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Evaluation of apical filling using different obturation techniques

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Abstract

The aim of this study was to compare the quality of the apical filling in root canals of extracted tooth filled with gutapercha and sealer using different obturation techniques. For this study we selected 200 extracted teeth, devided in 4 study groups, each containing a number of 50 teeth, with fully formed apices and permeable canals. Root canal preparation was performedusing the ProTaper Next System (Dentsply, Ballaigues, Switzerland), in accordance with the manufacturer's instructions. At the end of instrumentation, each root canal was irrigated with 5 ml 17% EDTA (MD Cleanser, META BIOMED) and 5 ml 2% NaOCl (Chloraxid 2% Cerkamed). Root canals of group 1 were filled using cold lateral condensation technique; the group 2 of teeth was filled using warm vertical condensation, continuous wave technique. The third group of teeth was filled using single cone technique. Regarding the fourth group of the teeth we used squirt technique with heated gutta-percha, after application of the AH Plus sealer, the entire root canal was backfilled with gutta-percha using a cartridge with gutta-percha 23-gauge, heated at 200 ° C. Imperfections of the quality of the apical fillings, like voids were observed particularly in the case of teeth obturated by monocone technique and in the cold lateral condensation technique, especially in the apical segment. Other deficiencies have also been highlighted: overextension of the sealer, incomplete filling of the radicular system, absence of the filling, fissures, restant dentinal chips. These deficiencies were identified by stereo microscopy on extracted teeth, analysing sections resulting from the apical segments of the root canals. Most significant images have been registered using the digital camera, establishing the total number of errors and in the same time the percentage of errors in each obturation technique used. As for conclusions, the presence of intercanalar isthmuses may be a factor favoring the retention of dentinal chips, produced during instrumentation. Most of the errors were encountered in the monocone technique. Practically half of the post-treatment stereomicroscopically investigated teeth were found to be incorrect, among which the most frequent were the voids found in the sealer (24% of the cases). In the cold lateral condensation technique were detected 46% imperfections in the total number of investigated extracted teeth; the number of irregularities is related to the identification of voids in the sealer, which is found in 18% of the investigated cases.

Key words: root canal obturation, stereomicroscopy, voids, fissures

1. Introduction

In order to obtain an optimal three-dimensional obturation of the endodontic system, there have been proposed a number of preparation techniques. For research purposes single-rooted teeth are commonly used to compare different filling techniques [7,8] to check the adaptation of the filling materials to the canal walls in order to facilitate the interpretation of the results.

The apical or coronar leakage adversly affects the long time outcome of root canal therapy [1,3,5]; the leakage, in filled root canals, propagates along dentin – sealer and guttapercha – sealer interfaces, dentin and sealer – root filling material interfaces or via voids and other type of imperfections in canal root obturation [2,4,6].

2. Material and Methods

Samples preparation

For this study we selected 200 extracted teeth, with fully formed apices and permeable canal, radiologically verified, devided in four groups, and kept in saline solution. The access openings were performed using a high speed dimond round bur and cooling water. Working lengths were determined with a size 10 K-file (*Dentsply*, Ballaigues, Switzerland) inserted passively until its tip was visible at the apical foramen. Then, using an operating microscope (Seliga SmartOptic microscopes, Poland), the true length of the canal was recorded. The working lenght has been calculated by subtracting one millimeter of this measurement. The preparation and filling of the root canals of the extracted teeth was performed by students in the Endodontic Department Faculty of Dental Medicine University of Medicine and Pharmacy "Carol Davila", Bucharest.

