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Comparative Study in J.Morita Accuitomo 170 Quality Settings on the Ability to Detect MB2 in Maxillary First and Second Molars

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ABSTRACT

In endodontics better outcomes are associated with cleaning and shaping all the instrumentable root canal space. The prevalence of second mesial-buccal (MB2) canals has been reported to be above 90 percent. In order to adequately treat the complex canal spaces, detection and identification is crucial. Digital imaging advancements including cone beam computed tomography (CBCT) have allowed greater identification of complex canal morphology. The aim of this study was to determine if the CBCT quality settings (standard, high resolution mode, high fidelity mode, high speed mode) on the J.Morita Accuitomo 170 would affect the ability to identify and locate MB2 canals. Fourteen extracted maxillary first and second molars were decoronated, mounted in putty and scanned using each of the quality settings. Measurements were obtained for x and y coordinates of the MB2 instrumentable space and compared to the gold standard of direct visualization under the operating microscope. An analysis of variance (ANOVA) was performed as well as mean difference. Significance was declared at $P < 0.05$ for all statistical tests. The one-way ANOVA test did not detect significant differences in the x axis, y axis coordinates or in total. No differences were noted in the scanning modality for either coordinate accuracy or precision ($p > 0.05$). Considering there was no superior quality setting, the principle of "as low as reasonably achievable" should be practiced to obtain imaging that will allow location and complete debridement of all canal spaces with minimal radiation to the patient.

INTRODUCTION

Maxillary first molars have four canals approximately 95 percent according to Kulild and Peters (6). Wolcott et al., states that there is a significant difference comparing initial treatment and retreatments in maxillary first and second molars regarding incidence of MB2 canals (12). It has been shown that during initial treatment of maxillary first molars MB2 prevalence was 58 percent and retreatment 66 percent (12). This trend of more MB2 prevalence in retreatments is also shown through maxillary second molars as the prevalence of MB2 being 34 percent for initial treatment and 40 percent for retreatment (12). The goal of root canal therapy is to thoroughly disinfect root canal systems and to seal them to prevent re-infection (13,10). The higher incidence of MB2 canals addressed in retreatments eludes to unidentified and uninstrumented space in primary treatment contributing to the need for secondary treatment. Without accurate identification and treatment of the root canal system in its entirety, treatment prognosis greatly decreases. Identification of the canal space is increased with more advanced three dimensional imaging modalities.

To aid in detection of the root canal space in its entirety, cone beam computed tomography (CBCT) is a tool that is a non-invasive way to visualize a three dimensional image that otherwise can only be visualized by two dimensions via peri-apical radiographs. Feldkamp et al. in 1984 developed the original cone-beam algorithm (11). In the late 1990s some of the first countries to utilize CBCT scanners for the oral and maxillofacial region were Japan and Italy(11). There has been a steady rise and exponential growth in development and use of the technology since its initial implementation. CBCT has become widely used and accepted as a diagnostic tool in endodontics. In May 2016, an updated American Association of Endodontics and American Academy of Oral and Maxillofacial Radiology joint position statement was released outlining the indications and guidelines for CBCT with endodontic treatment (1). This position statement outlines that a limited field of view (FOV) CBCT can be taken when additional canals or complex morphology is suspected (1). Maxillary molars indicated for endodontic treatment with suspected complex morphology, would thus fall into the category which a CBCT image is acceptable. When using CBCT imaging for detection, the prevalence of MB2 canals is 85.4 percent stated by Zhang et al, (13).

Martin et al., states that the “aim in balancing radiation dose and image quality is to provide an image which is adequate for the clinical task with the minimum radiation dose to the patient”(7). Loubele et al., states that the lower the radiation dose results in increased noise in an image and that high contrast resolution performs better for bony detail (7). There is a need to find the balance where the most detailed, clinically relevant, CBCT image can be captured while maintaining the as low as reasonably achievable radiation dosage. Mettler et al., states that 1 millisievert (mSv) is the dose produced by the exposure to 1 milligray (mGy) of radiation (8). Nagashima et al., states that the critical radiation exposure to create mutation induction is between 0.1 gray (Gy) and 0.2 Gy (9). There was a statistically significant difference in mutation frequency comparing induced doses of radiation at non significant levels of 0.1 Gy and significant levels of 0.15 Gy (5). It is also important to note the average amount of background radiation that occurs naturally is 3 mSv per year (5). The amount of medically induced radiation exposure has increased from 15 percent in the 1980s to 50 percent in 2018 (5). Due to increased medical radiation exposure, it is crucial to ensure imaging modalities are necessary and beneficial to the proposed treatment.

