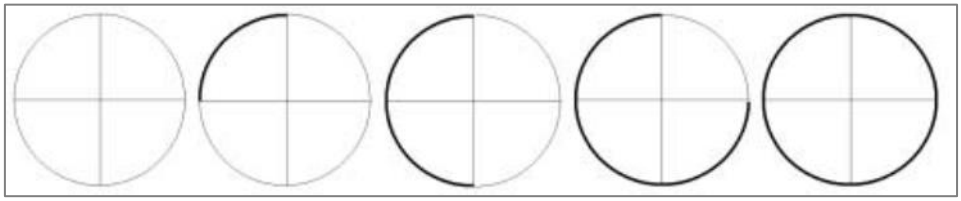
Pluggers are clinically selected for ensuring penetration to the appropriate depth. After a last irrigation, sterile paper cones are used for canals drying. Canal walls are coated with sealing cement and cannula is introduced 3-5 mm to the apical stop. Fluid gutta-percha fluid is injected slowly into the canal, keeping enough space around the cannula to prevent filling bubbles. The ultrasonic insert is applied and condensing is achieved with previously selected plugs. Gutta-percha is thermo treated at 170 ° C using BeeFill system (figure 1).

Figure 1. Gutta-percha injection into the canal.

Teeth clipping

After filling of all the three groups, all teeth are dried and the root surface is covered with a thin layer of varnish from the enamel-cement junction to 2 mm to the apex. The teeth are then placed into a closed container with methylene blue dye, to avoid evaporation of the dye. Samples were then washed under running tap water and dried. The dye penetration was possible only through the apical and coronal sites.

Teeth clipping is carried out transversally, from the apex to the coronal part, with a Dia-disk made by Diamond Disk BestQual Company, acted by a straight hand piece resulting 0.5-1 mm thick slices. A schematic diagram is used for correct scoring of the samples (figure 2). The highest score identified for a cross section slice was considered the final score of the tooth. The chosen slices are photographed and analyzed using a camera equipped optical microscope (NIKON Eclipse Ti with the TI-TIRF illumination and confocal system).



0 points 0.75 points 0.5 points 0.25 points 1 point

Figure 2. Schematic diagram of the criteria for samples grading system

RESULTS

The study results showed a higher degree of dye infiltration in the teeth root, filled with monocone classic technique compared to cold lateral condensation and hot vertical condensation ultrasound associated methods; slightly higher dye infiltration in teeth filled by cold lateral condensation technique compared to the teeth group with hot vertical condensation ultrasound associated technique; the control group showed overall richest dye penetration in root canals and dentinal tubules. Infiltration average for all restorations is 0.92 mm for hot vertical condensation ultrasound associated technique; 2.6 mm for cold lateral condensation technique and, 4.9 mm for monocone classic technique. The difference is statistically significant ($p < 0.05$).

Standard and mean deviations of methylene blue seepage in studied teeth groups are 5.05 ± 0.87 for classic monocone technique; 2.75 ± 0.85 in teeth filled by cold lateral condensation technique and 0.50 ± 0.35 for hot vertical condensation ultrasound associated method.

Control group: teeth filled by monocone classic technique.

This group has most gaps and parietal dentinal wall areas infiltrated with methylene blue, with a final score of 15 points (15 teeth were scored with 1 point) (figure 3).

Study group I: teeth filled by cold lateral condensation technique

This group has showed less marginal areas of root fillings infiltration compared to the control group (figure 4). According to the schematic diagram study group I was noted with 10.5 points (12 teeth were scored with 0.75 points and 3 teeth with 0.5 points) compared to the control group of 15 points.

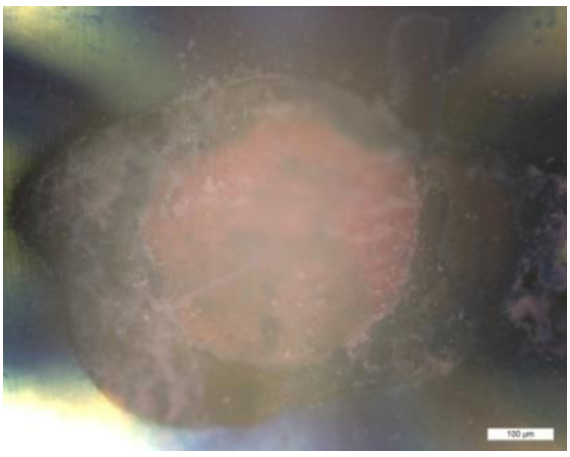


Figure 3. Three massive infiltration around the master cone and the presence of root canal irregularities scored with 1 point (magnification x20)

