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THE INFLUENCE OF CANAL PATENCY ON THE SUCCESS OF ROOT CANAL TREATMENT

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ABSTRACT

Introduction: Treatment involving complete obliteration of root canal system requires extensive analysis, both because of numerous existing clinical problems involved and limited research conducted in this area.

Objectives: The objective of the study was to provide a comparative clinical and radiological evaluation of two gutta-percha obturation methods applied in root canal treatment in conditions of total obliteration: lateral condensation versus continuous wave condensation technique.

Material and methods: A total of 310 teeth from 121 patients were analyzed. Overall, 35 teeth contained various degree of root canal calcification. A comparison was made between the following two obturation techniques: lateral condensation method and continuous wave of condensation approach (taking into account the existence of periapical lesions, and whether the patient was undergoing primary treatment or re-treatment).

Results: The healing process in the case of two root canal obturation method depended on the number of variables, such as the presence of obliteration ($p < 0.001$) and CWC treatment method selected ($p = 0.018$).

Conclusions: The positive treatment outcomes achieved with the CWC method suggest that this thermal technique should be the treatment of choice when obliterations occur and in the absence of patency in the apical part of the root canal.

Key words: clinical outcomes, endodontics, canal obliteration.

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INTRODUCTION

The goal of root canal treatment is to create right conditions that allow for effective periapical periodontal tissue functioning. This objective is attained by following a correct treatment algorithm. The purpose of endodontic treatment is to repair compromised periapical tissue caused by inflammation, and to prevent damage from recurring. Every stage of the algorithm offers gold standards for treatment based on procedural methods applicable to any clinical situation, and provide a benchmark for comparing the efficacy of different methods [1-8].

Among many factors that may impede a successful outcome of root canal treatment is the presence of calcification in root canal (Figure 1). Pre-operative radiographs often appear to reveal total or nearly total calcification of the pulp chamber and radicular canal spaces. These spaces provide a suitable channel for the passage of millions of micro-organisms, which induce chronic inflammatory processes (Figure 2). This often causes narrowing of the canal system, for example, due to calcification (this happens during retrograde changes in blood supply to the pulp as a result of inflammation, or when the root cement is repositioned in its apical part). Despite the presence of severe coronal calcification, clinicians must assume that all canals exist according to the accepted norm, and try to locate them. These canals must be endodontically treated, otherwise they form

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FIGURE 1. Tooth 46. The presence of complete calcifications in root canals

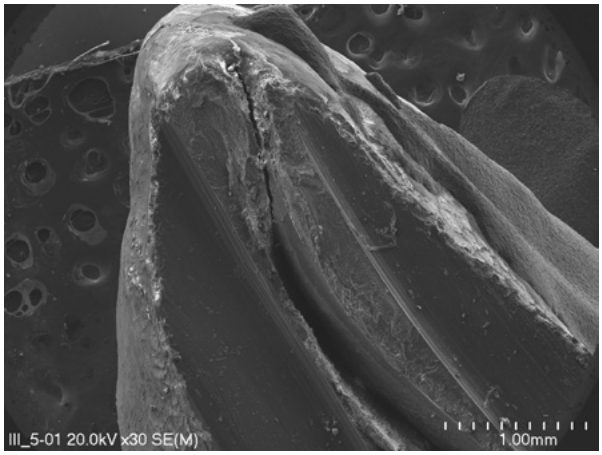

FIGURE 2. Photo from SEM microscope showing image of obliteration of the tooth apex

potential bacterial reservoirs that lead to post-treatment complications (Figure 3) [9]. Complete obliteration, especially at the apex of the root, may be the cause of inadequate mechanical preparation (e.g., during primary treatment) and obturation of the root canal up to the physiological foramen. Practical value of achieving this objective is to help dental practitioners identify the optimal method of root canal obturation, and help to assess the prognosis for the treatment [4, 5, 10-13].

OBJECTIVES

The goal of the current study was to provide the clinical and radiological comparative evaluation of two root canal obturation techniques, including gutta-percha lateral condensation method versus continuous wave condensation (CWC) technique. Additionally, the presence of total obliteration in root canals ten years post-treatment as well as the impact of root canal patency on ensuring a positive treatment outcome were all considered.

