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Outcomes of Endodontic Treatments Performed by Dental Students - A Follow-Up Study

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Abstract

Aim: We aimed to evaluate the quality of the root canal treatments performed by undergraduate dental students.

Material and Methods: Data comprised 105 teeth of which digital radiographs were analyzed. Radiographic periapical findings at baseline were compared with those after the follow-up period. Properties of the root fillings i.e. length and density, as well as types of teeth were considered in analyses. Patients with missing information i.e. no diagnosis or poor quality radiographs, were excluded.

Results: Second premolar was the most common tooth for endodontic treatment. Teeth with preoperative periapical lesions had healing rate of 84.0%, when the respective figure for teeth without preoperative periapical lesions was 96.7%. The best healing rate was detected in mandibular premolars and poorest in mandibular incisors and canines. Maxillary molars had biggest proportion of negative changes. Outcome was significantly better for root fillings of optimal length compared to those which were not (p=0.019). Teeth with filling material outside the apex were noticed to have the lowest healing rate (69.2%). No effect on periapical healing due to the use of posts was observed. Isolating the root canal filling was associated with better outcome compared to the situation without any isolation.

Conclusion: In our study, the outcome of endodontic treatments by dental students was better than reported in earlier studies. Good outcome was associated with good quality of root fillings. There still are unnecessary short-comings in recording diagnosis and the course of treatment.

Keywords: Endodontic treatment; Outcome; Dental students

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Introduction

The purpose of endodontic treatment is to eliminate micro-organism from the root canal, prevent infection from spreading periapically and to create conditions enabling and promoting healing and enabling preserving of the tooth [1]. The outcome of endodontic treatment has been shown to depend on diagnosis at baseline, tooth involved, anatomy of the root canals, root filling density, root filling length in relation to radiographic apex, all possible complications and falls during the treatment period, and the restoration on a tooth [2,3].

Preoperative periapical status and the severity of periapical periodontitis both have a significant role when considering the prognosis of endodontic treatment. One year after the treatment, teeth with preoperative changes in apical bone structures with mineral loss, radiolucency or severe apical periodontitis have shown more often no improvement than teeth with normal periapical structures at baseline. The healing of periapical lesions could take even more than 10 years. Furthermore, during the first year after treatment, teeth with small preoperative changes in bone structure can even develop minor periapical lesion before healing completely [4].

A root filling of good quality is not alone effective in preventing oral bacteria from reaching periapical area, but good and well-sealed coronal restoration play an important role in endodontic treatment with good outcome. Teeth with adequate root filling and coronal restoration have better prognosis (81% succeeded) compared with teeth having adequate root filling and poor coronal restoration (71% succeeded) [5]. Kayahan et al. [6] reported that teeth with prefabricated posts had significantly more postoperative complications than teeth without posts whereas in the study of Tronstad et al. [5] no differences between teeth with or without posts were found.

The studies on technical quality of root fillings performed by undergraduate dental students have been carried out in several countries [6-9]. Proportion of adequate root fillings performed by students (length within 2mm from radiographic apex and no void or space seen between filling and root canal walls) is reported to vary greatly (23% [7] to 55% [6-9]). Respectively, 41% [10] to 47% [4] of root fillings performed by postgraduate clinicians have been reported to be adequate when considering only the length of the root filling within 2 or 3mm from radiographic apex and 13% [11] to 58% [12] when considering both the length and the density of the filling. While treating single rooted teeth, the share of adequate root fillings was reported to be as high as 70% [13], whereas need for higher quality was obvious when treating molar teeth [8]. Comparing different tooth types, maxillary lateral incisors had the poorest rate, whereas that of the mandibular premolars was the best during the first year after the root canal treatment [4]. After reports of poor technical quality of root canal treatments by undergraduate students [6-9], new Guidelines for Undergraduate Curricilum in Endodontics were published [14].

The aim of this follow-up study based on patient documents, was to evaluate quality of the root canal treatments performed by undergraduate dental students in the University of Oulu, Finland. The success of the treatments was evaluated by radiographic findings. The hypothesis was that the diagnosis/radiographic finding at baseline are the most important variable predisposing the outcome. According to previous literature, other important factors associated with the outcome were hypothesized to be quality of the root filling and restoration, and possible complications during the treatment.

