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A CBCT- BASED COMPARISION OF ROOT CANAL FILLING QUALITY FOLLOWING DIFFERENT INSTRUMENTATION & OBTURATION TECHNIQUES - AN IN-VITRO STUDY

Dental Science

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ABSTRACT

AIM-A CBCT based technique for quantitative evaluation of voidsin root canal fillings done after endodontic procedures

OBJECTIVES-To find best quality of biomechanical preparation through hand vs. Rotary instrument.To find voids in two different obturation techniques i.e. single vs. Thermoplasticized condensation.

Materials and Methods: Forty maxillary premolars will be randomly divided into two groups, 20 teeth will be hand instrumented (H) and 20 will be instrumented with rotary instrument (ROT).Both the above groups will again be divided into 2 groups of 10 each on random basis.The "H-SC and ROT-SC" groups will be instrumented with hand ProTaper files and rotary system respectively and filled with SINGLE CONE compaction. The "H-TH and ROT-TH" groups will be instrumented with Hand ProTaper filesand rotary system respectively and filled with Thermoplasticized obturation system. The volume at the filling/dentine interface (i-voids) and voids surrounded by filling material (s-voids) will be measured using CBCT.The software used for calculating volume will be ANATOMAGE-INVIVO5 software (Anatomage. 303 Almaden Blvd, Suite 700. San Jose, CA 95110).

Statistical Analysis: The inter group comparison was done using the One Way ANOVA and Independent t-test.

Results:hand instrumented canal obturated with Thermoplasticized technique was having less amount of volume of voids than Rotary instrumented and obturated with single cone technique.

Conclusion-Among the collected data Hand instrumented Canal was having less amount of volume of voids than Rotary instrumented.Single cone obturation technique was having highest amount of volume of voids than Thermoplasticized technique.

KEYWORDS

Hand,Rotary,Single Cone,Thermoplasticized, CBCT, Voids.

Introduction

The goal of root canal therapy is to save teeth with compromised pulps by preventing bacterial colonization or disinfecting previously infected root canal systems. This is achieved using a combination of mechanical debridement using instruments, and disinfection with irrigants solutions, referred to as chemo-mechanical debridement, before filling with an inert material. [1,2]The mechanical aspect involves the use of files to debride the canal and prepare a smooth sided shape that will both maximize the efficacy of the chemical disinfectants and permit the placement of a filling to seal the space and prevent re-entry of bacteria. It is the combination of intra-visit irrigation and inter-visit medication that enables effective disinfection.Modern root canal treatment involves using stainless steel or nickel titanium files to negotiate and shape the root canals after they have been accessed. This provides access for irrigating solutions to disinfect the canal, and root canal Obturation materials to fill and seal the canal when preparation has been completed. The latest systems use nickel titanium instruments and use either 360 degree rotation or a combination of clockwise and anti-clockwise movement.

In order to achieve satisfactory canal preparation, both conventional hand files and nickel-titanium (NiTi) rotary instruments are usually used. The NiTi rotary systems were introduced to reduce the time required for the biomechanical preparation of root canals, especially curved and difficult ones[3]. In addition to their great efficiency, these instruments present advantages like flexibility, and they reduce the possibility of apical transportation[4]. Obturation of the root canal must be hermetic to ensure eradication of microorganisms and prevent their re-growth to avoid subsequent periapical diseases[5]. Several studies have shown the high sealing capacity of various filling techniques based on thermoplasticized guttapercha[6]. The potential disadvantages of this technique may result in the extrusion of sealer and guttapercha into the periapical tissues. However, Lateral condensation continues to be a very popular method throughout the world due to its simple execution, low cost and high sealing ability. Disadvantages include the potential lack of homogeneity of the gutta-percha mass.[5,7] The quality of root fillings is often determined by leakage tests and other more precise methods.[8]So in this study we are studying both hand ProTaper and rotary ProTaper with single cone and thermoplasticized guttapercha Obturation.Clinicians must acknowledge that clinical recommendations based on such evidence are deductive and must be interpreted with caution. With this in mind in the last few years, new techniques have been studied to find void in this regard were CT scan, Digital radiography, Micro CT, CBCT and among them, CBCT seems to be very promising.[9]To assess these techniques several methods have been described in literatureincluding