Root canal preparation

The root canals were prepared using the ProTaper Next System (*Dentsply*, Ballaigues, Switzerland). The glide path was obtained by using the ProGlider instrument (Dentsply, Ballaigues, Switzerland). The rotative system used was X-Smart *(Dentsply Tulsa Dental*, Tulsa, UK), in accordance with the manufacturer's instructions, all ProTaper Next instruments were used at a speed of 300 rpm and a torque of 2.0 Ncm, each instrument was used by brushing motion. They were used on the entire working length of the root canals. Instrumentation sequence was as follows: X1 (0.17 mm diameter at the top, 4% taper), X2 (0,26mm diameter at the top, 6% taper) and X3 (0.30mm diameter at the top, 8% taper). Each instrument was cleaned after three brushing movements and the canal was irrigated with 2.5ml of 3% sodium hypoclorite using a lue-lock syringe (*Roeko*) and 30-gauge needle introduced up to 3 mm from the apex. The permeability of each root canal was checked with a size 10 K-file. At the end of instrumentation, each root canal was irrigated with 5 ml 17% EDTA (*MD Cleanser*, META BIOMED) and 5 ml 2% NaOCl (*Chloraxid 2%*, Cerkamed) and dried with paper points (*Diadent*, USA).

Filling of the root canals

Root canals of group 1 were filled by cold lateral condensation technique; we selected a size 35 master gutta-percha cone (*Diadent*, USA), adapted by cutting to obtain tug-back. We prepared the AH Plus sealer (*Dentsply*, Maillefer) according to the manufacturer instructions. Master cone was passed through the sealer and inserted into the canal. Medium-fine accessory cones (*Dentsply*, Maillefer) were condensed with a finger spreader (*VDW*, Germany) until they could not be placed in the canal more than 4 mm. A heated plugger was used for sectioning the bundle of cones in the orifices of the emergence of the root canal, followed by the vertical condensation with a cold plugger . Each tooth was radiographed from 2 incidence to verify the accuracy of root canal fillings. If the canal fillings were incomplete or heterogeneous ,condensations were restored. The Group 2 of teeth was filled by warm vertical condensation, continuous wave technique. A gutta-percha cone Protaper Next X3 (*VDW*, Germany) was used as a master cone, AH Plus (*Dentsply*, Maillefer) as a sealer and BeeFill system 2 in 1 (*VDW*, Germany) for performing the vertical condensation technique. For providing tug-back, 0.5 mm were cut from the top of the master cone. The electric plugger was selected with a similar taper as the master cone, inserted into the root canal to confirm reaching of the working length minus 4 mm by adjusting the stopper at the reference point. The master cone was passed through the sealer, gently inserted into the canal and cut with the previously selected heated plugger from the emergence of the root canal orifices. A 3/4 manual plugger (*Dentsply*, Maillefer) was used to laterally and vertically compact the

gutta-percha. The BeeFill electric plugger was again heated to 200° C and in a single continuous movement was inserted in the gutta-percha mass by up to 4 mm of working length. This stage was limited to 2-4 seconds. The plugger was disabled while firm pressure continued to be applied to cold instrument. Then the plugger was again activated for one second and then removed from the canal with gutta-percha excess. A cold hand plugger (*Dentsply*, Maillefer) was used for the gutta-percha vertical compaction that remained in the canal. The rest of the root canal has been backfilled with gutta-percha, using a 23-gauge cartridge gutta-percha heated to 200 ° C. Again the heated gutta-percha was condensed with a 3/4 cold plugger (*Dentsply*, Maillefer). The Group 3 of teeth was filled by a single cone and sealer using single cone technique. Protaper Next X3 cone was chosen (*Dentsply*, Maillefer) and previously tested in the root canal. The AH Plus sealer was used as a sealer. The Group 4 of the studied teeth was filled by squirt technique with heated gutta-percha, after application of the AH Plus sealer. Furthermore, the entire root canal was backfilled with gutta-percha, using a cartridge with gutta-percha 23-gauge, heated at 200 ° C. All access cavities were sealed with Coltosol (*Roeko*) and the teeth were kept in100% humidity conditions, at a temperature of 37 ° C for 48 hours to allow complete set of the sealer.

3. Results

Imperfections in the quality of endodontic obturation using different techniques were observed by stereomicroscopy (*Leica EZ4 HD*, Switzerland); for this reason, several sections of the apical segment were analysed. Where the frequency of imperfections was high, additional sections have been prepared, followed by a stereomicroscopic analysis of the new sectional areas. With the digital camera of the stereomicroscope, photos were taken for the aspects considered significant. In order to determine the types of errors and the most likely ways to produce them, the authors consulted by analyzing each part of the fragments of the stereomicroscope and not by simply reviewing the digital images taken [Table 1].