MATERIAL AND METHODS

A total of 310 teeth from 121 patients over 18-years-old were endodontically treated. These procedures were performed by the author personally. A total of 35 teeth were found with root canal obliterations (calcifications) covering the apical third. The consent for the study was obtained from the Bioethics Committee of the Jagiellonian University (Approval No.: KBET/236/B/2010). Certain inclusion and exclusion criteria were adopted for the study. Patients meeting the inclusion criteria were scheduled for primary root canal treatment or re-treatment with or without periapical lesions. Patients excluded from the study were those who refused consent for the treatment, underwent oncological treatment, those

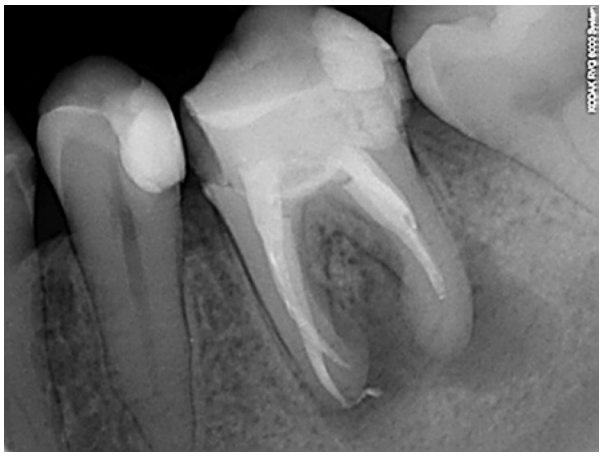

FIGURE 3. Tooth 36. Complete obliteration, especially beyond 2 mm at the apex of the root, may be the cause of inadequate mechanical preparation

with immunological diseases, and requiring surgical intervention, e.g., root resection or radectomy. Teeth were excluded from occlusion for the duration of observation to avoid accidental fractures and negative impact of overloading on healing process of the periapical tissue.

SUB-DIVISION OF GROUPS

The study population was divided into two main groups according to treatment method selected.

Group 1: The root canal system was filled using a cold lateral condensation technique. A total of 163 teeth were treated, including 98 multi-rooted and 65 single-rooted teeth. The average age of this group of patients was 41 years and 6 months.

Group 2: The root canal system was obturated by means of a continuous wave condensation (CWC) technique. A total of 147 teeth were treated in this way, in-

cluding 76 multi-rooted and 71 single-rooted teeth. The average age of this group of patients was 44 years and 7 months.

The study population was also divided according to the presence or absence of periapical lesions and the type of treatment applied. On this basis, the following sub-groups were formed: (1) sub-group A: teeth with a healthy periapical periodontium; (2) sub-group B: teeth with periapical lesions.

In addition, study material was separated into teeth undergoing primary treatment and teeth that were the subject of re-treatment.

Class I: Primary endodontic treatment.

Class II: Teeth re-treated endodontically.

The groups were randomized according to time-based criteria. In the first six months, lateral condensation technique was used, while in the following six months, CWC technique was employed.

The patients were assessed during follow-up visits scheduled at 3, 6, 12, and 24 months after treatment, and then annually.

ASSESSMENT CRITERIA

The assessment was based on an interpretation of clinical examination and radiographs. PAI index was determined on the basis of an X-ray, while the quality of obturation process was evaluated on the basis of appropriate criteria. Moreover, to ensure the procedures were evaluated according to objective standards, the teeth were examined by two individuals. Data were gathered and stored in patients personal examination cards. The assessment took into account outcome predictors based on an analysis of the following parameters: morphological state, continuity of the obturation, and type of treatment selected.

For the need of this article, results concerning root canal obliteration were shown. The existence of calcification (obliteration) in the apical third of the root clearly indicated the absence of canal patency at 2 mm above the radiological apex.

FIGURE 4. Tooth 36. Radiograph image taken based on right angle technique with RINN positioners

FOLLOW-UP

Clinical and radiological follow-up visits were scheduled over the course of a ten-year period. During the treatment, two radiological images were taken based on right-angle images and using RINN positioners both before and after treatment. The same physician took the radiographs using the same technique (Figure 4). The presence of calcification was identified with a cone bean computed tomography (CBCT), which also turned out to be an effective tool in the treatment planning intended to achieve root canal patency.

STATISTICAL ANALYSIS

Statistical analysis involved comparing the initial state with the present state of ten years post-treatment. All statistical analyses were based on the following tools: Fisher exact test, χ^2 test, and logistic regression model.

RESULTS

First, the entire data of all the examined factors were analyzed, and one-dimensional analysis of the factors was performed. Two-dimensional analysis based on Fisher's exact test and the χ^2 test allowed to determine potential prognostic value of these factors. On the other hand, multi-dimensional analysis using logistic regression model enabled to identify actual prognostic factors. Subsequently, interesting data were selected, and a narrower analysis was performed of those teeth, in which during treatment, calcification was noted in the apical third of the root. A statistical difference ($p < 0.001$) was observed between healing processes occurring in these teeth, in which obliteration was found initially, and healing processes in teeth treated with either of the two obturation techniques, i.e., CWC and lateral condensation. When a radiograph revealed the presence or absence of pre-treatment radiolucency in relation to root obliteration (1%) after treatment, the tooth was regarded as treated with radiograph revealing absence of radiolucency (Table 1). Table 2 shows the negative impact on the presence of root canal obliteration in both CWC and lateral condensation methods (Figure 5). Furthermore, two-dimensional analysis of this group allowed to identify significant statistical differences in the degree of healing achieved in connection with the following factors: the presence of a periapical lesion ($p < 0.0001$) (Table 3), the use of CWC technique ($p < 0.001$), and the use of lateral condensation technique ($p < 0.001$) (Table 2)

