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CONE BEAM COMPUTED TOMOGRAPHIC EVALUATION OF ROOT CANAL OBTURATION: AN IN VITRO STUDY

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ABSTRACT:

Introduction: To volumetrically evaluate and compare 3 endodontic obturation techniques: Cold Lateral compaction, Single cone technique and Thermoplasticized gutta-percha technique by using Cone Beam Computed Tomography.

Materials and Methods: Sixty intact, extracted mandibular Premolars with single canal were selected. Biomechanical preparation was done with WaveOne Gold NiTi rotary file system. The samples were randomly divided into 3 groups (n=20) according to the obturation technique– Group A - Lateral Compaction, Group B- Single Cone technique and Group C-Thermoplasticized gutta- percha technique using Calamus. The volume percentage of obturated area were measured using Cone beam computed tomography before and after obturation at 4 levels- the entire canal space and at the coronal, middle and apical 3rd of the root canals. Statistical analysis was done with Kruskal-Wallis analysis and Friedman tests.

Results: Comparing the 3 groups, the highest overall percentage of filling material was observed in the Group C (94.5%) thermoplastic guttapercha obturation than that of Group A - Cold lateral compaction (83.2%) and Group B Single cone obturation (81.5%). At the apical, middle and coronal 3rd of the canals, the thermoplastic guttapercha obturation group showed highest volume percentage of filling material. The results were statistically significant.

Conclusion: The maximum volume of obturating material with minimum voids was observed in the Thermoplasticized gutta-percha technique followed by Cold lateral compaction and single cone technique.

Keywords: 3D obturation, Hermetic seal, Cold lateral compaction, Single cone technique, Thermoplastized Guttapercha, Guttaflow 2, WaveOne Gold, CBCT.

iNTRODUCTION

One of the keys to successful endodontic treatment is to obturate the entire root canal system and all its complex anatomic pathways completely and densely with non-irritating hermetic sealing agents.[1] Total obliteration of the canal space and perfect sealing of the apical foramen at the cementum-dentin junction and the lateral canals with an inert, dimensionally stable and biologically compatible material are the goals for consistently successful endodontic treatment.[2]

As stated by the classic Washington study, nearly 60% of endodontic failures were apparently caused by incomplete obturation of the canal space.[3] Unless a dense, well-adapted root canal filling is achieved, the prognosis may be jeopardized regardless of how well other phases of the treatment are carried out.

Although cement sealers enhance the sealing ability of the root canal filling, serious effort should be made to maximize the volume of the core material and minimize the amount of sealer between the inert core and the dentinal

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wall.[4] An excellently compacted and tightly adapted endodontic filling should result in the complete closure of the dentinal wall-core material interface, achieving the best apical seal.[5]

Previous studies in this field qualitatively measured the percentage of surface areas of filling material and voids by analysis of sectioned roots and by using digital imaging software.[6] These methods allow only two dimensional analysis and chances of filling material loss and smearing of filling on the sectioned surface might also occur which may give inaccurate measurements of small voids area. Cone beam computed tomography (CBCT) had been used in the present study is a quantitative and non-invasive method, that aids in 3D reconstruction and visualization of the anatomical variation of the teeth and canal ramifications.[7,29]

Hence the aim of this in vitro study was to volumetrically evaluate and compare 3 obturation techniques: Cold Lateral compaction, Single cone technique and Thermoplasticized gutta- percha technique by using Cone Beam Computed Tomography.

MATERIALS AND METHODS:

In this study 60 extracted human single-rooted mandibular premolars, were selected and stored in 0.1% thymol. Teeth with curved roots, fractures, cracks, caries or any other defects were excluded from the study (Fig 1). Access cavity preparation was done using EX 41 bur, canal was located with 10K file (MANI). After working length determination the biomechanical preparation of the root canals were done using WaveOne Gold NiTi rotary files. Coltene Canal Pro 2 Endomotor was used to activate the instrument in a reciprocating motion. A brushing action was combined with a gentle apical pressure against the lateral walls. Irrigation was done by 5 mL of 2.5% NaOCl followed by 5 mL of 17% EDTA solution. Final irrigation was done with 5mL of a 2.5% NaOCl solution. The canals were dried with sterile paper points.