The aim of this study was to determine if the CBCT quality settings (standard, high resolution mode, high fidelity mode, high speed mode) on the J.Morita Accuitomo 170 would affect the ability to identify and locate MB2 canals when compared to direct visualization. This will aid in determining capture settings to get results with lowest patient radiation dosage. The null hypothesis for this study was that there is no difference in the quality settings on the ability to identify and locate MB2 canals in maxillary first and second molars when compared to direct visualization.

METHODS AND MATERIALS

Tooth Selection and Preparation

Fourteen de-identified extracted maxillary first and second molars were acquired at the dental treatment facility. The teeth had been acquired over a period of the past year for educational purposes. Each tooth was noted to have been sterilized at the time of extraction and stored in 10% Neutral Buffered Formalin. At the time of use in the present study, 14 teeth with minimal restorations and no previous endodontic treatment were selected. These teeth were then mounted in Biocryl ICE acrylic blocks and decoronated at the level of the CEJ an axial cut direction using an IsoMet low speed saw. The acrylic blocks were then surrounded by VP Mix Putty and placed in a small plastic cup for containment. A mounting jig using the J. Morita Phantom Kit was created using the VP Mix Putty (figure 1). The plastic cups were fit exactly into the custom created jig to not allow movement during the rotation as a part of the scanning process.

Scanning

Each of the 14 samples were randomly numbered and subjected to limited FOV CBCT scans using the J.Morita Accuitomo 170 CBCT machine (table 4). Each tooth sample was subjected to an 80x80mm Scout Image Scan, and a 40x40 mm scan using the following settings: Standard, High Resolution Mode, High Fidelity Mode and High Speed Mode. The standard mode was 17.5 seconds, 180 degree scan and 9.0 seconds exposure time. High resolution mode was 30.8 seconds, 180 degree scan and 15.8 second exposure time. High fidelity mode had the same scan parameters of high resolution mode with the density being the differentiation in the fidelity mode. The high speed mode has settings of 10.5 seconds, 180 degree scan and 5.4 second exposure time which reduces motion artifacts. Each tooth underwent a 40x40 mm CBCT, voxel size 0.08 mm, with the respective quality setting based on the category. See table 1 for voltage, current and micro grays exposure. After each scan, the images were saved on the local program digital drive for review.

Data Collection

The time of each sample was recorded on a master tracker as well as on the sample itself. The same user conducted all of the scans for consistency. One consistent reviewer reviewed the scans for each sample. The scans were not identified as to which quality setting was used. The reviewer reviewed each image using i-Dixel software in the same room on the same Dell monitor under consistent lighting conditions. The reviewer was allowed to manipulate and scroll through the image. Once the reviewer had placed the image in their desired location to visualize the MB2 canal, it was then measured using the measuring tool on the system. Measurements were taken for the X position, horizontal location from the buccal surface of the root and the Y position, the vertical position. where the first independent instrumentable space can be detected going in the coronal to apical position from the most coronal tooth structure (table 5). If no MB2 canal space could be visualized on the CBCT, that was recorded. These measurements were recorded and a screenshot of each measurement for each quality setting was taken and stored on the local database (figure 2).