TABLE 1. Two-dimensional analysis. Results of prognostic factor of the whole study

Prognostic factor	Healing absent		Healing present		*p*-value
	%	*n*	%	*n*	
Obliterations					
Present	14	58.3	3	**1.0**	< 0.001
Absent	10	41.7	283	**99.0**	

in the treatment of obliteration. A statistical difference was found in the degree of healing achieved (with obliterations present) between primary (p = 0.001) endodontic procedures and re-treatment procedures (p < 0.001), but no statistical difference was observed between re-treatment and primary treatment in terms of the number of successfully treated teeth (Table 4). This concerned only 3 of the 14 teeth treated with the CWC method, which healed following obliteration of the roots. Moreover, apical periodontitis was observed in 2 of these 3 teeth, while the other tooth was free of pre-operative apical periodontitis (Table 3). No healing was observed in the teeth treated using the lateral condensation method (Table 2). Only in 2 of the 14 teeth with apical periodontitis treated with the CWC technique, a positive outcome with obliteration present was found (Table 2).

The multi-dimensional analysis revealed a significant impact of obliteration (absence of healing) (p < 0.0001; OR = 0.0023) and the choice of CWC method (presence of healing) (p = 0.018; OR = 12.1) on the treatment outcome. The overall results of the statistical analysis of CWC technique are provided for all prognostic criteria along with obliterations in Table 5. No statistical difference was observed between the two techniques regarding the number of treated teeth with obliterations. To provide an objective basis for the research, a statistical test was conducted to identify any possible statistical differences between the researchers. The test revealed no such differences, which indicated a convergent interpretation of the analyzed data (p > 0.2).

DISCUSSION

The issue of complete root canal obliteration has only been addressed by a small group of researchers [14, 15]. Any discussion on this topic tended to focus on the methods and techniques that must be applied to achieve root canal patency [16]. From a clinical point of view, more information is needed to provide prognoses for individual teeth treatment. When considering the appropriate treatment for a particular patient, i.e., whether to retain a tooth, pursue endodontic treatment, or opt for a surgical procedure, the choice should be based on tests with a clinical outcome. The above

TABLE 2. Results of prognostic factor in the lateral condensation and CWC methods

Prognostic factor	Lateral condensation method				*p*-value
	Healing absent		Healing present		
	n	%	*n*	%	
Obliterations					
Present	8	47.1	0	0.0	**< 0.001**
Absent	9	52.9	146	100.0	
Prognostic factor	**CWC**				***p*-value**
	Healing absent		**Healing present**		
	n	**%**	***n***	**%**	
Obliterations					
Present	6	85.7	3	2.1	**< 0.001**
Absent	1	14.3	137	97.9	

FIGURE 5. Tooth 46 shows the negative impact on the presence of root canal obliteration, and it is not beneficial for the healing process

TABLE 3. Results of prognostic factor in the group of apical periodontitis

Obliterations/apical periodontitis	Healing present		Healing absent		*p*-value
	n	%	*n*	%	
Present	2	14.3	12	85.7	**< 0.0001**
Absent	126	95.5	6	4.5	

results show that failing to negotiate a root canal up to 2 mm from the radiological apex has a negative impact on the treatment outcome in most cases. According to Langeland, the deposition of calcified tissue in the pulp stump cannot be regarded as proof of physiological healing, where in majority of situations it constitutes a case of a pathological calcification [17]. As a conse-

TABLE 4. Results of prognostic factor in the group of primary and secondary treatments

Obliterations	Primary treatment				Re-treatment				*p*-value
	Healing present		Healing absent		Healing present		Healing absent		
	n	%	*n*	%	*n*	%	*n*	%	
Present	1	0.8	3	42.9	2	1.2	11	64.7	0.659
Absent	120	99.2	4	57.1	163	98.8	6	35.3	0.880
p-value	**0.001**				**< 0.001**				-

TABLE 5. Multi-dimensional analysis (model of logistic regression)

	Constant	Obliteration present	Treatment method, CWC
Model of logistic regression	2.75	–6.08	2.49
p-value	< 0.0001	**< 0.0001**	**0.018**
Quotient of chance (OR)	15.7	0.0023	12.1
95% confidence interval, OR	8.1-30.4	0.00023-0.0212	1.5-96.4

quence, terms such as "biological closure" and "physiological closure" do not appear accurate, since they are phenomena that occur in combination with inflammation [8].