Once the canal preparation was completed, all the 60 samples, were subjected to a pre- obturation CBCT evaluation (NEWTOM cone beam 3D imaging system) to measure the volume percentage of the prepared canal space with a field of view (FOV) of 100mm x H 80mm. The volumes of interest were then reconstructed with an isometric voxel size of 0.260 mm. The tube voltage was kept at 90kVp and 8 mA and the exposure time was 9.4 seconds.

The average height of the canal space(h) was measured from orifice to the root tip in the coronal and sagittal CBCT slices. The D1 and D2 were the diagonals of the prepared canal space measured in the axial section.The area of the canal space was then calculated using the formula,

Area of the canal space

$$= \left\{ \frac{\text{Length of diagonal } D_1 \times D_2}{2} \right\}$$

The volume of the prepared canal space

(R) was measured using diagonals method.

R= Area of canal space x Height of the canal

Teeth were then randomly divided into three experimental groups according to the obturation technique. (Fig 3)

GROUP A- COLD LATERAL COMPACTION: Cold lateral compaction was done by a master gutta-percha cone of size 35 and accessory gutta-percha points of size 20 and 15 with Guttaflow-2 sealer using finger spreaders. The excess coronal gutta-percha was removed by a heated instrument and condensed with a cold plugger.

GROUP B – SINGLE CONE TECHNIQUE: A master cone of 35 size and taper 6% corresponding to the master apical file was selected and checked for tug- back upto the working length. The single cone was coated with Guttaflow-2 sealer and placed inside the canal till the working length and the excess coronal GP was sheared off by a heated instrument and condensed with a cold plugger.

GROUP C- THERMOPLASTICIZED GUTTAPERCHA TECHNIQUE: (CALAMUS)

A 35 size GP cone with 2% taper was coated with the Guttaflow sealer and placed in the canal up to the working length. A medium-sized Calamus System - B insert tip which bound in the canal 3 mm short of working length was used at a temperature of 200°C and pressed against the cone so that the remaining cone in the canal was 3 mm and condensed using a plugger. The 23-gauge cartridge’s needle tip was placed next to the master point to a depth without binding or forcing to the canal wall. The backfill was achieved by setting the temperature to 180°C and pressing the trigger so that the molten GP flowed from the tip and was withdrawn slowly out of the canal. The GP at the CEJ was compacted using a cold plugger.

The canal access of all the teeth was restored with Cavit-G (3M Espe, Germany), and the teeth were stored under 100% humidity at 37°C and subjected to a post- obturation CBCT. Using the DiaCom 3D App software, the volume percentage of the obturated area in each tooth sample at overall and coronal, middle and apical third of the root canal were calculated. (Fig 4:a,b,c)

• At each levels the volume of filling materials was calculated using the formula

$$d1 \times d2 \times h$$

where d1 and d2 were the obturation material diagonals measured in the axial section, h - the height measured in coronal section. The volume percentage of the obturated area in the 3 groups were calculated using formula:

$$(\text{Volume of filling} / \text{Total volume of prepared canal space}) \times 100.$$

• The specimen where void was seen, the inner area of the void was calculated using the linear measurements obtained using the Galileos viewer software and this value was multiplied by the slice thickness in order to calculate the Volume of the Void (V). The Volume Percentage of the voids in the obturated root canal was calculated by using the formula,

(R-V) ×100/R

where, R is the volume of the root canal space and V is the volume of the void space

STATISTICAL ANALYSIS:

Statistical analysis was performed with nonparametric tests Kruskal-Wallis and Friedman tests for intergroup comparisons. The software used was SPSS Version 20.0 (IBM Corp., Armonk, US). The level of significance was set at $p < 0.05$.

RESULTS:

i)Volume Percentage of The Obturated Material

The values of the volume percentage of the obturated material (VP) at different levels of root canals are summarized in Table 2. On overall comparison, the highest percentage of filling material in the apical third and the whole length of the root canal was observed in the thermoplasticized GP group which was statistically significant in comparison to group A and B (P<0.05)., Group C and Group B techniques showed the highest (94.5%) and the lowest (81.5%) percentage of GP, respectively and was statistically significant.

