MASTEROPPGAVE

Evaluation of the outcome of non-surgical root canal treatment performed at the student clinic, University of Tromsø

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Abstract

Aim: The aim of this study was to evaluate the outcome of non-surgical root canal treatment performed at the student clinic and the factors influencing this outcome.

Materials and methods: This retrospective study involved follow-up of patients who had been receiving root canal treatments at the Student Clinic University of Tromsø (UTK). Endodontic records and periapical radiographs of 141 teeth from 126 patients were collected, 89 patients met our inclusion criterias. The recall rate was 76% with 68 patients, and we followed up 83 teeth. Chi-square tests were used for statistical analysis.

Results: The rate of healed/healing of root canal treatments ranged from 81% to 92%, depending on the pulp status pretreatment. Higher failure rate occurred in 4th year students compared to 5th year students (20 and 7% respectively), and in multi rooted teeth compared to single rooted (17 and 8%) and more than 2 sessions compared to 2 sessions (19 and 6%) and in the use of handfiles compared to Pro Taper (17 and 8%). Overall quality of obturation was low, with only 33 complete filled teeth (40%). When root canal fillings were more than 2 mm short from radiological apex failure rate was high, 7 teeth (26%), as compared to flush fillings with 4 (9%) cases of failure. Overfilled teeth did not show any failures.

Conclusion: Overall, in spite of a relative high healed/healing rate, there is need for improvement when it comes to the quality of obturation and number of treatment sessions. Further long-term follow-up is recommended to achieve a more reliable outcome result.

Contents

Introduction

Endodontic therapy is one of the basic procedures that are designed to maintain the health of all or part of the dental pulp. When the dental pulp is diseased or injured, treatment is aimed at preserving normal periradicular tissue. When apical periodontitis has occurred treatment is aimed at restoring the periradicular tissue to health (1, 2, 3).

Criteria for successful root canal treatment (RCT) outcome are lack of symptoms, radiographic healing, and restored functionality of the tooth (4,5,6). Healing of the apical periodontitis (AP) is a dynamic process. It has been shown that changes of bone structure can be visualized on a radiograph after an observation period of minimum of six months (7). After the RCT, clinical and radiographic follow ups at regular intervals for a minimum observation period of 1 year are desirable, but longer may be required where healing is incomplete or there is a history of trauma (1, 8, 9). If apical periodontitis do not heal after 4 years, root canal treatment is considered a failure (1).

For vital teeth a successful outcome can be expected in up to 90-95% of the cases (10, 11, 12). The success rates for necrotic teeth with radiographic lesions are 10% to 25% lower compared to vital teeth (10, 11, 12, 13, 14, 15, 16, 17). The success rates for vital and non-vital teeth without periapical lesion, on the contrary, are equal (17). This is important information when determining prognosis and outcome of endodontic treatment.

When evaluating the outcome of RCT there is a need for a reliable, comparable and non- bias and non-subjective assessment of apical periodontitis. Calibration of the observers is a requirement when reliable assessments are desired, particularly when multiple observers are employed (18). On this basis the periapical index, PAI, was introduced by Ørstavik et al in 1986. It is a scoring system for radiographic interpretation on a 5 point scale from 1-5 in order of healthy (score 1 and 2) and diseased (score 3 to 5) periapical tissue, using 5 pre-evaluated radiographic images. To avoid bias the examiner is calibrated until reaching a level of sufficient consistency (silver standard).

There are several prognostic factors that are able to affect the prognosis of root canal treatment. All these factors can be divided as pretreatment, during and after treatment (13, 16, 19, 20, 21, 22, 23).

An assessment of the clinical outcomes of RCT performed by undergraduate students is important for a critical re-evaluation of teaching methods (24). There are some reports on quality and outcome of root canal treatments performed by undergraduate students. Brazilian Dental School reported a

combined percentage of successful and healing cases of 93.5% after one year for primary RCT, but 75.5% after three years. In retreatment cases the healed and healing was 81 % after one year (25). In Norway we were able to find one study from Oslo where the overall success rate of endodontic treatment performed by undergraduate students was 91 % (10).