1. Microscopic examination of cross sections
2. Dissolution of teeth
3. SEM observation of the interface between the guttapercha and the dentinal walls

All the above techniques[10] were invasive and caused damage to the root canal filling. Hence, an ideal experimental model should involve such methodology which does not cause damage to the root canal filling and at the same time allows three dimensional observations. So for the purpose of this study CBCT was considered which is a non-invasive digital method of evaluation and has gained increasing popularity since its introduction.

CBCT can be applied for the analysis of root canal fillings, especially because of their non-homogeneous character and porosity.[11,12] A non-destructive CBCT technique provides insight into the details of 3D images of fillings, especially voids and defects, at a level that is impossible to achieve with other methods.[13] In this context, it would be interesting to assess and compare the quality of canal fillings after commonly used endodontic techniques.

So mainly there are two parts, one is Instrumentation and other is Obturation

AIM & OBJECTIVES

AIM-A CBCT based technique for quantitative evaluation of voidsin root canal fillings done after endodontic procedures.

OBJECTIVES-To find best quality of biomechanical preparation through hand vs. Rotary instrument and to find voids in two different obturation techniques i.e. single vs. Thermoplasticized condensation.

MATERIALS & METHODS

Fourty human premolars extracted for orthodontic reasons and free of carious and other defects were selected for the study. Teeth were cleaned and kept in 0.1% thymol solution until use (up to 30 days), after preparation of solution from Thymol tabletsTeeth will be placed in a 5.25% Sodium Hypochlorite (NaoCl) solution for two hours to dissolve the periodontal ligament, then will be copiously rinsed with tap water and finally it will be stored in 0.2% Thymol solution.The specimens were randomly allocated to 4 groups: (n=10)

- Group 1: Hand –Single cone (Hand-SC)
- Group 2: Hand –Thermoplasticized(Hand-TH)
- Group 3: Rotary –Single cone (ROT-SC)
- Group 4: : Rotary–Thermoplasticized(ROT-TH)

Fourty maxillary premolars will be randomly divided into two groups, 20 teeth will be hand instrumented (H) and 20 will be instrumented with rotary instrument (ROT).Both the above groups will again be divided into 2 groups of 10 each on random basis. So total 4 groups of 10 teeth will be available for the study.The "H-SC" groups will be instrumented with hand ProTaper files and filled with SINGLE CONE compaction. The "H-TH" groups will be instrumented with Hand ProTaper files and filled with Thermoplasticized obturation system.The "ROT-SC" groups will be instrumented with RotaryProTaper files and filled with SINGLE CONE compaction.The "ROT-TH" groups will be instrumented with RotaryProTaper files and filled with Thermoplasticized obturation system.Sealing material in all the group will be AH-Plus seal (DENTSPLY). The roots will be scanned and 3-dimensional (3D) visualization will be obtained. The volume at the filling/dentine interface (i-voids) and voids surrounded by filling material (s-voids) will be measured using CBCT.From CBCT Dicom file will be generated and that Dicom file will be used for calculating volume through software.The software used for calculating volume will be ANATOMAGE-INVIVO5 software (*Anatomage*. 303 Almaden Blvd, Suite 700. San Jose, CA 95110).

Fig-Screen shot of ANATOMAGE (INVIVO5) software for calculating volume of voids

METHODS OF COLLECTION OF DATA:

The crown of each tooth will be access opened with a diamond bur (KERR, size-012, length-1.2,MFG REF.-801) and the access to the pulp chamber obtained; the potency of the apex will be verified with a stainless steel size 10 K-file (DENTSPLY). Working length determination will be performed by inserting the file until the tip of the instrument will be visible at the foramen confirmed by radiograph (Kodak) and then shortening this length by 0.5 mm.Canals will be mechanically instrumented with rotary files/Hand files. While rotating, the files will be maintained at the working length for only 2-3 seconds. We will follow the Crown Down technique for Bio-mechanical preparation.