Table 1. The identified errors (expressed as total number of errors and percentage of errors).

Total number of errors								
	Obturation technique	Voids	Fissures	Restant dentinal chips	Exceedings	Incomplete obturations	Lack of filling	Number total errors per technique
Group 1	Lateral cold condensation	9	5	4	2	1	0	2. 3
Group 2	Vertical warm condensation	2	7	1	0	0	0	10
Group 3	Monocone technique	12	0	6	1	4	2	25
Group 4	Injection technique for guttapercha	1	0	1	2	0	0	4
Percentage of errors								
	Obturation technique	Voids	Fissures	Restant dentinal chips	Exceedings	Incomplerte obturations	Lack offilling	Percentage of total errors per technique
Group 1	Lateral cold condensation	18 %	10 %	8 %	4 %	2 %	0 %	46 %
Group 2	Vertical condensation	4 %	14 %	2 %	0 %	0 %	0 %	20 %
Group 3	Monocone technique	24 %	0 %	12 %	2 %	8 %	4 %	50 %
Group 4	Injection technique for guttapercha	2 %	0 %	2 %	4 %	0 %	0 %	8 %

To obtain images with magnification over 50x a Zeiss Jena calcographic microscope was used. Calcographic microscopy was applied only in some cases to detect aspects requiring greater magnification order than those that can be obtained with the stereomicroscope. Deficiencies in the quality of the obturation that were most frequently identified are: voids, fissures, restant dentinal chips, exceedings, incomplete obturations, lack of filling.

(1) Voids

The voids have been observed in particulary in the case of the teeth that were filled using the monocone and lateral cold condensation technique. The voids were identified within the sealer of the filling, especially in the apical segment, and were unique or multiple. The multiple ones were most commonly observed as being locally grouped. The stereomicroscopic investigation provides three-dimensional images and allows to establish the lack of sealing material to the depth of the studied root fragments. Thus, there were considered voids from technical errors, those that saw an extension within the canal portion of the root fragment studied. Obviously we did not consider, as obturation techniques errors, the small sealer depressions on the analyzed surface area that appeared almost without exception when the root was cut during sectioning procedure. In case of a "C" shaped root canal [Fig. 1]; from the apical aspect we detected sealer, voids and dentinal chips [Fig. 2]. In case of cold lateral condensation [Fig. 3], two non-confluent voids are observed and [Fig. 4] in the proximity of the vestibular canal a void is present in the sealer. In the proximity of the palatal canal continuous dentinal detritus is identified. We notice the presence of two microvoids [Fig. 5] in the sealer, one in the diverticula of the main canal, probably by not preparing the oval extension of the root canal.

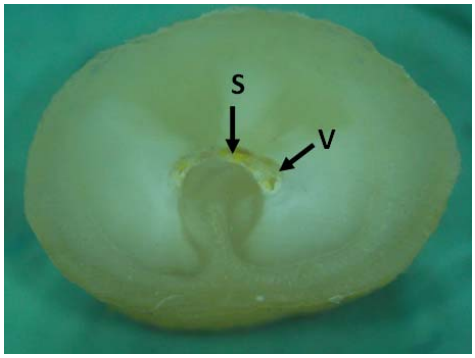

Fig. 1. C-shaped channel; only the sealer (S) is present in the apical area. Voids are also observed in the sealer (25x)

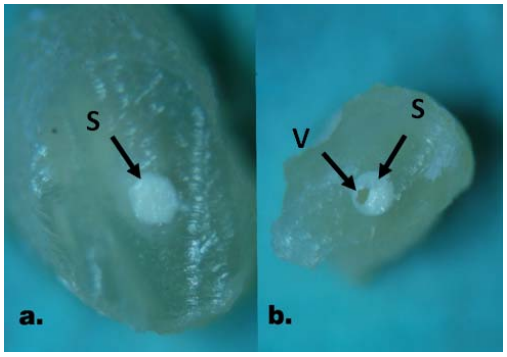

Fig. 2.
a) Obturation only with sealer at the limit of the median and apical segment (40x). b) In the case of the same tooth, in the section through the apical third filling with sealer is unsatisfactory by the presence of voids (V) – V(40x)