Group A, Cold lateral compaction technique showed greater overall volume percentage than Group B and lesser value than that of Group C. In the coronal 3rd group A (81.2%) showed lesser volume percentage than both Group B and C. in the middle and apical 3rd Group A greater volume percentage than Group B and lesser value than Group C.

Group B, the Single Cone technique showed the lowest volume percentage of GP (81.5%) in comparison with other two groups. In the coronal third, Group B showed greater volume of GP than Group A and lesser value than Group C. In the middle and the apical 3rd Group B showed the lowest (80.5%) values of volume percentage than group A and C.

Group C, the thermoplasticized GP technique, showed the highest overall volume percentage(94.5%) than the other two groups. The coronal, middle and the apical 3rd of group C also showed highest values (91.8 %, 94.7%, 96.9% respectively) among all the other two groups.

II) Volume Percentage of the voids

The highest Void volume percentage (5.01%) was detected in single cone technique (Group B) and the lowest (2.73%) was observed in (Group C). Group C showed lowest voids % at all 3 levels, Group B showed highest void % at middle 3rd and Group A showed highest void % at apical 3rd and the results were statistically significant.

Since the p - value is between 0.010-0.050 there is significant difference between the methods/materials used for condensation. Hence, we reject the null hypothesis at 5% level. Based on the mean rank, Thermoplastic GP technique was better than the other two methods.

DISCUSSION:

The success of endodontic treatment can be attributed to the triad of Biomechanical preparation along with chemical irrigation and a three-dimensional obturation of the root canal system providing a tight seal[8]. According to Ingle and Dow, this hermeticity of the root canal filling plays a key role in preventing the bacterial penetration and their products into the peri radicular tissues and also create a favourable biological environment for peri-apical healing.[3,25]

Of all the techniques to study the root canal anatomy, an ideal one should be not only accurate, simple, non-destructive, but also and most importantly, feasible and reproducible even in an in-vivo clinical scenario[7,8]. In an ex-vivo scenario, Cone Beam Computed Tomography techniques (CBCT) provides a detailed quantitative and qualitative measurements of root canal anatomy and has gained popularity because of its accuracy, high-resolution.[25] Henceforth in this in vitro study, CBCT was used to evaluate the homogeneity of different obturation techniques.

Greater the taper of the root canal, greater the efficiency of irrigant flow, resulting in more efficient replacement and debridement in the apical part of the root canal and subsequently better obturation, which could be an advantage of WaveOne Gold systems.[10] WaveOne GOLD single- file reciprocating system is manufactured utilising a new proprietary thermal process which provides superelasticity and also gives the file its distinctive gold finish. This heat treatment considerably improves its strength and flexibility. There are four tip sizes in the WaveOne GOLD instruments: Small (20.07, yellow), Primary (25.07, red), Medium (35.06, green) and Large (45.05, white). In this study, the mandibular premolars were enlarged with Medium (35, 0.06) size files. The reciprocation file movement is a cutting cycle of 120° and therefore after three cycles the file made a reverse rotation of 360° inside the canal.[14]

Root canal sealer aids in apical sealing by binding the master cone into a canal, fills the intricacies between the cones and canal space, as a filler for lateral canals and as a lubricant to enable the placement of the gutta-percha.[12] In this study Gutta flow 2, a silicon-based sealer was used for its rheologic properties. GuttaFlow sealer has the property of slight expansion after mixing due to the incorporation of gutta-percha particles and helps in better sealing. It also provides natural repair compounds, such as calcium and silicates that forms hydroxyapatite crystals when it comes into contact with fluids and improves the adhesion of sealer with guttapercha.[15]

Cold lateral condensation being the gold standard method of filling root canals with the advantages of predictability, ease to perform, controlled placement of guttapercha. But the final filling in CLC had the appearance of numerous GP cones tightly adhered by frictional grip and the sealer, while the spreader tracts could be devoid of sealer or the sealer can resorb later resulting in voids[16]. In accordance with this concept, our study also showed that there were multiple voids between the accessory cones in CLC group. However, voids noted may be attributed to improper preparation and spreader selection. When evaluated 3 dimensionally, they showed lesser adaptation to canal walls lacked homogeneity of gutta-percha mass.[17]