Materials and Methods

In the University of Oulu, Finland, dental students have to accomplish sufficient clinical compliance before graduation and are required to complete minimum of 20 root canals including at least one molar tooth. Endodontic theory is taught in three separate courses during the three clinical school-years including lectures, simulations and hands-on workshops. Students performing endodontic treatments in the dental training clinic have to get every step approved by a teacher before proceeding to the next step. Most of the teachers supervising endodontic treatments are specialized or specializing in endodontics and/or restorative dentistry.

During the years 2010-2011, a total of 840 root canal fillings were performed by 3th -5th year dental students in the University of Oulu. The data were collected from patient records and a total of 351 teeth were first included in the study. All cases with incomplete patient information i. e. missing or poor quality radiographs were excluded; the causes for exclusion were summarized. The final data comprised 105 teeth (altogether 93 patients). The total length of the treatment period was calculated as days from the date of diagnosis to root filling and the follow-up period was calculated from the date of the root filling to the date of the follow-up.

Digital radiographs were analyzed on a PC screen by one undergraduate dental student (HR). Altogether 10 radiographs were double checked twice during the data collection. Additionally, 10 randomly selected radiographs were analyzed with an experienced clinician (KO-J) in the beginning and in the end of the project. Measuring tool of the software was not used when analyzing the length of the root canal fillings or the size of the periapical lesion.

The teeth involved and the diagnosis at baseline (pulpitis / necrosis / periapical periodontitis / periapical cyst) were collected from the patient records as it was first set by a clinician starting the treatment and was not changed in cases it did not equate radiographic periapical status seen later in radiographs. Included cases involved both primary and secondary treatments of the root canals. General health of the patient was not considered in this study. For the analyses, teeth were categorized in six tooth types: *'maxillary molars', 'mandibular molars', 'maxillary premolars', 'mandibular premolars', maxillary canines and incisors*' and *'mandibular canines and incisors'*. The diagnoses at the baseline were classified as '*pulpitis*' and '*periapical periodontitis*' (including periapical periodontitis, tooth necrosis and periapical cysts).

Periapical status was analyzed from preoperative and postoperative radiographs separately as follows: '*no periapical lesion'* when there was no radiolucency seen in the periapical area and the periodontal ligament was normal, '*expanded periodontal ligament*' and '*periapical lesion*' when radiolucency was seen in the periapical area. For the analyses, preoperative and postoperative periapical radiographic status was dichotomized as '*no lesion*' and '*lesion*' when there was radiolucency in apical area or periodontal ligament was expanded.

Radiographic healing was measured by comparing preoperative and follow-up radiographs: when no radiolucency was seen periapically and periodontal ligament was not expanded at the follow-up visit, the tooth was considered as '*completely healed*'. When the periapical lesion had become smaller after follow-up time the tooth was considered '*partially healed*'. The tooth was considered as '*no healing*' when no change in periapical lesion size was noted or periodontal ligament was still expanded. When the lesion was expanded, tooth was considered as '*negative change*' and as '*extracted*' when tooth was extracted during the follow-up time.

The quality of the root filling was evaluated by measuring the length and density of the filling in association with the radiographic apex. The length of the filling was considered to be adequate '*in apex*' when it was 0-2mm short, whereas it was considered '*short*' if the distance was more than 2mm short from the apex. Filling was considered '*over filled*' if the filling material was seen outside of the radiographic apex. Density of a root filling was recorded as '*adequate density*' or '*inadequate density*'. The density of the filling was considered adequate if no empty space was seen between the filling and root canal walls and inadequate when voids between root canal walls and the filling were noticed. The quality of root canal filling was '*adequate*' if both length and density were recorded adequate. In multi rooted teeth, filling was '*inadequate*' if the filling was considered as inadequate at least in one root canal.

The instrumentation method of the root canals was recorded (manual / rotary instrumentation) as well as materials used for sealing the top of the root canal fillings. The materials placed on top of the root filling to ensure the isolation were classified as '*no isolation*" (when the material was compomer / composite resin / no isolation material mentioned), as *'isolation'* (all other materials) and as '*post*' (teeth with root canal posts). Materials used for final restoration of the tooth were registered and classified into three groups: '*laboratory manufactured crown*' (metallo ceramic or ceramic crown), '*composite resin or glass ionomer-cement filling*' and '*temporary filling*' when no permanent filling used. All complications during the treatments were registered (periapical penetration of sealer material/over instrumentation/lateral perforation of the root).