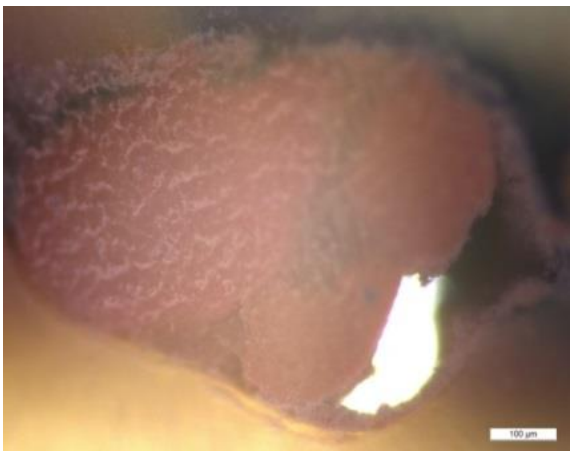


Figure 4. The presence of a lacunar space near a parietal dentin irregularity not properly plugged and laterally condensed is scored with 0.75 (magnification x20)

Study group II: teeth filled by hot vertical condensation ultrasound associated technique

This group showed the fewest marginal root fillings infiltration compared to the control group and the study group I (figure 5). Group II was scored with 3 points (6 teeth were scored with 0.5 points).

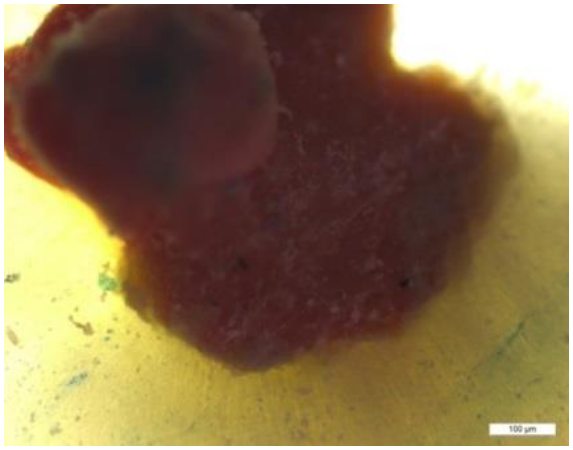


Figure 5. Thermo treated gutta-percha associated to ultrasonic vibrations shown a superior grip to the dentin walls hindering the penetration of methylene blue; this tooth is scored with 0 points (magnification x20)

DISCUSSIONS

The main goal of a root filling is to seal any penetrating way of micro-organisms and to prevent any microbial exchange between the periodontal and endodontic space and vice versa. So, to achieve this goal is necessary a dense, tight root filling, void of empty spaces or gaps enabling the growth of microorganisms [5,6]. It is shown that the vast majority of endodontic failures are closely related to root incorrect and incomplete fillings. Theoretically, if endodontic space is three-dimensionally plugged the remaining microorganisms they stay “trapped" between the dentinal tubules and sealing and gutta-percha material, while unable to survive [7.9].

Classic monocone canals shutter technique is quick and easy, requiring no important tools, but does not provide a root tightness pretty good, being inferior to other techniques. Canals are never a circular section along their whole length after manual mechanical preparation, so, applying a single cone leaves spaces where there is only cement seal that is while reabsorbed into contact with tissue fluids [8]. The control group was generally the richest dye impregnation in root canals and dentinal tubules were rated in the final by 15 points.

Shahriar et al. (2008) concluded that mechanical lateral condensation technique is a better method and more suitable for root canal filling compared to the cold lateral condensation technique. Lateral mechanical condensation involves placing a master cone in the main canal , followed by a nickel-titanium spreader activated by a hand piece having reciprocal functions. “T”-test showed that teeth fillings with mechanical lateral condensation technique had fewer areas of dye penetration compared with cold lateral condensation technique ($p < 0.05$).

In our study we observed fairly significant empty spaces existence due to spreader peaks printing (facilitating the gaps appearance) particularly in the apical third. However, this technique provides a seal superior to the fillings made with a single cone, especially in the medium third and in the coronary third. Heated gutta-percha and vertically compacted ultrasound associated technique proved to be a high quality canal filler particularly for curved root-canals and for accessories or auxiliary canals as well as for side or multiple foramens. It achieves a gutta-percha plug on the last endoapical millimeters with good adhesion to dentin parietal walls. That's for the fact that melted gutta-percha simply flows in waves penetrating even irregular root canal areas.