Hand-SC and ROT-SC- A paper point will be used to smear the canal walls with AH-Plus Sealer. The apical portion of a single gutta-percha master point corresponding to the final hand/Rotary file will be coated with the sealer; the gutta-percha master point F1 (DENTSPLY) will be inserted into the canal to the working length. A radiograph will be taken to check the proper canal filling; the coronal excess of gutta-percha and sealer will be removed by cutting the point at orifice level with a hot instrument.Orifice will be sealed with Glass Inomer cement.

Hand-TH and ROT-TH - Obturation will be of vertical condensation with obturation pen (DENJOY DENTAL CO LTD).A paper point will be used to smear the canal walls with AH-Plus Sealer. The apical portion of a single gutta-percha master point corresponding to the final hand/Rotary file will be coated with the sealer; the gutta-percha master point F1 (DENTSPLY) will be inserted into the canal to the working length.

- Heat tips should be 4-5 mm far from apex point of root canal
- Heat tips should be fixed with white slide caliper provided after determining the length of root canal.
- Root canal perforation should be avoided when heating.

Thermoplasticized pallets will be loaded in the obturation gun and tip will be inserted inside the orifice.Slowly tip will be removed while pressing the gun so that melted guttapercha will flow in the canal. Obturation pen will be used to compress the Thermoplasticized guttapercha.Orifice will be sealed with Glass Inomer cement.

CBCT analysis of the samples

A custom designed sample holder will be made to optimize the scanning procedure to obtain valid data for the subsequent reconstruction procedure. The samples will be scanned using a CBCT. CBCT analysis will obtain the volume of the internal voids distributed inside the filling material(s-voids), the external voids along the canal walls (i-voids).Region of interest will be established for void volume.The percentages of root canal filling materials and voids would be also obtained. For each slice, regions of interest (ROI) would be chosen to each contain one single object entirely to allow the calculation of the void volume. After scanning procedure, the samples would be re-placed in the saline solution.

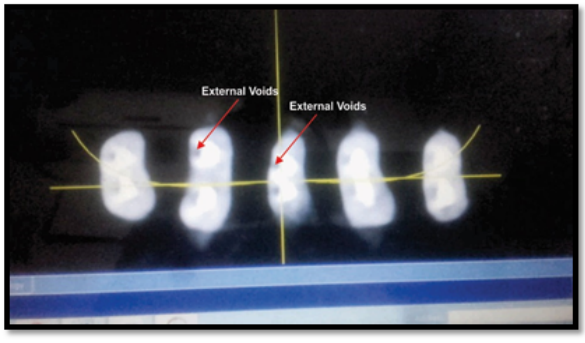

Fig-16 Screen shot of Axial view from above after CBCT

FIG-5 SCREEN SHOT OF VOIDS IN TANGENTIAL VIEW AFTER CBCT

The data collected will be statistically analysed by using SPSS software version 19.0(statistical package for social science) Chicago Inc.The test applied will be one way ANNOVA and Independent t-test.

RESULT

The statistical analysis of the all four groups evaluating the volume of voids in the Hand-SC, Hand-TH, ROT-SC and ROT–TH shows that none of the groups were free from the voids. Volume of voids was less in group instrumented with Hand system that is Hand-SC and Hand-TH (126mm^3, 123mm^{3}respectively) as compared to rotary system that is ROT-SC and ROT-TH (219mm^3, 200mm^3 respectively).

COMPARISION OF FOUR GROUP

Table-1Showing comparison of volume of voids in all four groups with Mean, Standard Deviation, Standard Error and P Value.

Groups	N	Mean	Std. Deviation	Std. Error	F value	P value	Significance
Gp-1/ Hand-SC	10	12.600	5.834	1.845	1.020	0.390	Non-Significant(NS)
Gp-2/ Hand-TH	10	12.300	6.700	2.118			
Gp-3/ ROT-SC	10	21.900	16.332	5.164			
Gp-4/ ROT-TH	10	20.000	24.957	7.892			

P≤0.05 significant using One Way ANOVA

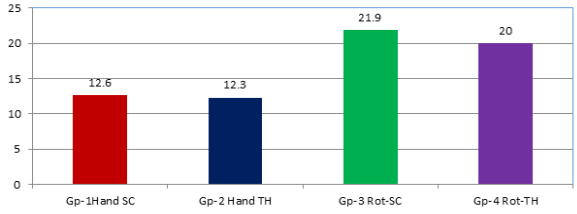

Chart-1 Showing comparisons of total volume of voids in all four groups.