The aim of the present investigation was to evaluate the outcome of non-surgical root canal treatment performed at the student clinic by undergraduate students and the factors influencing this outcome.

Materials and Methods

For this follow-up study we recalled patients who underwent initial root canal treatment and retreatment at the Student Clinic University of Tromsø (UTK). All treatments were performed at UTK by undergraduate students, between the years 2008 to March 2012. All of the treatments were supervised and acknowledged by dental practitioners working as supervisors at the student clinic. Specialists in endodontics were only consulted when needed.

The inclusion criteria were;
a) There had to be a minimum of 6 months since the RCT was performed
b) All RCTs were performed by the undergraduate students at UTK
c) Preoperative and postoperative radiographs of the treated teeth had to be of good quality. It had to show the entire length of the root and the periapical area

A chart with patient information, symptoms and diagnosis must be completed when endodontic treatment is performed by students at UTK. All available diagnostic charts, annex 1 (Appendix 1) of endodontically treated patients were collected, and a total sample of 126 patients was obtained from these charts. We phone called the patients to attend recall examinations. To improve the recall rate, attempts to reach the non-responding patients were repeated by further phone calls and also sending recall letters.

It was advised that ethics approval was not required because the clinical and radiographic procedures constituted a routine check-up and did not expose the patients to any unnecessary or additional risk(s).

The patients were divided in three groups, and the operators examined one group each. The operators followed a pre-developed (in cooperation with tutor) form (appendix 2) to ensure uniform examinations and collected information. At the follow-up examination, the patients were asked about the presence of pain (spontaneous, or upon chewing or pressure) from the treated teeth, which also were examined clinically for any swelling, sinus tract, mobility, tenderness to palpation/percussion and coronal restoration. Because it requested additional inter observer calibration and was time consuming to evaluate the quality of the coronal fillings, we chose to only distinguish between temporary and permanent coronal restorations.

In addition a follow-up radiograph was taken, using a size 2 photostimulable storage phosphor (PSP) imaging plate with a positioning device (Eggen holder). The intraoral x-ray unit was SoredexMinray, and the imaging plates were developed in an automatic processing machine (DigoraOptime, Soredex).

The radiographs were investigated in a darkroom on a computer screen with "Olórin" software (QUBYX). The screen resolution was 1280x1024, grayscale consisting of 1024, color quality of 32 bit, refresh rate of 85 hertz and memory size of 256 MB.

Cohen's Kappa value (26) was used for intraobserver calibration.

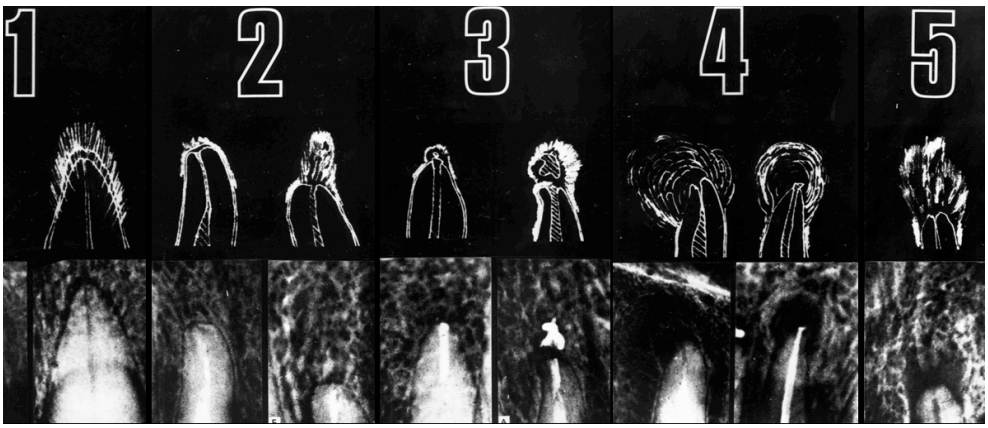

Figure 1 PAI index

The three operators together with tutor evaluated and discussed another set of radiographs to agree on radiographic quality of root fillings, prior to the clinical study.