Although Single cone technique is the most common clinical method of obturation in recent years, very limited studies which have compared the quality of this obturation. In this study voids seen at the middle third of root canals in single-cone obturation can be attributed to the root canal anatomy of mandibular premolar where the single cone has failed to fill the canal space completely[19]. A single-cone obturation technique matching the master file taper may be more effective in narrow round canals. The single cone technique seems simple but its application must be limited to round canals that have taken a precise shape given by the instrumentation procedure.[22]

This study revealed that 3D obturation was the best with the thermoplasticized GP technique as compared to Single cone and Cold lateral condensation. Previous studies reported overextension of GP as a drawback of thermoplasticized GP technique and therefore it was used as a backfill to obtain controlled placement in the present study.[28] Best results with the thermoplasticized GP technique could be attributed to the maximum inert core material, a superior flow properties, phase transformation and lesser sealer.[27] When heated, it changes to α - phase and becomes pliable and therefore it is made to flow. When α phase gutta-percha cools normally, it crystallizes to the β - form with a slight shrinkage.[17] Hence the voids seen with thermoplasticized GP technique were found to be internal voids probably created by air entrapment during the backfill and are not in communication with the canal walls.[28]

The internal voids provide an unfavourable environment for the bacteria that remain in the root canal system and hence its prevalence is less relevant from a clinical point of view.[24] But the external voids are caused due to unsuccessful adaptation of the filling materials due to air entrapment between the obturating materials and the root dentin. When such voids are present, the potential risk for microleakage is likely to be increase and can have a negative influence in the endodontic prognosis.[23,26]

The present study demonstrated that the thermoplasticized GP technique of obturation using Calamus showed greater volume percentage of complete 3D fillings and resulted in the fewest voids. The technique was fast and user-friendly. In addition to the in vitro studies, clinical studies evaluating the quality of different endodontic obturation systems would be beneficial.

CONCLUSION:

Within the limitations of the present *in vitro* study, it is concluded that none of the root canal filled teeth were gap-free. Thermoplasticized GP technique had the highest volume percentage of obturation materials with minimal voids followed by Cold Lateral Compaction and Single Cone obturation, respectively. Thermoplasticized GP technique may be a good alternative for perfect quality of 3D Obturation and it is a promising technique to achieve the good hermetic seal in endodontically treated teeth.

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FIGURE:

FIGURE :1 Sample selection

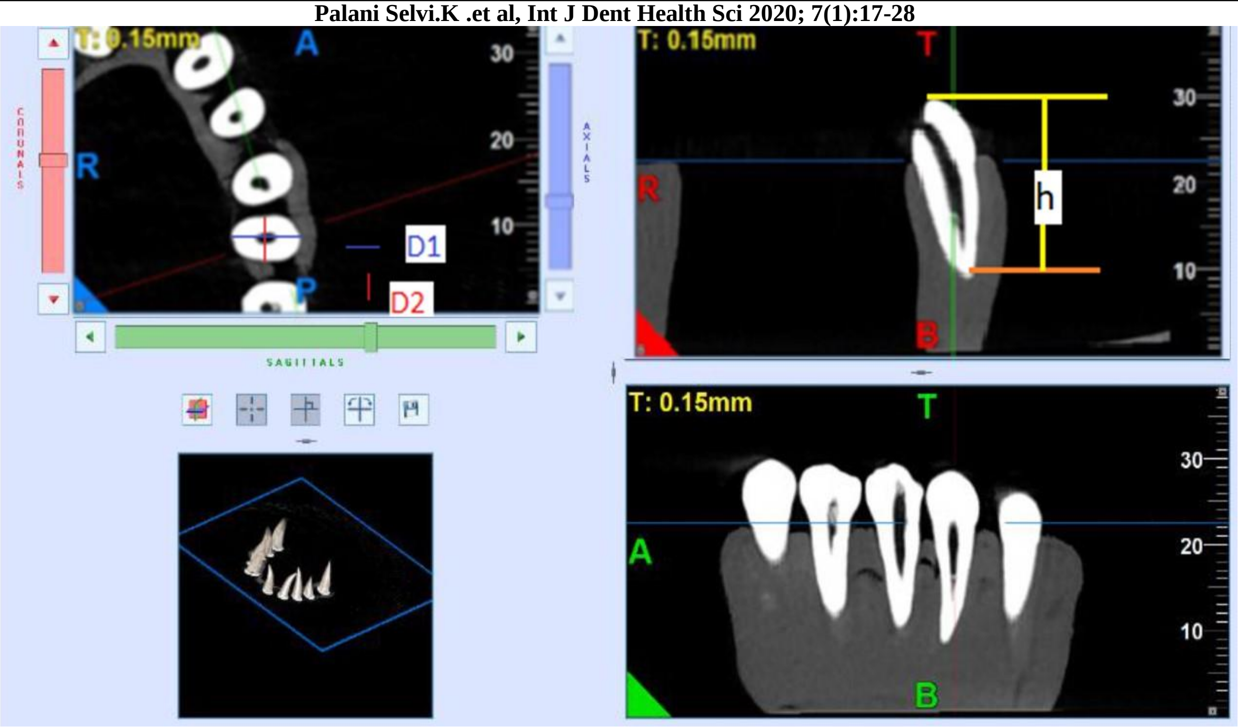

FIGURE:2 PRE OBTURATION CBCT

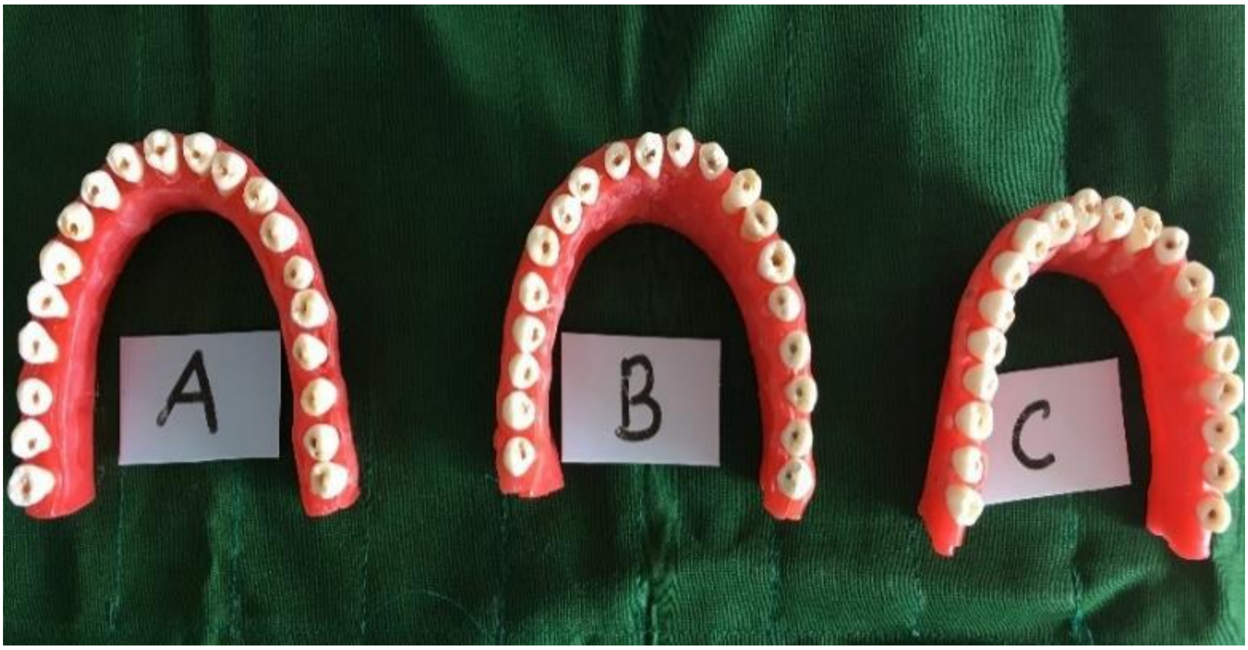