McRobert and Lumley (1997) compared the B System, Obtura II, and Alphaseal to cold lateral condensation technique in terms of coronary percolation and found no significant difference between the four groups regarding the presence of radiological evaluated holes. Both B System and Obtura II exhibited significantly smaller infiltrations than Alphaseal and cold lateral condensation techniques (P <0.001).

NS Kumar et al. (2012) analyzed the tightness root fillings, presence of empty spaces and adaptability of fillings to the ductal walls between the cold lateral condensation techniques, thermo treated gutta-percha, and fluid gutta-percha. Sixty premolars with a single canal were randomly divided into 3 groups: the first group of teeth was filled by cold lateral condensation, second with thermo treated gutta-percha (Obtura III MAX) and third with fluid gutta-percha (Guttaflow). Each tooth was sectioned at five levels, sliced with a thickness of 1-2.5 mm. Coronary aspects of each section were digitally photographed and measured at a 40 × stereo-magnification. The fewest gaps were found in teeth filled with Obtura Max III thermotreated gutta-percha [1.0% (95% CI = 0.5-1.5)], there is a considerable difference between this and Gutta Flow fluid gutta-percha [3.0% (95% CI = 2.1- 3.9)]. Thermotreated gutta-percha was significantly superior to lateral condensation in terms of dimensional adaptation. Fluid gutta-percha showed the highest number of empty spaces but no technique was found to be superior to all three analyzed aspects.

Emmanuel S et al. (2013) conducted a study comparing three different obturation techniques: gutta-percha cold lateral condensation, Obtura II and Thermafil. They evaluated 120 extracted monoradicular teeth divided into 3 groups: teeth in the first group were filled by cold lateral condensation technique, in the second by Obtura II technique and in the third by Thermafil technique. The analysis was done with the spectrophotometer and concluded that the smallest apical space penetration was found in obstructed teeth with Thermafil technique and the biggest penetrated space in Obtura II filled teeth. There was revealed a significant difference between lateral cold condensation and Obtura II techniques. An over filled sealant was found for Thermafil technique.

Cohen St. et al. (2006) De Deus G. et al. (2006) showed that the accuracy of root filler is another important factor in addition to different materials used in fillings techniques.

The sealant is able to fill the remaining dehiscence between gutta-percha cones and ensures good adaptation to the canal walls. Also it enters the side and accessories canals due to its fluidity. Lateral condensation results compared to other methods show better quality of the filling in the middle third of the canal than warm vertical condensation [4, 5, 16]. It was confirmed that the dye infiltration can occur either by the material dissolving at the interface between sealants and dentin or between the sealant and gutta-percha [5]. Confirmed solubility of the sealers involves the need to limit its usage to a thin layer and increase the gutta-percha mass [5]. All currently available filling materials allow marginal infiltration. They are not waterproof.

Actually, most problems concerning root canal fillings are the instrumentation quality. This basically reflects how the canal was handled.

CONCLUSIONS

In terms of the level sealing of the root filling to the dentinal walls and prevention of apical infiltration, there was a higher quality

of tightness in the filling done with warm vertical condensation associated with ultrasound, followed by cold lateral condensation techniques and then classical mono-cone technique. The correct determination of the working length and keeping it all the way to the end of endodontic instrumentation and also avoiding to do a defect preparation within the chemical-mechanical instrumentation of the root canal, remains crucial in achieving best results. The dye infiltration test offers information regarding the amount of apical infiltration and the level of sealing of the filling to the root dentinal walls and also the level of material adaptation to the walls of the canal.

Based on the results mentioned above we can conclude the following:

1. cold lateral condensation technique presented less methylene blue colored areas comparing to mono-cone technique and more colored areas comparing to warm vertical condensation technique ultrasound associated; this was seen especially in the apical third of the canal, due to improper use of the spreader or improper gutta-percha master cone match.
2. warm vertical condensation ultrasound associated technique produces a homogeneous and compact mass of gutta-percha (which reduces the occurrence of empty spaces and increases the adeshion of warm gutta-percha to the canal walls) comparing to cold condensation technique;
3. warm root canal filling with fluid gutta-percha makes a more qualitative 3D sealing, especially in the medium and coronal thirds compared to other techniques used;
4. the sealing cement enters better to the dentinal tubules in those teeth that have been filled with warm vertical condensation ultrasound associated technique.

Conflict of interests

The authors deny any conflict of interests, funding, and other personal relationship with other people or organizations related to this study.

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