Evaluation of the periapical status was based on two radiographic images; pre-operative and follow-up radiograph. Evaluation of the technical quality was based on the post-operative radiograph and was evaluated according to length from the root apex and homogeneity using a modified version of Peterssons`criteria (27). "Complete root filling" was assigned for a homogenous filling finishing 0-

2mm (flush) from radiographic apex. “Incomplete root filling” was recorded if the filling terminated more than 2mm from radiographic or extended beyond radiographic apex and/or showing voids and porosities.

Each radiograph was examined and discussed by all three operators together. When operators disagreed, the tutor was consulted.

The outcome evaluation was based on the variables;

1. Pre-operative factors: number of roots (one or more), diagnose (vital, non-vital with AP, non-vital without AP), retreatment cases

2. Intra-operative factors: year of student, number of treatment sessions, time between first session and obturation, the use of hand or rotary files, the technical quality of the root fillings and iatrogenic mistakes (fractured instrument, perforations, ledges)

3. Post-operative factors: clinical signs and coronal restoration

The root used as unit of measure is controversial as it is considered inappropriate and has a tendency to over-estimate success rates (28). It was therefore decided to use the tooth as a unit of measure in this study. The status of a multi-rooted tooth was represented by the worst-appearing root and, hence they would have multiple chances for post-treatment disease.

Outcome assessment was based on clinical and radiographic evaluation (28):
HEALED – if there was absence of periradicular radiolucency and absence of clinical signs and symptoms.
HEALING – if there was periradicular radiolucency smaller in size than pre-treatment radiograph showed, and absence of clinical signs and symptoms
DISEASED – if there was emerged or periradicular radiolucency at the same size as the pre-treatment radiograph and presence of signs and symptoms

IBM SPSS Statistics 19, was used for statistical analysis. We looked at bivariate associations between the pre-, intra- and post-treatment factors and the treatment outcome, using contingency tables and the Chi-square Test of Proportions or the Fisher`s Exact Test. All statistical tests were performed as two-tailed. To simplify the processing of statistical data we dichotomized the variables healed and healing. All the tests were interpreted at the 5% significance level.

Results

All the available diagnostic forms completed in the period from 2008 to 2012 were received. A sample of 141 charts from 126 patients was collected. We were able to recall totally 68 patients and observe 83 teeth out of the diagnostic charts. Recall rate was 76%.

We excluded 37 patients (29%), due to either lack of patient information, which made it impossible to find them in the journal system, or there was less than 6 months since obturation or students had not completed the treatments. In addition, another 21 patients could not be reached of various reasons; 6 patients had moved from the county, 3 patients did not want a follow-up examination and 12 patients did neither respond to phone calls or letters.

All results of the frequencies of pre-, intra- and postoperative factors and their association with treatment outcome are presented in Table 1.

None of the included prognostic factors showed statistically significance in the association with treatment outcome. The preoperative factors: single rooted teeth had fewer failures than multi rooted teeth, 3 (8%) and 8 (17%) respectively. We divided the necrotic teeth in two groups; necrotic teeth with and without AP. The first group showed healed/healing in 34 cases (87%), whereas the latter group had a healed/healing rate in 11 cases (92%). Vital teeth showed a healed/healing in 14 cases (88%), and retreatment cases showed a lower healed/healing rate with 13 cases (81%).

Table 1 Frequencies (%) of pre-, intra- and postoperative factors and association with treatment outcome. N= 83

	Prognostic factor		*Frequency (%)*	*Healed/healing (%)*	*Failure (%)*	*Significance*[a]
Pre-operative factors	Number of roots	1	37 (45)	34 (92)	3 (8)	N.S.
		≥2	46 (55)	38 (83)	8 (17)	
	Pulp status					N.S.
		vital	16 (19)	14 (88)	2 (12)	
		necrotic no AP	12 (15)	11 (92)	1 (8)	
		necrotic + AP	39 (47)	34 (87)	5 (13)	
		retreatment	16 (19)	13 (81)	3 (19)	