FIGURE: 3 RANDOMIZATION

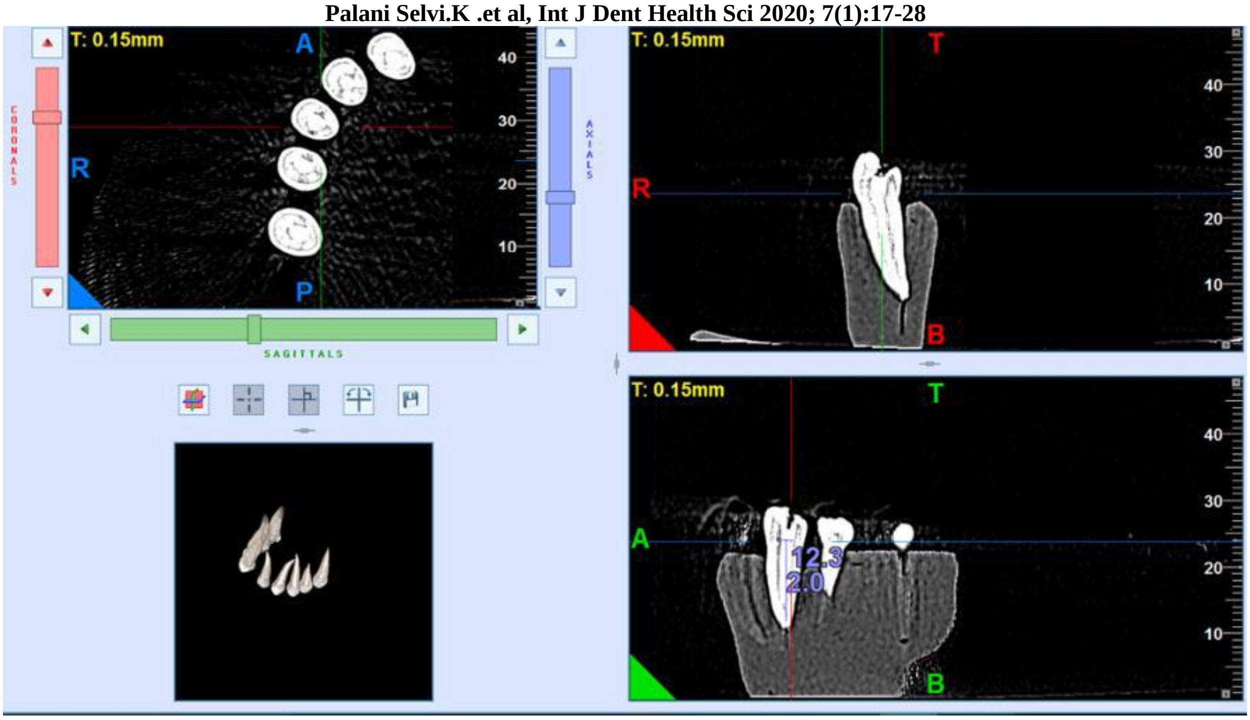

FIGURE: 4 POST-OBTURATION CBCT

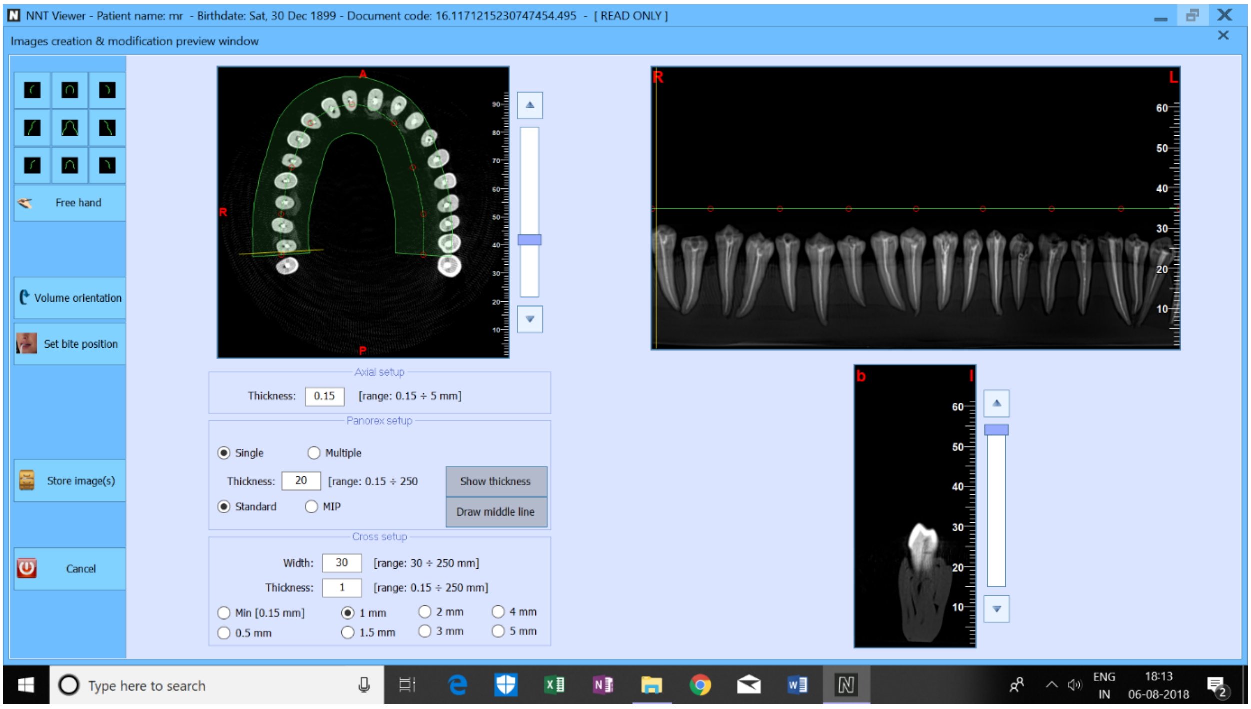