Table 1: Diagnoses at baseline (n, %) and pre- and postoperative findings (n, %) in different tooth types.

Tooth type	Frequency		Diagnose at baseline				Preoperative finding				Postoperative finding			
			P		AP		NL		L		NL		L	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Maxillary molar	8	7.6	5	62.5	3	37.5	4	50.0	4	50.0	7	87.1	1	12.5
Maxillary premolar	29	27.6	13	44.8	16	55.2	9	31.0	20	69.0	20	69.0	9	31.0
Maxillary incisor/canine	15	14.3	3	20.0	12	80.0	3	20.0	12	90.0	7	46.7	8	53.3
Mandibular molar	13	12.4	7	53.8	6	46.2	2	15.4	11	84.6	4	30.8	9	69.2
Mandibular premolar	28	26.7	16	57.1	12	42.9	10	35.7	18	64.3	21	77.8	6	22.2
Mandibular incisor/canine	12	11.4	2	16.7	10	83.3	2	16.7	10	83.3	4	33.3	7	58.3
Total	105	100	46	43.8	59	56.2	30	28.6	75	71.4	63	60.6	40	38.5

P = pulpitis, AP = apical periodontitis, NL= no periapical lesion, L= periapical lesion

Table 2: Quality of the root fillings and frequency of complications in the different tooth types.

Tooth type n (%)		Quality of root filling n (%)		Complication n (%)			
		Adequate	In adequate	Over preparation	Sealer periapically	Lateral perforation	Total
Max. molar	8 (7.6)	3 (37.5)	5 (62.5)	2 (25.0)	1 (12.5)	0 (0.0)	3 (37.5)
Max. premolar	29 (27.6)	22 (75.9)	7 (24.1)	2 (6.9)	4 (13.8)	1 (3.4)	7 (24.1)
Max. incisor/canine	15 (14.3)	13 (86.7)	2 (13.3)	1 (6.7)	1 (6.7)	0 (0.0)	2 (13.4)
Mand. molar	13 (12.4)	5 (38.5)	8 (61.5)	3 (23.1)	0 (0.0)	1 (7.7)	4 (30.8)
Mand. premolar	28 (26.7)	20 (71.4)	8 (28.6)	3 (10.7)	3 (10.7)	1 (3.6)	7 (25.0)
Mand. incisor/canine	12 (11.4)	6 (50.0)	6 (50.0)	5 (41.7)	1 (8.3)	1 (8.3)	7 (58.3)
Total	105	69 (65.7)	36 (34.3)	16 (15.2)	10 (9.5)	4 (3.8)	30 (28.6)

Over preparation includes also tooth with filling beyond radiographic apex
Some teeth had more than one complication, thus, all the complications (n=30) were placed in altogether 26 teeth.

Table 3: Use of isolation material on the top of the root canal filling in association with changes in periapical status.

Lining	Change in periapical status n (%)			Tooth extracted n (%)	Total n (%)
	Radiolucency expanding	No change	Partially or completely healed		
Lining	1 (2.6)	2 (5.3)	35 (92.1)	0 (0)	38 (36.2)
No lining	0 (0.0)	3 (18.8)	12 (75.0)	1 (6.2)	16 (15.2)
Post	3 (5.9)	3 (5.9)	45 (88.2)	0 (0.0)	51 (48.6)
Total	4 (3.8)	8 (7.6)	92(87.6)	1 (1.0)	105 (100.0)

Statistical analyses

The data were described as frequencies and proportions as well as graphically. Cross-tabulation was used to investigate the association between the groups. The differences between the groups were tested using Pearson's chi-square and Fisher's exact tests, the differences between the groups were considered statistically significant when the p-value was less than 0.05. All statistical analyses were performed using SPSS 22.0 for Windows (Chicago, IL, USA).

Ethical considerations

Data were collected according to endodontic diagnosis codes with the permission of the register keeper, City of Oulu, Finland; which is considered sufficient without consent from the patients. Data were analyzed without personal IDs.

Results

Duration of root canal treatment periods varied from single appointment to 616 days (mean 67, SD 81.3). Majority (63.8%) of the cases were treated within two months from the date of the diagnosis. The follow-up time varied from 159 to 979 days (mean 439, SD 137.3). In 82.0% of the cases, the healing was controlled during 18 months from the date of root canal filling.