Intra-operative factors	Year of Student	4^{th}	40 (48)	32 (80)	8 (20)	N.S.
		5^{th}	43 (52)	40 (93)	3 (7)	
	Treatment Sessions	2	36 (43)	34 (94)	2 (6)	N.S.
		>2	47 (57)	38 (81)	9 (19)	
	1st session To obturation	≤ 1 month	46 (55)	42 (91)	4 (9)	N.S.
		> 1 month	37 (45)	30 (81)	7 (19)	
	Type of Instrument	handfiles	49 (59)	41 (83)	8 (17)	N.S.
		ProTaper	34 (41)	31 (92)	3 (8)	
	Filling from radiological Apex	short	27 (33)	20 (74)	7 (26)	N.S.
		flush	46 (55)	42 (91)	4 (9)	
		overfilled	10 (12)	10 (100)	0 (0)	
	Voids					N.S.
		Yes	23 (28)	19 (83)	4 (17)	
		no	60 (72)	53 (88)	7 (12)	
	Perforations					N.S.
		Yes	5 (6)	4 (80)	1 (20)	
		no	78 (94)	68 (87)	10 (13)	
	Fractured instrument					N.S.
		Yes	2 (2)	2 (100)	0 (0)	
		no	81 (88)	70 (86)	11 (14)	
	Quality of obturation					N.S.
		complete	33 (40)	31 (94)	2 (6)	
		incomplete	50 (60)	41 (82)	9 (18)	
	Time after RCT completed					N.S.
		6-11md.	35 (42)	33 (94)	2 (6)	
		>11 md.	48 (58)	39 (81)	9 (19)	
Post-operative factor	Restoration					N.S.
		permanent	79 (95)	68 (86)	11 (14)	
		temporary	4 (5)	4 (100)	0 (0)	

a: P-value: Fisher's Exact Test; N.S. : p>0,05

4^{th} year students had more failures than 5^{th} year students, 8 teeth (20%) and 3 (7%) respectively. Also, the number of treatment sessions had impact on failure rate; more than 2 sessions had higher failure rate 7 (19%) than only 2 sessions 2 (6%). When it comes to type of instrument there was a difference in failure between handfiles and ProTaper. When the root canal was prepared with hand files, failures were observed in 8 (17%) cases and 3 (8%) cases failed when canals were prepared with ProTaper.

Overall quality of obturation was low, with only 33 complete filled teeth (40%) out of 83 evaluated. But only 9 (18%) of the incomplete obturated fillings were failures and only 2 (6%) teeth of the complete fillings showed the same. When root canal fillings were more than 2 mm short from

radiological apex, failure rate was high, 7 (26%), as compared to flush fillings with 4 (9%) cases of failure. Overfilled teeth did not show any failures.

Table 2 Complete and incomplete root fillings performed by students according to tooth type

Tooth type	Total	Complete	Incomplete
Singel rooted	37	20 (54%)	17 (46%)
Multi rooted	46	13 (28%)	33 (72%)
Total	83	33 (40%)	50 (60%)

$p< 0,05$, Chi square

Statistical significance was found between complete and incomplete root canal fillings in single and multirooted teeth (Table 2).

In total, a positive outcome of the RCT completed before 11 months was (94%), 33 teeth healed out of 35. When follow up was more than 11 months, positive outcome was observed in 39 out of 48 (81%) cases.

In this study only 4 teeth had temporary filling at the moment of recall and none of these teeth were failures.

Discussion

This retrospective study was conducted to evaluate the outcome of endodontically treated teeth at UTK. All treatment procedures and the recording of the data followed a standardized protocol.

The relative small sample distributed on approximately 90 students in this period, may be due to several factors. Charts have failed to be handed in, but more importantly the students have less clinical sessions at the University student clinic than other dental schools (29). The Dental School at The University of Tromsø complies with a decentralized education model where students have external clinical education in 7th semester and 10 weeks in the 10th semester. We did not include treatments performed in external clinics because we did not have access to external journals.

In our study a response rate of 76 % is considered acceptable. Castelot-Enkel et al (30) had in comparison a reply rate of only 27%. Ng et al (31) refers to a 53 % median recall rate in previous studies for initial RCT and 74 % for retreatments.

In the majority of studies a successful outcome is defined by strict criteria, defined by full normalcy, radiological and clinical (28). Our outcome criteria could give higher success rate in comparison to the strict criteria, and give a false-positive result (28).