Direct Visualization

The samples were then accessed for direct visualization of the MB2 canal. The samples were accessed by the same operator for consistency with a standard protocol. The teeth were accessed at random using a Global Operating Microscope at 2.0x magnification and Global LED Light Source operating microscope light. Using an Obtura Spartan CPR-2D Diamond ultrasonic tip, a trough was created from the MB canal along the mesial wall of the tooth in a palatal direction. After each troughing, the tooth was irrigated with sterile saline. A combination of 20/06Vortex Blue rotary file and ISO 10 K file were used to locate the canal. The Vortex Blue Rotary was used on a DentSply ProMark Rotary system at 200 RPM, 1000 g-cm, 8:1 gear ratio. Once the canal had been located, the 10 K file with a stopper was used to measure the Y coordinate measurement for the location of the first instrumentable MB2 space in the coronal-apical direction. The coronal tooth structure was used as the origin (same as the CBCT measurement) and the length from the stopper to the end of the 10 K file was measured using an endodontic ruler and measured to the nearest quarter of a millimeter. The X, horizontal measurement was then taken using an endodontic explorer with a stopper from the buccal surface of the tooth to the 10 K file that was placed in the MB2 canal. The measurement was taken from the stopper to the end of the endodontic explorer using an endodontic ruler, measured to the nearest quarter of a millimeter (figure 3). The X and Y measurements were recorded (table 6). If no MB2 canal could be located it was recorded as such. The recorded measurements taken on the CBCT were compared to the clinical measurements to compare accuracy of location. If clinically and/or on the CBCT image no MB2 canal was detected, that was also recorded. The location measurements were compared to determine consistency, with location of canal using the clinical location as the gold standard.

Data Analysis

Exploratory data analyses were conducted on the observed MB2 canal coordinates. The Shapiro-Wilk test was used to assess the normality of the data distribution. Measures of central tendency are provided for continuous data are provided as means with associated standard deviations. An analysis of variance (ANOVA) was performed to compare the vertical and horizontal differences in location between the four groups and the observed MB2 canal location. Additionally, vector length was calculated for each MB2 canal location. Group differences in overall magnitude were assessed using ANOVA. These were also used to compute measures of accuracy and precision. Data were analyzed using SPSS v25 (IBM, Armonk, NY, USA). Statistical significance for all statistical tests was declared at $p < 0.05$.

RESULTS

Of the initial 14 samples, two did not have MB2 canals that were able to be located via scans nor direct visualization. Thus the subsequent analyses were accomplished using the 12 samples for which the MB2 canal could be located. Mean differences between the scans and direct visualization are shown in Table 2. Overall, scans identified the MB2 canal as being -0.13mm horizontally displaced from its directly visualized location as well as 0.30mm higher.

A one-way ANOVA comparing the effect of scan type on MB2 canal coordinates failed to detect significant differences in the x-axis, y-axis, or in total, (all $P>0.05$). Similarly, no differences by scanning modality were found for either coordinate accuracy or precision (both $P>0.05$). Of note however is the consistency between scanning modalities. All scan types identified the MB2 canal as being both higher and to the left of its location found by direct visualization.

To check whether the non-significant results were due to a lack of statistical power, a post-hoc power analyses was conducted using G*power (v3.1.9.2). The observed power to detect a large difference (f=0.43) between the scans was determined to be 0.67. A total of 80 samples would have been required to detect a large difference between scan coordinates at the 0.05 significance level with power set at 0.90. Thus given the limited sample size, we cannot rule out the existence of differences in either precision or accuracy between the scans (table 3).

DISCUSSION

The prevalence of MB2 canals has been reported to be 96.1 (6). The possibility that there may be some additional instrumentable space after primary treatment that harbors residual tissue and bacteria can contribute to primary treatment failure. The initial location of this instrumentable space and adequate chemomechanical debridement of the area is a key to long term treatment success. To adequately provide treatment to the instrumentable spaced within the canal system, identification of those canals is the first step.

A minimally invasive method to identify the canal space and anatomy is ideal. A widely accepted method of obtaining the morphological information is a CBCT. The American Academy of Endodontics and American Academy of Medical Radiologists Joint Position Statement- Use of Cone Beam Computed Tomography in Endodontics- 2015/2016 Update, states that an initial treatment recommendation for use of limited FOV CBCT is for potential for extra canals and suspected complex morphology. The statement further recommends limited FOV CBCT for non-surgical retreatment when evaluating the non-healing of previous endodontic treatment to help determine the need for further treatment (1).