The mean, standard deviation, standard error of the volume of voids in the group, which was instrumented with hand file, was evaluated in table 4 which shows the P value non-significant (NS).There was statistically no significant difference in voids volume when hand instrumented canals was obturated with either single cone obturation technique (Hand-SC) or thermoplasticized obturation(Hand-TH) technique.[P value=0.906, p value>0.05,(**NS**)]

Discussion

In our investigation, CBCT analysis was done and volume calculating software was effectively applied.A comprehensive assessment provided two types of voids within the root canal obturation after the most commonly used endodontic techniques. Our results also showed good sealing ability of techniques frequently used in daily endodontics in-vitro study, although none of the instrumentation/obturation combinations evaluated resulted in void-free root canal fillings. This outcome is consistent with the observations of other authors.[14,15,16]

We found that the groups of obturated canals differed significantly in terms of the total volume of voids in favour of hand instrumentation and the Thermoplasticized (TH) obturation techniques. After single cone condensation, more external voids (i-voids) with a high percentage of volume were noticed. I-voids may be in contact with potentially infected canal walls and may promote micro- leakage and, ultimately, the clinical failure of root canal treatment. Keçeci et al.[16]in a stereomicroscopic examination, showed no significant relationship between the preparation and obturation techniques in terms of the distribution of filling material or voids. However, sectioning does not provide volume information, and thus better precision can be expected from a CBCT-based assessment of voids.

Several authors Peters et al[17], Gandofil et al[18], İriboz et al[19],Shemesh et al[20] have claimed that NiTi instruments have markedly improved the quality of root canal shaping compared with their stainless steel counterparts, because they produce a well-tapered root canal form suitable for obturation. However, they still produce micro-defects and irregularities on the dentine surface which may remain unfilled. The popular system ProTaper File instrument is designed to U-file, with cutting edges that help keep the instrument in the center of the canal[21]. Several studies like Chole et al[4] have shown that Ni-Ti instruments demonstrated less canal transportation than stainless steel files. On the other hand, the traditional hand biomechanical instrumentation technique resulted in less untouched surface areas than in the case of rotary files; this may be related to the use of hand files in a circumferential filing motion and an anti-curvature direction of filing[22].In this study, we demonstrated that in canals which were Hand instrumented, the volume of voids of the canal filling were observed less, but that after using the Rotary system, external voids (I-voids) were significantly larger with both filling methods. This result can be partially explained by the findings of less untouched surface areas of the canal walls after hand instrumentation compared with the rotary technique. Which lead to a smaller average volume of external voids.[22]

Several studies like that of Natera et al[23], Shivana et al[24]have confirmed that warmed guttapercha is more adaptable to the irregularities in the canal walls, enabling better sealing than with traditional lateral condensation. However, it has been suggested that using the Thermoplasticized(TH) method might have a negative effect on the apical seal, at least initially, when the gutta-percha cools.[25] It has been found that the combination of sealer contraction and air entrapment during Thermoplasticized (TH) compaction promotes apical void formation[26]. Our findings are consistent with these. We observed that i-voids were particularly common in the apical third of the canal with Thermoplasticized (TH) compaction.