The highest percentage of acceptable root fillings was noted in single rooted teeth and the lowest in multi rooted teeth. This was not surprising, considering that the evaluated unit was the tooth, not the individual root. Similar results were found in other educational institutes (32, 33).

The pre-operative status of the tooth seems to be relevant for the outcome of endodontic treatment. Some studies show that vital teeth have significantly higher success rate than non-vital teeth (7, 15, 34). Other studies have found no such statistical difference (35, 36, 37). Ng et al (17) shows no difference between vital cases and necrotic teeth without AP, but necrotic teeth with AP had a lower success rate than the two other groups. The fact that in our study necrotic teeth with no AP had a higher healed/healing compared with vital cases, may be due to number of treatment visits. In the standard of care (Appendix 3) at UTK it is advised to finish pulpectomy at the first visit, but this has not been the case in any of the treatments in our study. Several studies (15, 35, 38, 39) shows that the success rate of non-vital teeth with AP is lower than non-vital teeth without AP and vital teeth. Our study however, showed that necrotic teeth with AP only had 1% difference in failure rate compared to vital teeth. A possible explanation can be that there were few vital cases included in our sample, in addition to the fact that none of the vital cases were finished in one visit. We found that the least favorable diagnose was retreatment. This is in accordance to other studies (13, 14, 34, 39, 40). It should be mentioned that in our study we had few vital and retreatment cases, compared to other studies where vital cases ranged between 32% and 37% (10, 41, 42, 43). Castelot-Enkel et al (30) had a frequency of 46% retreatment cases, while Kerekes and Tronstad (10) had 12%. The lack of vital cases may be due to that UTK has no acute department, so very few acute vital cases are treated here.

Of the intra-operative factors analyzed, competence of the operator stands out. It is reason to believe that both clinical competence, knowledge and self-esteem is of matter when performing root canal treatment, and that this is progressing from 4^{th} to 5^{th} year. But, it has earlier been found that there is no significant difference in success rates in relation to qualification and experience of the (8, 17, 32, 43). Kerekes and Tronstad (10) states that their overall results clearly indicate that the treatment method in endodontics is difficult to master for practitioner less experienced in endodontic therapy. This is in correlation with Castellot-Enkel et al (30), who found that undergraduate students had a lower success rate in RCT than postgraduates.

As stated earlier none of our recorded treatments were carried out in one single visit. This is probably due to the increased time used on treatment in a student environment. Teeth treated in more than 2 visits had a lower rate of healed/healing. This is in correlation with Lee et al (42) who found that over 2 treatment session lowers the survival of the treated tooth.

Time between 1st session and obturation date showed to be of notice. Treatments carried out within 1 month failed in fewer cases than treatments carried out over 1 month. It should be mentioned that between treatment sessions, antiseptic calcium hydroxide is placed in the canals for minimum 5 days and maximum 4 weeks at UTK. We could not find any studies that evaluated time between 1st session and obturation.

We found few clinical and radiological studies that compared outcome to the use of handfiles and rotary instruments. However Majid et al (44) concluded that there is fair evidence to recommend use of rotary over hand instrumentation in root canal preparation. In our study outcome of treatments performed with ProTaper had a lower failure rate.

In our study there was a difference in healed/healing rate in relation to the distance of the root filling from the apex. Many studies found that flush fillings are associated with higher success rates than short root fillings or long root fillings. Short root fillings in turn are associated with significantly higher success rates than overfilled root fillings (7, 10, 15, 17, 38, 42). We had 100 % success rate for overfilled root fillings. This may be connected to our small sample size, only 10 teeth were overfilled, or because of the short follow up time. Two of these teeth had one overfilled canal and one short canal, and in these two cases we labeled the tooth as overfilled since most of the literature shows more failure cases when overfilled compared with short root fillings (36, 38, 45). However, some has stated that apical excess of material alone does not prevent healing, but is seen in association with a defective apical seal, and that the material in the periapical area may disappear and thus return to normal radiographically (10, 46). Another factor to be taken in consideration is the reliability of using periapical radiographs (PA). Several studies (47, 48, 49) have shown that PA can ignore overfillings, because apical foramen is often shorter than the anatomic apex. Liang et al (50) found that over 16% of flush fillings on PA were diagnosed as long fillings on CBCT, and over 76% of short fillings on PA appeared as flush fillings on CBCT. This means that some of our flush fillings may be overfilled in reality and some of our short fillings actually may be flushed.