Following the recommendations of AAE/AAOMR obtaining a limited FOV CBCT is indicated for maxillary molars considering the reported prevalence of MB2 instrumentable spaces. The balance of radiation exposure to the patient and desire to have high quality imaging should be balanced. The as low as reasonably achievable (ALARA) principle should be followed. Various CBCT settings can be used which vary in amount of radiation exposure to the patient. The imaging tool used in this study was the J.Morita Accuitomo 170 CBCT machine. This machine has four quality settings, standard, high speed, high fidelity and high resolution which have different settings, that vary the image parameters of mA and time which effects the Grays Exposure (table 1). If the desired image to provide diagnostic quality for the clinician can be obtained with a quality setting that exposes the patient to less radiation that should be used.

Overall in the obtained data, there was no significant difference noted between the samples. The data did show high consistency amongst the scans across the various quality settings. Interestingly comparing the scans to direct visualization the scans identified the MB2 canal 0.30 mm more coronally than were identified with direct visualization. This would be beneficial for the clinician to have this information prior to searching more apical for the MB2 instrumentable space. Comparing the scanning location compared to the direct visualization, the scans noted MB2 canal higher and to the left than it's true location.

The study conducted had limitations, mainly the sample size. Due to the sample size being of 14 teeth it is more suitable as a pilot study for future research. With a sample size of 14 and only 12 samples having an MB2 space, each scanned with the four different quality settings that provided 48 data points. After analysis a sample size of 80 would be necessary to adequately determine a difference in the scanning modalities. A sample size of 80 each scanned with the four quality settings would provide 320 data points to analyze for statistical analysis. Additionally, in experimental design the addition of multiple blinded calibrated reviewers could be beneficial to establish more external validity that would be generalizable practitioner population. That variation in image interpretation would provide increased external validity to account for slight variation which exists in image interpretation amongst clinicians. Variation among clinicians has been shown by a study conducted by Goldman et al., by clinicians viewing periapical radiographs and having and inter observer agreement only approximately 46 percent of the time and shockingly having only an approximately 70% intraobserver agreement when the same images were shown six to eight months later (3,4). In the study it was noted that upper molars resulted in the examiners of the study having the largest percentage of disagreement (3). in the Goldman et al, study theThere also exists treatment changes that occur when viewing PA in addition to CBCT images. A study conducted by Ee et al., showed that when viewing the two imaging modalities the clinicians changes the treatment plan 62 percent of the time (2). Advanced imaging overall can greatly improve and facilitate treatment however it is an adjunct to use not to rely solely on to dictate the treatment.

CONCLUSION

Endodontic treatment can be challenging and wide variations in anatomy add to that challenge. Adequate identification and chemomechanical debridement of these areas is crucial to the long term success of treatment. The MB2 canal may have a wide range of anatomical variations however the instrumentable space is important to negotiate. The treatment that is provided to patients should be the of the highest quality and as a specialty it is our job to address areas of the canal space and problems that have may be missed or overlooked in prior treatments. Often missed anatomy results in patient symptoms and alleviating patients pain with being able to identify and address these canal spaces is of the utmost importance.

Providing this high quality care, with the least amount of radiation exposure to the patient is necessary. Although it cannot be determined through this preliminary study that one CBCT quality setting is superior to the others, it is important for each clinician to acknowledge that variation in scanning settings exists. These variations in settings will result in varying patient radiation dose and subsequent differences in image quality. It should be the discretion of the clinician to choose the imaging that will provide the best diagnostic quality for the procedure while exposing the patient to the least radiation possible.

TABLES AND FIGURES

TABLE 1. Scan Characteristics

Scan Type	Voltage (kVp)	Current (mA)	Grays Exposure (mGy*cm^2)	Time (sec)
Standard	90	7	560	17.5
High Resolution	90	7	985	30.8
High Fidelity	90	7	985	30.8
High Speed	90	8	384	10.5

Abbreviations: kVP = Kilovoltage Peak; mA = milliamp; mGy * cm^2 =milligray*centimeter^2 ; sec = seconds.
The scout image is 80 kVp, 2 mA, 1 sec with 23 mGy*cm^2. (FOV-80x 80mm)

Table 2. Mean Difference from Observed MB2 Location (mm)

Scan Type	n	Δ_x	Std. Deviation	Δ_y	Std. Deviation	Δ_{total}	Std. Deviation
Standard	12	-0.20	0.73	0.25	1.89	1.62	1.17
Hi Speed	12	-0.01	0.54	0.25	1.89	1.42	1.32
Hi Fidelity	12	-0.24	0.54	0.30	1.73	1.37	1.17
Hi Resolution	12	-0.06	0.63	0.42	1.91	1.58	1.24