Second premolar was the most common tooth for root canal treatment (54.3% of the cases). Most of the cases were primary endodontic treatments (90 out of 105). Periapical periodontitis was more common (56.2%) diagnosis given at baseline than pulpitis. Before the root canal treatment periapical involvement was seen in 71.4% of the cases (expanded periodontal ligament 19.0%, periapical radiolucency 52.4%) (Table 1). After the follow-up time the respective figure was 38.1% (Figure 1).

One tooth was extracted during the follow-up period. Healing was noticed in 87.6%; no change in 7.6 % and deterioration ('*negative change*') in 3.8% of the cases. Teeth with preoperative periapical lesion had healing rate of 84.0 %, when the respective figure for teeth without preoperative periapical lesion was 96.7%. Healing was noticed in 93.5% of teeth with pulpitis diagnosis and in 83.0% of those with periapical periodontitis. Three fourths (75.0%) of teeth with expanded periapical lesions at follow-up, had periapical lesion also preoperatively. The best healing rate was detected in mandibular premolars (92.9%) and poorest in mandibular incisors and canines. Maxillary molars had biggest proportion of negative changes (Figure 2). Pre-graduate students used mainly manual instrumentation (87.6%). The technique had no significant effect on healing, nor if the

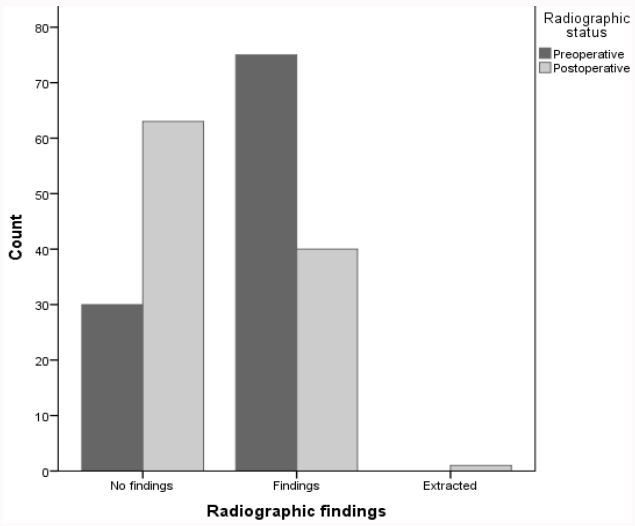

Figure 1: Preoperative and postoperative periapical findings.

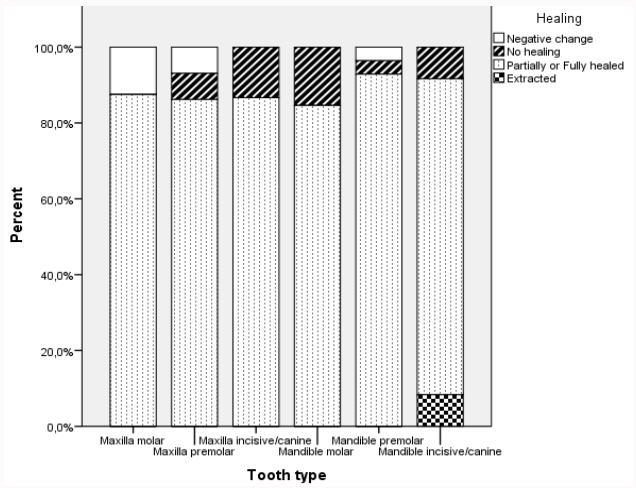

Figure 2: Changes in periapical status during the follow up period in different tooth types.

treatment was primary or secondary.

Adequate root filling length was found in 68.6% and adequate density in 94.3% of the teeth. Two thirds (65.7%) of the root fillings were considered '*adequate*'. The best technical success rate was in the *'maxillary canines and incisors'* (86.7%) and the poorest in maxillary and mandibular molars (Table 2).

Healing (partially or completely) was significantly better when the root filling was of optimal length compared to when it was not (p=0.019). When the filling length was considered to be in the radiographic apex, the healing rate was 93.1% and in only 1.4% of those cases, the lesion had expanded. The teeth with filling material outside the apex were noticed to have the lowest healing rate (69.2%) and they were also noticed to have the highest rate of expanded periapical lesions (15.4%; 50.0% of all expanded lesions). The one tooth which was extracted had overfilling. The density of the fillings was not adequate only in 5.7% of all the cases. Almost two thirds (61.0%) of partially or completely healed teeth had root filling classified as adequate. Of the cases with worsened periapical status, 75.0% had inadequate root filling whereas of those teeth with no periapical changes during the follow-up time, 50.0% had adequate filling.