Our results indicate that Thermoplasticized (TH) compaction of guttapercha resulted in less amount of volume of the voids as the external i-voids and very few, almost insignificant s-voids. In SC condensation s-voids were also insignificant but i-voids were more as compared to TH-condensation. Moreover, these voids were more compact than those formed after SC condensation. It may be due to their small size and volume that they were not noticeable on conventional and digital radiography or even on spiral tomography[27]. Internal voids(s-voids) were very insignificant which may be explained by, "*The minimal size of voids which could be detected using CBCT was directly related to the voxel size of the CBCT images; voids that occupied only a few voxels could not be distinguished from the background due to the partial volume effect"*.Our study is also similar to that done by Nabeshima et al[28] who reported that Thermoplasticized (TH) compaction produced an obturation with greater density than conventional SC condensation in-vitro.AndRobberecht et al [29]also commented the same thing but included that root canal morphology influences guttapercha adjustment. On the contrary, Keçeci et al[16] reported that SC condensation had a similar formation of voids in comparison with the other obturation technique used**.** Daniel et al [30]through Micro-tomography studied that single cone technique was more effective in narrow round canals. Kaur et al[10]also showed that external voids were found to be more common in single cone technique than lateral condensation.Suleiman et al[31]showed that in the coronal two third of root canal, single matched cone technique showed inferior density of root canal filling which can be improved by accessory cones guttapercha in wide canal.Celiketen et al[32]in 2015 concluded that void volumes were highest for single cone technique as compared to Thermafil. Above all study was in favour of our result which shows that single cone has the highest amount of voids volume. But in 2016 Ellakany et al[33] using CBCT in his study found that apically single cone produced less volume of voids than from other part of canal.

With regard to SC condensation, the final filling is composed of only one gutta-percha cones tightly pressed against dentine wall but still remaining space filled with sealer, so canal filling is less homogeneous than after application of the heated guttapercha technique[34]. According to Kierklo et al[5] and Peng et al[35], Its poorer adaptation to the canal wall can be the result of poor canal preparation, inadequate pressure during condensation or a mismatch between the gutta-percha cones and the prepared root canal dentine. This could explain the fact that, in our study, a lot of unfilled spaces were identified mainly as the voids formed between the material and the canal wall. External voids (i-voids) occupied the largest percentage of the total canal filling volume, but very few (insignificant) s-voids were also found mostly in middle and coronal third. With SC condensation, only the apical third was found to be homogenous, and CBCT revealed the presence of voids in the middle and coronal thirds. It may be due to the fact that only one cone was used in apical third which was snugly fit with remaining space used by sealer.Our results show that CBCT is a tool providing an insight into the quality of root canal filling. Indeed, using CBCT, quantitative assessment of canal filling volume can be performed without destruction of the teeth[36]. Although a high correlation between CBCT images and histological cross-sections of root canal fillings has been reported[37,38].As with other methods, CBCT has several limitations which are to be considered before drawing conclusions from the data. Firstly, in this study, the minimal size of voids which could be detected using CBCT was directly related to the "voxel" size of the CBCT images; voids that occupied only a few voxels could not be distinguished from the background due to the partial volume effect.[39] The sensitivity of CBCT to the detection of voids is also limited by other factors, with beam hardening probably the most significant.[40,41]Other artifacts areBeam hardening, Cupping artifact, Extinction or

missing value artifact. Beam hardening artifacts are especially intrusive for their marked differences in contrast to the materials present in the field of view, with a seriously deteriorated image quality disabling the reliable detection of voids.[36] In order to suppress these artifacts, we chose filling materials that would minimize the difference between the radiopacities of gutta-percha, sealer and dentine. Note that, for polychromatic X-ray beams, the problem of beam hardening cannot be fully addressed even if dedicated filters are used. Results obtained by CBCT can be underestimated as a consequence of the dehydration and possible dimensional changes that accompany the prolonged scanning and reconstruction time [42]. To minimize these adverse effects, we kept the roots in a water environment except for during scanning.

CONCLUSION

- None of the above techniques were free from voids.
- Among the collected data Hand instrumented Canal was having less amount of volume of voids than Rotary instrumented.
- Single cone obturation technique was having highest amount of volume of voids than Thermoplasticized technique.

From our result we can conclude that hand instrumented canal obturated with Thermoplasticized technique was having less amount of volume of voids(123mm^3) than Rotary instrumented and obturated with single cone technique(219mm^3).Despite this, the results suggest that all the studied techniques of instrumentation and obturation of the root canal are acceptable and effective in clinical practice and more research is required in this field to find the best method.

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