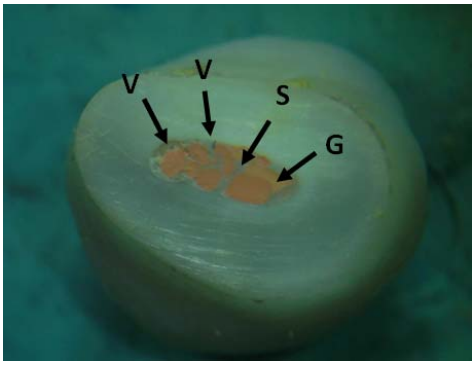

Fig. 3. Small voids (V) in the sealer used to fill the remaining spaces between the cones and the root canal walls in cold lateral condensation technique (12.5x)

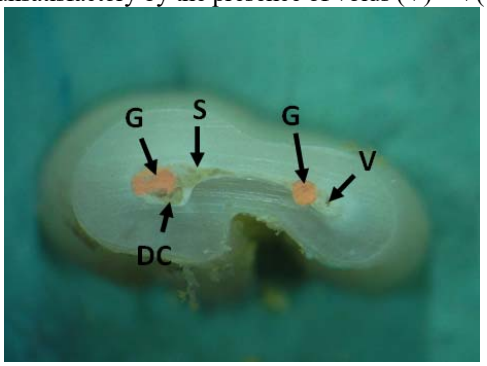

Fig. 4. Fragments of dentine (DC) and goals (G) in the sealer (S) (16x)

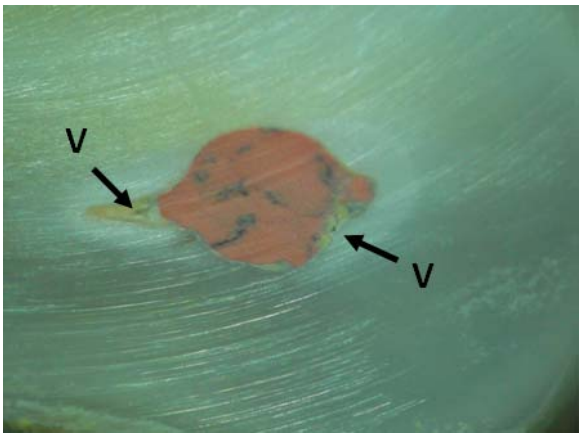

Fig. 5. Small voids in the sealer in root canal with cold lateral condensation; it is noticed that the section passes through the oval extension of the canal that has not been instrumentated (25x)

(2) Fissures (cracks)

In the present study the cracks have been encountered especially in the case of teeth obturated by warm and cold condensation technique. The following types of cracks have been encountered: *open* (those that partially or totally detach a root fragment) and *closed* (those that do not detach the root fragment). These cracks may also be classified into *radiar* (those extending from the root canal to the root surface) and *paracanalar* (those that pass next to the root canal without intersecting it, at the level of the surface section analysed). In Figure 6 it is evident on the apical segment, the apical root that contains two channels are united by isthmus, visualizing the dentin debris located in the isthmus, also relatively frequently cracks are identified [fig.6 and fig.7].

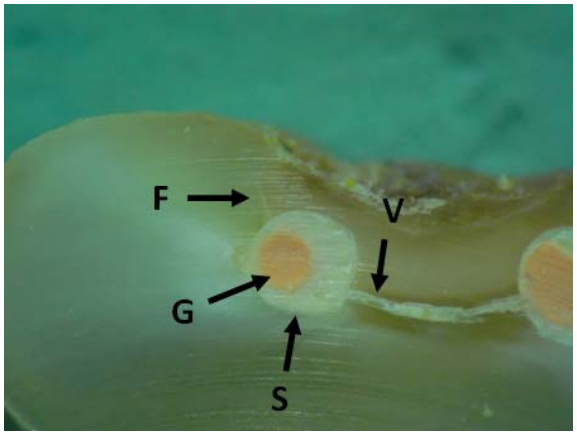

Fig. 6. Crack that starts from the root canal to the external surface of the root (the crack does not detach a dental fragment); an intercanalar isthmus is only partially filled with sealer (V voids have been identified) (30x)