Table 3. Accuracy and Precision by Scan Type

		Accuracy		Precision	
Scan Type	n	% error	Std. Deviation	Deviation	Std. Deviation
Standard	12	-1.80	17.00	0.23	1.22
Hi Speed	12	1.10	13.90	0.20	1.32
Hi Fidelity	12	-4.00	11.80	0.20	1.29
Hi Resolution	12	0.70	14.50	0.23	1.27

TABLE 4- Time stamp of CBCT Taken

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13	Sample 14
Date Scanned	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	15 Jun 20	15 Jun 20	15 Jun 20	15 Jun 20	16 Jun 20	16 Jun 20	17 Jun 20
Scout	14:35	15:07	15:36	16:04	16:33	17:01	17:29	17:21	17:50	18:17	18:46	18:08	18:49	17:46
Std	14:38	15:08	15:38	16:06	16:34	17:03	17:31	17:23	17:52	18:18	18:47	18:09	18:51	17:47
Hi Spd	14:41	15:11	15:39	16:07	16:36	17:05	17:33	17:25	17:54	18:20	18:48	18:13	18:52	17:49
Hi Fi	15:03	15:16	15:45	16:13	16:41	17:10	17:37	17:30	18:09	18:39	19:08	18:19	19:04	18:03
Hi Res	14:46	15:33	16:02	16:30	16:59	17:27	17:54	17:46	18:14	18:43	19:16	18:28	19:08	18:09

TABLE 5- Coordinates of MB2 Space on i-Dixel CBCT Software from Scans

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13	Sample 14
Date	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20	18 Jul 20
X (in mm)	5.25	5.75	4	None	4.5	3.5	4.5	4.25	None	4.75	4	5	3.75	4.25
Y (in mm)	3	8.5	3.5	None	6	5.75	3.75	4.5	None	3	4.5	2.75	2	3.25

TABLE 6- Coordinates of MB2 Space Obtained Clinically

(X, Y) (in mm)	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13	Sample 14
Date Read	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	14 Jun 20	17 Jun 20	19 Jun 20	19 Jun 20	19 Jun 20	19 Jun 20	19 Jun 20	19 Jun 20
Std	(5.11, 2.56)	(6.71, 5.85)	(4.47, 3.10)	Not detected	(4.15, 10.25)	(3.84, 5.96)	(4.89, 2.88)	(5.52, 2.55)	Not detected	(3.41, 2.82)	(3.41, 6.94)	(5.99, 1.39)	(3.85, 0.67)	(4.49, 2.56)
Hi Spd	(5.32, 2.66)	(5.54, 5.85)	(4.08, 3.41)	Not detected	(3.51, 10.88)	(3.73, 6.17)	(4.79, 2.94)	(5.12, 2.88)	Not detected	(4.27, 2.56)	(3.19, 5.65)	(5.35, 1.38)	(4.04, 0.67)	(4.68, 2.47)
Hi Fi	(5.33, 2.98)	(6.39, 6.08)	(4.50, 3.72)	Not detected	(3.72, 10.33)	(3.90, 5.60)	(4.59, 2.77)	(5.35, 2.87)	Not detected	(4.28, 2.84)	(3.73, 5.43)	(5.78, 1.49)	(4.15, 0.62)	(4.68, 2.13)
Hi Res	(5.43, 2.34)	(6.17, 5.43)	(3.99, 4.15)	Not detected	(3.30, 10.43)	(3.52, 5.45)	(4.17, 2.66)	(5.62, 2.56)	Not detected	(4.32, 2.71)	(3.78, 5.85)	(5.68, 1.28)	(3.83, 0.74)	(4.36, 1.91)