The most common complication was over preparation (n=16) and of those teeth 73.3% showed healing. Cases with no reported complications had healing rate of 88.6%. Healing was noticed in all cases with only sealer outside of the apex or lateral perforation of the root. About half of the cases (51.0%) had root canal post, 38.0% of the teeth had isolation on top of the root canal filling whereas 16.0% had no isolation material. Teeth with isolating material were partially or completely healed in 92.1% of cases when teeth with no isolating showed healing in 75.0% and with post in 88.2% of the cases (Table 3) (n. s.). Comparing healing with teeth with and without posts, the healing rate was at the same level (88.7% / 86.5%). The restoration material made also no difference in healing, most common restoration material being composite (86.7%).

Total of 246 cases were excluded from this study. The reasons for exclusion were missing follow-up radiographs (58.5%), endodontic treatment for other reasons than infection i. e. restorative reasons (23.2%), missing diagnosis at baseline (16.3%), other missing information (0.4%), as well as poor quality of radiographs (1.6%). Some cases had more than one cause for exclusion.

Inter-examiner agreement was calculated considering both pre- and postoperative radiographs. Agreement between the observers considering healing ('*no healing*' noticed or '*healing*' noticed) was 1.00 and when analyzing length of the filling 0.75) and density of the filling (1.00). When periapical status was classified as 'no lesion' kappa value was 0.61. Proportion of equal results between the two observers was 77.8%. Intra-examiner agreement kappa values varied between 0.71-1.00, in 93.3% results were equal.

Discussion

Radiographically evaluated healing after endodontic treatments performed by dental students were good, *per se* in all tooth types. Our results are better than in other studies on endodontic treatments performed by undergraduate dental students [6-9]. High proportion of adequate root canal fillings made by undergraduates in the University of Oulu might be due to fairly strict protocol and teaching principles followed in the clinic: all non-adequate root fillings are redone if there is considered any possibility of achieving more acceptable outcome. Every step is supervised by the experienced clinicians and teeth with the most complex root anatomy are not treated in dental clinic by undergraduates either but referred to dentists or endodontists.

Comparing healing rates between tooth types in this study and other studies, the findings are similar. Huumonen and Ørstavik [4] reported that mandibular premolars have the best prognosis in postoperative healing, observed also here, although the difference between the tooth types in our study was not statistically significant. Studies concerning the effect of root canal posts in restorations on periapical healing after endodontic treatment have reported contradictory results [5,15]. In our study, no effect on periapical healing when using the posts, were observed. The quality of restorations and the effect of irrigate or other materials used during treatment on the outcome of endodontic treatments were not considered in this study.

Baseline diagnosis seems to have an essential effect on healing. Our results support findings in previous studies: teeth with vital pulp have better success rate than teeth with non-vital pulp [2]. Teeth diagnosed with pulpitis at baseline have better healing capacity

compared to teeth with apical periodontitis, noticed also here when teeth with healthy radiographic apical status was compared to teeth with expanded periodontal ligament or radiolucency seen in apical area.

The length of the root filling turned out to be the most significant factor for a radiographic healing. Influence of the length of the filling together with the density of filling to the healing has been evidenced in many studies [3,7,13]. Among the root canal fillings performed by the undergraduate students in the University of Oulu, the success rate in density was remarkably high, thus, the effect of density was not manifested. In almost 70% of the cases the length of the root filling was adequate and in almost all of them (93.1%) healing was seen in the follow-up radiographic pictures. When the root filling was of adequate length, postoperative periapical lesions were noticed in only in 35.2% of the cases. On the other hand, in teeth with a root filling more than 2mm short from the radiographic apex, there was a periapical finding in 45.0% of the cases. These findings are in accordance with other studies: teeth with root filling within 0-2mm from the radiological apex are manifested with less post-operative complications compared to those with root filling more than 2mm short from the radiographic apex [2,7]. On the other hand, overfilled root canals have shown postoperative periapical periodontitis in 75% of the cases [14] and survival of the tooth decreases after 22 months [3]. This was also the outcome in this study.