In the present study, it was clearly seen that canal patency had a significant prognostic effect during the course of treatment. Calcification was present in approximately 11% of all root canals (35 out of 310 teeth). Most of the canals obliterated by calcification (6% of 11%) could be negotiated up to approximately 2 mm from the radiological apex, and sometimes as far as the physiological foramen using advanced endodontic techniques. This distance was recognized to be within the range of the norm in criteria regarding obturation of the apex area, with a positive impact on the healing process. On the other hand, 5% of the root canals could not be properly negotiated, which proved to contribute to the absence of healing in many cases (due to apical periodontitis) [18]. A negative treatment outcome was usually associated with complete obliteration of the tooth apex as well as with a diagnosis of apical periodontitis prior to treatment. Moreover, treatment was considered unsuccessful when complete obliteration was present, but no apical periodontitis was observed before clinical procedures. Similar treatment outcomes were registered for both primary and secondary endodontic treatments (no statistical difference was observed between primary treatment and secondary procedures in the group), regardless of the obturation method employed indicating the advantages of secondary root canal treatment (only when obliteration extended a little further). According to a study, complete calcification was mainly noted in molars and premolars as well as in certain anterior teeth. Such situation, where patency could not be achieved due to calcification, was primarily an issue that affected molars and some premolars. Regarding endodontic concerns, since apical periodontitis is caused by bacteria, every possible bacterial retention impede bone healing, and thus must be removed or reduced to the smallest size possible [9].

One problem often encountered in root canal treatment is dystrophic and excessive linear calcification in the root canal system. Clinicians must be aware that pulpal calcification is a sign of pathosis and not its cause. The nature and course of calcification is often unpredictable, and can pose considerable clinical challenges [9]. Over a lifetime, every tooth is exposed to the deposition of secondary dentin, whether normal or irrational in nature. When the pulp is subjected to a rapid and overwhelming buildup of bacteria or to traumatic event, there is limited time for normal reparative dentin to form. In such a scenario, the dental pulp may rapidly die, leaving the canal space patent and full of necrotic and often infected tissue. Clinically and radiographically, the pulp chamber and canal system are still patent and easy to navigate. However, if irritants gradually affect the tooth over a long period of time, both the pulp chamber and the pulp canal system undergo calcification that can make an access more difficult during root canal preparation. However, reducing the size of obliterated tubules and main canals may limit bacterial penetration, and make disinfectant solutions less effective [19, 20].

Radiographically, calcification is deemed complete when full canal closure is confirmed histologically, with the exception of small areas that contain minimal tissue remnants. Ensuring successful negotiation of such a canal up to its apical third is extremely difficult. Fortunately, only a small percentage of cases, in which fine or unidentifiable canals or calcified blockages are identified with a radiograph, turn out to be unmanageable using non-surgical root canal techniques [15, 21]. Effective negotiation of small or calcified canals is predicated upon proper

access to, identification of the canal orifice or orifices as well as the application of ultrasonic instruments [22].

It is widely accepted that complete sterilization of an infected root canal poses a significant, if not impossible, challenge, as does the complete removal of all pulpal debris [21, 23, 24]. Micro-organisms remain isolated inside the root canal system, and possibly the dentinal tubules continue to be infected at a level deeper than the dentinal wall is shaped. As a consequence, they are beyond the reach of the organism phagocytic defenses, and the presence of necrotic pulp remnants combined with accumulating exudate may function as a pabulum, and thus help ensure their continued viability [25, 26]. In summary, if all three dimensions of a root canal system are fully obturated, any remainder of microorganisms will be trapped within the dentinal tubules located between the cementum on one side and the canal filling material on the other, with no chance of survival [16, 27]. Morse findings demonstrated that such bacteria entrapped within a completely filled root canal are non-viable within five days of filling a root canal [28].

In light of the above, it is imperative that cleaned and shaped root canals are fully obturated, not with the aim of impeding bacterial colonization of the tissue fluids, but rather to prevent their survival and multiplication inside the fluids that inevitably accumulate in these places [3, 11, 29]. In view of this fact, the continuous wave compaction technique is superior to the lateral compaction (condensation) technique because it can fill a bigger surface area of the dentinal canal system, which can be presumed to result in better outcomes [30].

CONCLUSIONS

The root canal total obliteration leads to poorer treatment results. Detecting calcified canals is a challenge. In cases where negotiation of obliterated root canals is impossible, the continuous wave of condensation technique should be applied. If a canal is clean up to 2 mm from the root canal apex and the CWC root canal filling method is selected, a positive prognosis can be anticipated. If canal patency is achieved below 2 mm of the root apex, a negative prognosis can be expected, and resection or other methods of surgical treatment should be considered in treatment planning. In the case of primary treatment, if complete obliteration is present, re-treatment does not increase the chances of healing.

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CONFLICT OF INTEREST

The author declares no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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