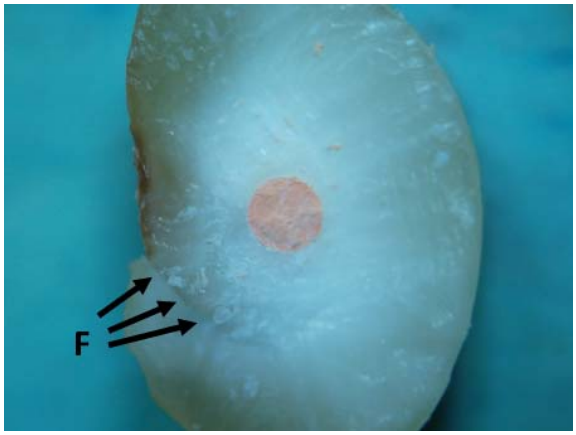

Fig. 7. A crack at this level (at the junction of the middle and apical segment of the root) does not intersect the root canal, but it is the extension of a crack that starts from the floor of the pulp chamber, so that we canassume that through it the endodontic space was open, although there are no color changes suggestive of infiltration (20x)

(3) Restant dentinal chips

The remaining dentinal fragments identified have been particularly surprised to be locked in interradicular isthmus areas. We have found that the dimensions of these fragments are generally relatively large, namely that they hold 10-15% of the small diameters of the root canal at the sectional area where they were observed. Excessive dentine fragments (chips) in the endodontic space, resulting from inappropriate preparation of the endodontic system, are depicted in Figures 8 and 9. In Figures 10 and 11, microvoids are visible at the guttapercha sealer interface and the sealer and the dentinal wall of the root canal.

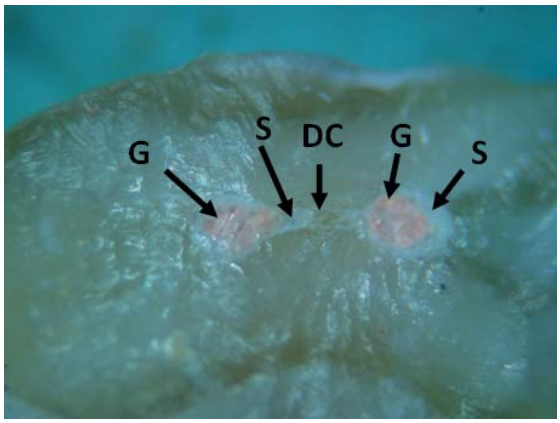

Fig. 8. Dentine chips (DC) trapped in the intercanalicular isthmus (40x)

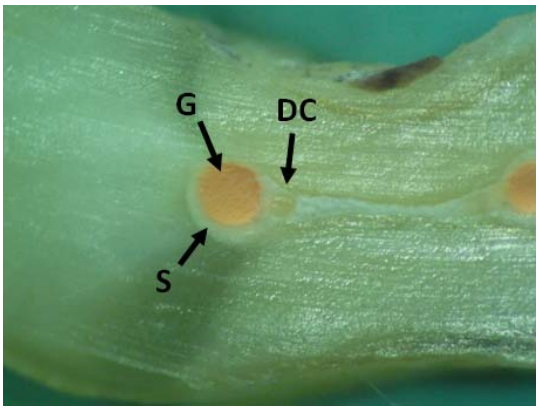

Fig. 9. Dentine chips (DC) fragments identified at the boundary between palatinal root canal of a premolar and intercanalicular istmus. In this case the endodontic sealer also passes through the intercanalar isthmus (35x)