We did not distinguish between voids in the apical part and the coronal part. Cheung (43) found that voids in root fillings present at the mid or apical third had significantly worse outcome than those with voids present in the coronal third or those without voids. Ng et al (17) found that radiographs with a presence of voids, had significantly lower success rates than those without any radiographic indication of a non-homogenous filling. Unfortunately there is no calibration or standardization for this sort of measurements (17). In addition, Liang et al (50) reveals that detection of voids with PAs can be ignored compared to CBCT scans. Voids along inadequate root fillings may be invisible on two-dimensional PA because of a superposition of root-filling materials. We used periapical radiographs and therefore some voids probably have not been detected.

The teeth we found to have incomplete fillings relates to the quality of the obturation, judged by radiographs. 9 of these teeth (18%) failed. How can it be that 82% of incomplete fillings were healed/healing? In the incomplete filling group, the degree of incomplete is not calculated. As mentioned above PA influences the evaluation of quality. It can be that some of the fillings we evaluated as incomplete on PA, in reality were complete. Also, voids in the coronal part were judged as incomplete, but Cheung (43) reported that coronal voids did not affect survival time as much as apical voids. Kerekes and Tronstad (10) reported from the university in Oslo in 1979 that undergraduate students achieved ideal root canal fillings in only 50 % of the roots under supervision of experienced endodontists. Of the ideal root fillings the success rate was 92%-93 %. We observed healed and healing of complete root fillings in 94 % of the cases.

The length of the observation period after the completion of an endodontic treatment is important for valid conclusions. Time must be allowed for healing after the treatment, but also to observe whether or not a wound infection has emerged. Gesi & Bergenholtz (22) among others states that the treatment outcome observed after a short period of time may differ from that observed at later time periods. Jokinen et al (38) concluded that results obtained with observation periods shorter than one year are unacceptable, since the vast majority of unsuccessful cases were noticed within two years of treatment. Almost half of the teeth included in our study were observed for only 6-12 months, which is a short period of time. These cases were included due to low sample available, and only 2 of these cases were failures. The healed/healing cases may not reflect the long-term outcome of the therapy. A periapical lesion may emerge sometime after RCT, but Ørstavik (9) states that the probability for this after 1-year-follow-up is not likely to be high. Ørstavik (9) recorded that the peak incidence of emerging apical periodontitis was at 1 year. Assessments after 2, 3 or 4 years of follow-up did not show an added risk for development of apical periodontitis (9). Healing of apical periodontitis is seen within the first year after nonsurgical treatment, and signs of healing are

evident in nearly 90% of the teeth that heal eventually (51. But according to Ørstavik (9) completion of the healing process, however, often requires a longer time. Therefore, of all the teeth that heal eventually, only about 50% appear completely healed by 1 year, the majority appear healed after 2 years, and a small percentage appear healed only after 4 to 5 years long follow-up periods. The follow-up group over 12 months had a 13% increase in failure rate compared to 6-11 months group. This is in correlation with Strindberg (13) and Engström & Lundberg (52) who found a significantly higher rate of failures at the 3, 5-4-year follow-up than at the 1-year check. Ng et al (53) reported success rate of root canal treatment from 60% to 100%, and found no obvious trend in success rate by duration after treatment when strict criteria was not used. Since this factor may influence the outcome, the long-term outcome of our study may differ from today's findings.