The quality of root canal fillings was analysed from conventional intraoral radiographic pictures, which is challenging for evaluating quality of root canal fillings or periapical lesions; radiographic pictures display a two-dimensional view and that is why length of the filling may not appear correctly [1]. In this respect, electronic apex finders are most valuable, and are also commonly used in the local dental teaching unit. It was noticed in this study that adequate filling length in one radiographic image might be short in another picture taken from different projection angle and also teeth with healthy periapical area seem to have a periapical lesion. Intraoral radiographs are also challenging way to evaluate density and voids in lateral seal in root canals. The evaluation is more reliable when radiographs are taken from mesial or distal angulation or both [1] which was not true in our data. In most cases there was only one radiograph to be analyzed. According to Møller et al. [16] all root canal fillings have voids when analyzed with micro-CT: 100% in the coronal third, 88% in the middle third and 96% in the apical third. Observers tend to underestimate the proportion of voids with radiographic systems compared to the cone beam computed tomography (CBCT) validation but at the same time with conventional radiography only few false positive records are done whereas cone beam computed tomography results in a several false positive recordings [16]. The method is still not commonly clinically used, but most likely in future.

Proportion of cases with missing diagnosis (16.3%) - the cause of the endodontic treatment was surprisingly high. This reduced our sample size distinctly - only 105 out of 351 cases could be included, which definitely is a weakness in the study. Some information or treatment procedures may be considered as self-evident which might be the reason for lack of written information. Categorizing teeth into groups for analyses reduced the group sizes even further. Routine postoperative follow-up appointment after 12 months of root treatments has been in practice in the dental clinic of Oulu from 2010, but, unfortunately, during the first years the recall system was not that systematic and lack of follow-up radiographs and long term follow-up times was common. Rather long variation in the follow-up time needs to be considered also when healing is evaluated, therefore, partially and completely healed teeth were combined in this study. The essential point was that healing was noted even though it was still in progress.

During the endodontic treatment students fill up a form of every step concerning details first manually and then information is transferred to electronic patient file afterwards. New electronic patient file system used in the dental clinic is different from the one used in between 2010 and 2011 - the new one has a specific site for a diagnose code; this site was lacking in the old version. That might partly explain missing diagnose codes in so many cases. In addition, diagnosis given at the baseline did not always equate preoperative radiographic status especially when given diagnosis was pulpitis. Delay after given first aid to pulpitis and starting the actual endodontic treatment and finally taking the preoperative radiograph, may partly explain the big proportion of periapical lesions in teeth originally diagnosed having pulpitis. Most of the teeth with pulpitis were treated within two months from the date of the diagnosis which predisposes the tooth for an infection due to i.e. leaking temporary restoration. With correct protection against infection during the treatment along with adequate cure, pulpitis should not progress to apical periodontitis if the treatment is performed within a reasonable period.

Individual factors were not considered in this study. Healing potential of tissues can be decreased because of poor general health (i.e. unstable diabetes mellitus) and high age. Marques et al. showed that age has an influence to the outcome of direct pulp capping [17]; the age of the patient most probably influences also to the severity of periapical lesion and especially to the healing. Ng et al. reported that patients suffering from diabetes did not have lower chance of healing, but did have higher chance of tooth loss after endodontic treatment [3]. Dental clinic of the University of Oulu accepts patients of all ages and also medically compromised.

Successful endodontic treatment depends on elimination of the existing infection and effective infection control of re-infection of the root canal [18]. It has been shown that saliva contamination inserts new micro-organisms to root canals and worsens the prognosis of the treatment [19]. To prevent re-infection, use of the rubber dam is the best way to isolate the operated tooth and the most essential factor to determine the success of the treatment [18,19]. Use of rubber dam was not mentioned on patient history so that factor could not be included in this study even though the rubber dam clamp was seen in radiographic pictures. The routine use of rubber dam in dental clinic of the University of Oulu seems to have effect on the good postoperative prognoses of endodontic treatment performed.

In accordance to our hypothesis teeth with preoperatively healthy periapical status or diagnosed pulpitis had better healing proportion compared to teeth with periapical lesion or diagnosed periapical periodontitis at baseline. However, length of the root canal filling compared to radiographic apex turned out to be the most significant individual factor predisposing the healing. Restoration materials seemed not to have effect to healing in this study. Root canals with over preparation had lower healing rate, but the proportion of those cases was too small to draw conclusion.

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