Figure 1

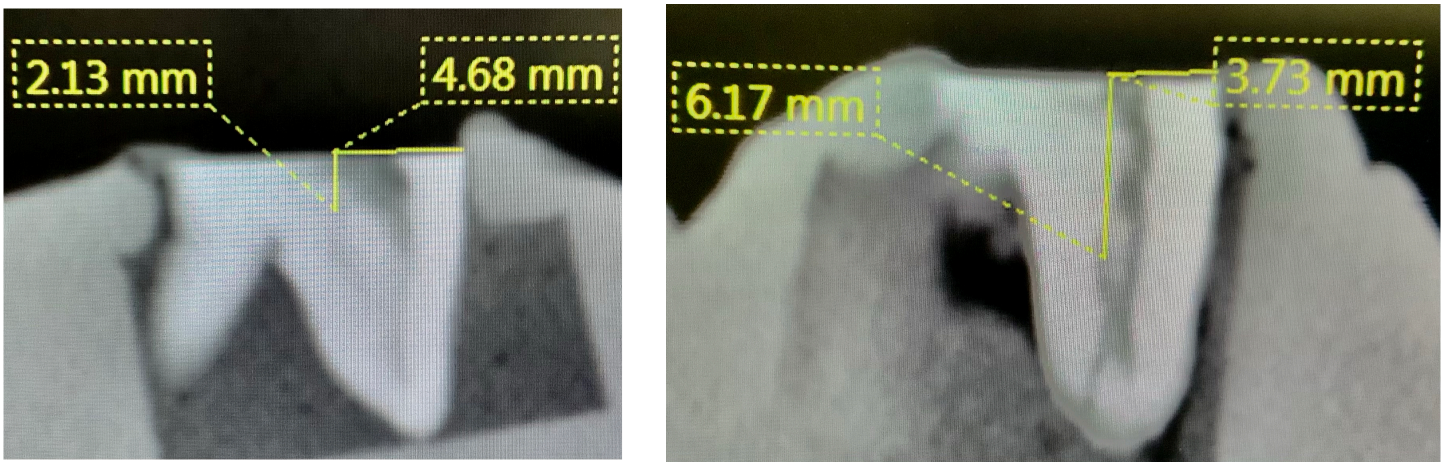


Figure 2

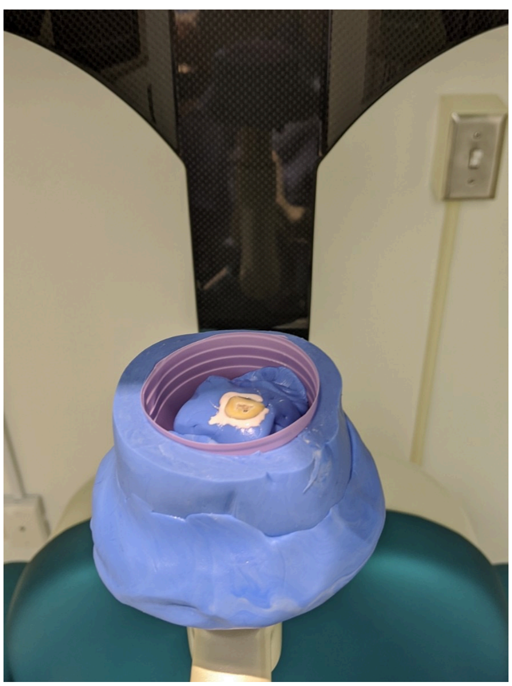
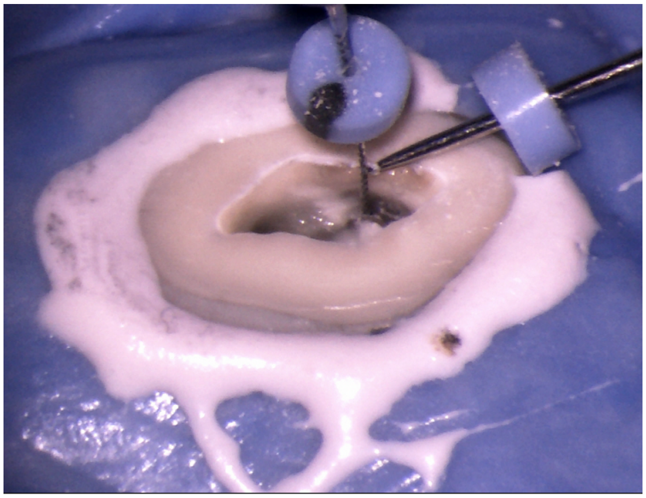


Figure 3



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