FIGURE: 4 (a): POST-OBTURATION CBCT GROUP A (*Cold Lateral Method)*

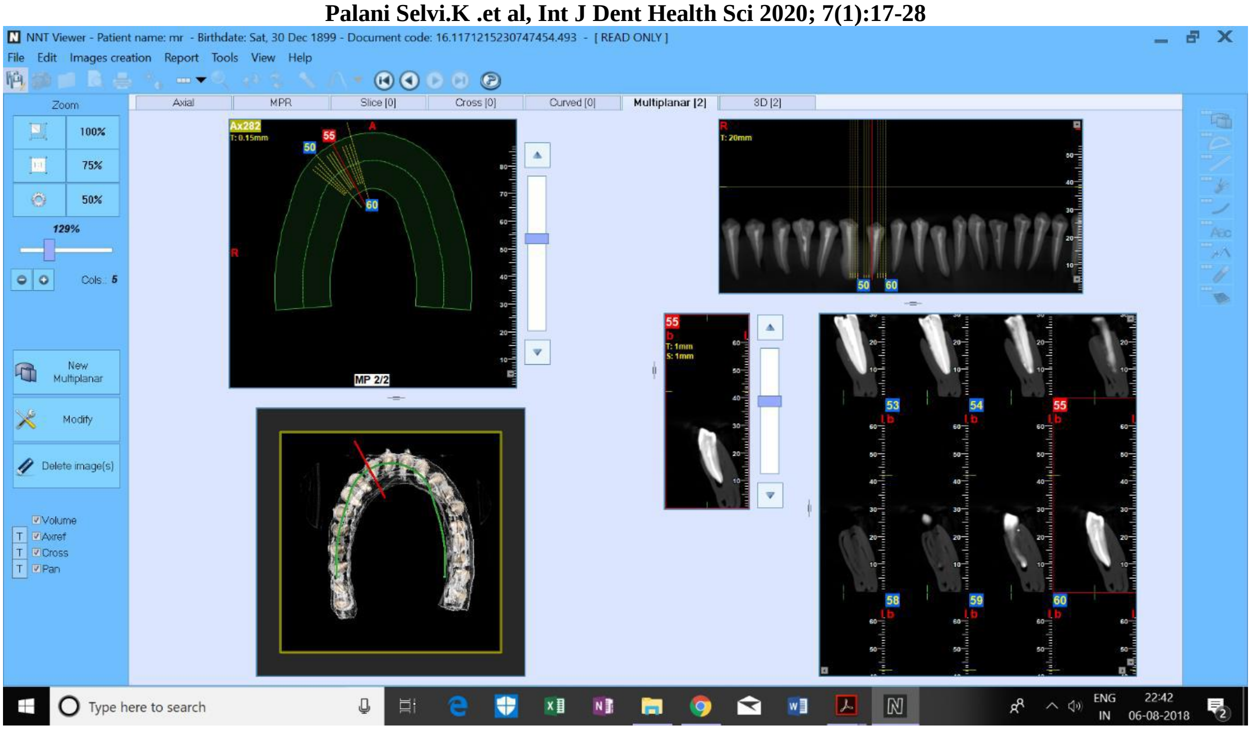

FIGURE: 4 (b): POST-OBTURATION CBCT GROUP B (*Single cone method)*