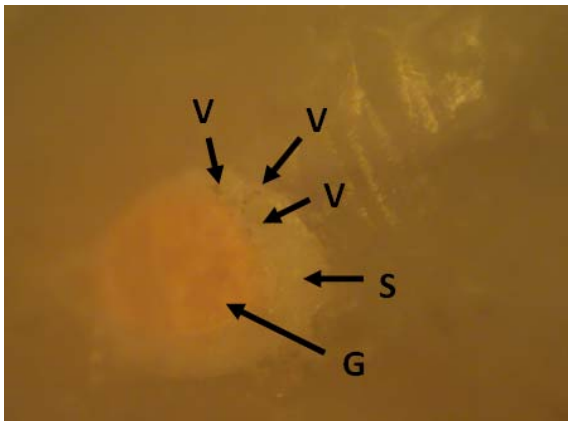

Fig. 10. Voids (cluster of voids) in the sealer (S) around the guttapercha (G) (100x)

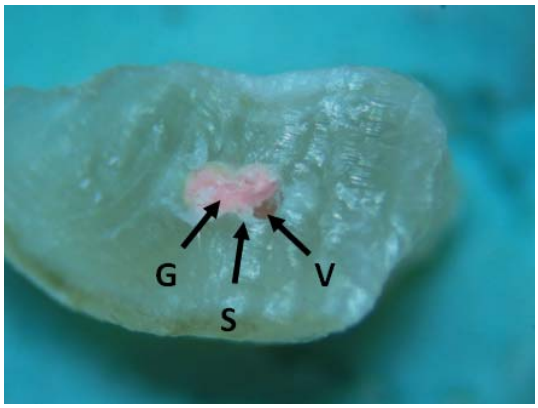

Fig. 11. Void (V) present between a guttapercha cone and the root canal wall at the limit of 2/3 coronary root and 1/3 apical segment, this level being the place where the two root canals join together (20x)

(4) Exceedings

We have identified exceedings by stereomicroscopic analysis of the root apex. In these situations, the gutta-percha, and sometimes even the sealer, passed through the apical constriction. In Figures 12 and 13 there is evidence of overextension of guttapercha through the apical foramen.

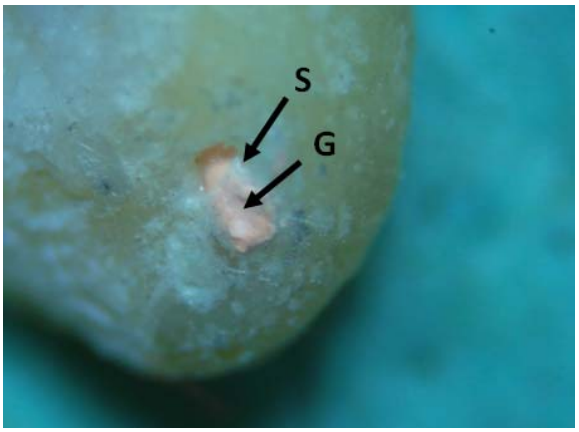

Fig. 12. Apex of a front tooth: Exceeding of guttapercha (G) through the apex (40x)

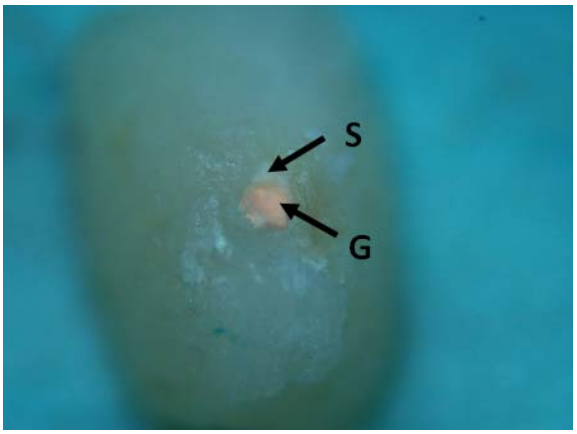

Fig. 13. The apexof a front tooth: Exceeding of guttapercha (G) and sealer (S); the guttaperchacone has passed the apical constriction as a result of its excessive widening by overinstrumentation (40x)

(5) Incomplete obturations

Under extesion of obturation facilitates apical infiltration and correct adaptation of filling to apical anatomy.

(6) Lack of filling

Although it seems an almost impossible error to occur, we have also detected such errors. In these situations, on the walls of the root canal there were traces of very thin stratiform sealer and discontinue depositions in other cases, although it is obvious that instrumentation was not performed. The single-cone technique did not use compaction forces, so in our study experiment, did not fill the last apical millimeters of root canal, preventing leakage as effective as vertical and lateral compaction techniques.

An omission of obturation has been identified in the canals contained in the extracted obturated root, in the digital image on the section it is observed that the palatal canal is not covered, in the presence of sealer traces [Fig. 14, 15].

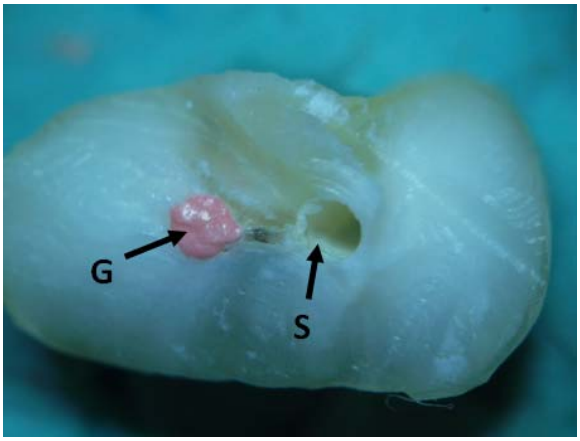

Fig. 14. Omission of obturation of one canal of the two rooted canals maxillary premolar; the stereomicroscopic investigation on the palatinal canal only found the presence of sealer (S) residues on the walls of this channel segment (20x)

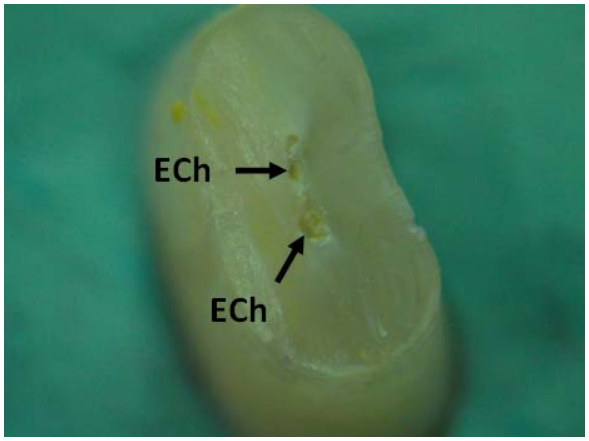

Fig.15. In the case of this premolar, although at the level of the obturation is no longer present and the level of mechanical preparation of the channels is appreciably weak or non-existent. In the central area of the root there are two hollow canal shaped areas (empty channel - ECh) (20x)

4. Conclusions

The imperfections of the final obturation ar conected with the quality of the canal filling technique. Voids are frecvently found in the last milimeters of the root canal and the isthmus area. Cracks were found in case of the warm and cold lateral condensation technique, eventually putting in account of excessive pressure application (in case of lateral condensation technique) or the excessive pressure with plugger in apical direction (the vertical condensation), and sometimes inadequate choice the spreader/plugger segment relative to that root segment. In case of an incomplete obturation were encountered probably unwise canal preparation, so that traces of sealer are observed. The presence of inter-canal isthmuses may be a factor favouring the retention of dentin fragments produced during instrumentation of the canals. Most errors were encountered with the monocone technique. Practically, in half of the post-treatment stereomicroscopically investigated teeth there were found imperfections, among which the most frequent were the voids within the sealer (24%). In case of the lateral condensation technique we found 46% errors from the total number of investigated tooth. For this technique, the maximum number of errors is related to the formation of voids in the sealer, which occured in 18% of the investigated cases. A notable error are the cracks, which, as can be seen from the tables, appear particularly in case of cold lateral condensation and the vertical condensation technique. According to our study, they occurred more frequently in case of vertical condensation than in cold lateral condensation (14%, respectively 10% of cases).

5. Acknowledgements

In this article, all authors have an equal contributions as the first author.

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