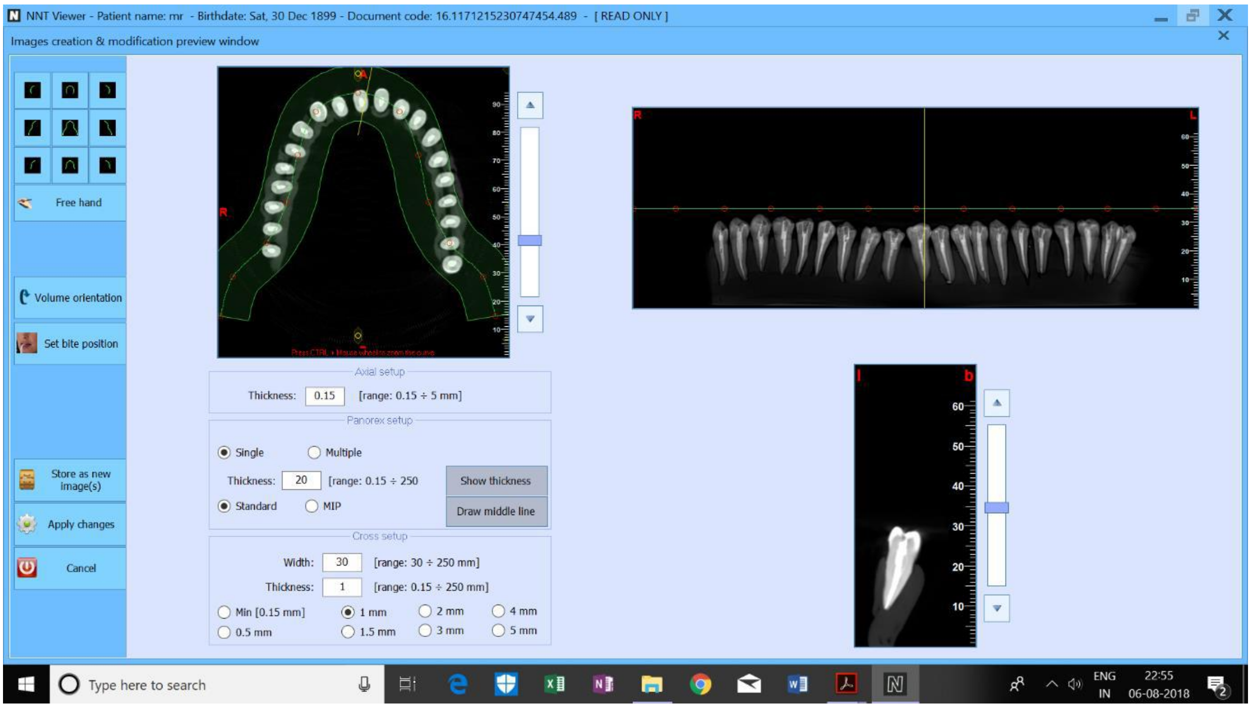

FIGURE: 4 (c) POST-OBTURATION CBCT GROUP C (*Thermoplasticized Guttapercha Method)*