According to Lee & Cheung (42) several studies have shown that exposure of root canal filling to saliva and bacteria has a negative effect on the outcome, and that a good-quality coronal restoration is important to ensure long-term success of root canal treatment. Ng et al (31) found that the type of coronal restoration had no significant influence on treatment success. Chugal et al (54) also reported this, that temporary vs. permanent restorations had no influence on periapical healing. However, Chugal et al (54) showed that the protective effect of coronal restoration is enhanced if it is placed soon after the completion of endodontic treatment, and temporary restoration teeth failed compared to the permanently restored teeth by 40% to 20,5%. In our study every tooth had a restoration on top of the root canal filling at follow-up. 4 teeth had a temporary filling, and all were healed/healing. The majority of the teeth with permanent top filling were in the same category. This may indicate that temporary fillings such as cavit and IRM serve as an adequate seal. Again, our results may be due to a small sample size. Ray&Trope (55) concluded that the quality of coronal restoration is significantly more important than the quality of the root filling in securing periapical health. This concept has been argued, but nevertheless coronal leakage is one of the main factors in long term outcome. Tronstad et al (56) found that the quality of the root filling was the most important factor for the outcome of endodontic treatment, where the coronal restoration was of no importance for the outcome of the endodontic treatment. This is in correlation with Riccuci et al (57) and Riccuci & Bergenholtz (58). They reported that coronal leakage may not be such a significant factor for lesion development, if the endodontic treatment is well performed. The latter studies showed that good fillings in optimally prepared canals may resist bacterial penetration, even after long-standing exposure to the oral environment. On the other hand, Castellot Enkel (30) found that the lack or imperfect coronal restoration compromised the long-term success of endodontic treatment.

Conclusion

Overall, in spite of a relative high healed/healing rate, there is need for improvement when it comes to the quality of obturation and number of treatment sessions. Further long-term follow-up is recommended to achieve a more reliable outcome result.

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Conflict of interest

The authors declare that they have no conflict of interest

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Appendix 1

ANNEX 1

OPUS journal #: Endodontic Diagnostics & Therapy Date: Patient Name:.....Age:.....Sex:..... Student Name:.....Instructor:..... Tooth #.....

1. Subjective Finding:

Chief Complaint..... ..... Significant Medical History..... .....

History of tooth : (Mark all appropriate)

1. Trauma 4. Restoration(2. Caries 5. Pulp capping 3. Carious exposure 6. Pulpotomy 7. R.C.T 8.....

Nature of pain(Mark all appropriate)

0. None 1. Spontaneous 2. Provocated (by.....) 3. Short 3. Prolonged 4. Localised 5. Diffuse

Reaction to thermal stimulus:

0. None 1. Short 2. Continuous

Reaction to mastication

0. None 1. Mild-Mod 2. Severe _____ 2. Objective Signs and Tests Tooth # ------ ------ ------ ------

Pulp testing (+, -, NA)

)

3. Radiographic Findings

0. Normal 1. Apical radiolucency 2. Apical root resorption 3. Apical radiopacity 4. Furcal Radiolucency _____ 4. Diagnosis

Pulpal

1. Normal 2. Reversible Pulpitis 3. Irreversible pulpitis 4. Necrotic pulp

Periapical

1. Normal 2. Acute apical periodontitis (AAP) 3. Chronic apical periodontitis(CAP)

- Condensing osteitis 4.Acute apical abscess (AAA)

5.Suppurative apical period. (SAP) WHO-ICD-10 code: K04._____

_____

5. Pre-treatment Prognosis

0. Favourable 1. Questionable 2. Unfavourable _____ 6. Treatment Plan

Endodontic: Urgent/emergency care.....

Definitive care..... Periodontic..... Restorative..... DATE AND SIGNATURE OF INSTRUCTOR ____ 7. Obturation Evaluation

0. 0-3 mm short of the apex (acceptable) 1. Overextended.....mm 2. Underfilled.....mm 3. Empty canal visible apical to the GP 4. Voids/buckling

_____
8. Post-Obturation Prognosis

0. Favourable 1. Questionable 2. Unfavourable DATE AND SIGNATURE OF INSTRUCTOR ____

EPT :

Thermal

------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------

Short Prolonged ------ ------ ------ ------

Periapical tests: None(0),mild-moderate (+),severe(++)

Perio probing ----- ------ No pockets deeper than 4 mm

=>

Percussion ------ ------ Palpation ------ ------

------ ------ ------ ------

------ ------ □

1. Present Diffuse Diffuse 1. Present

Swelling: Intraoral: Extraoral: Sinus tract:

0.Absent Localized Localized 0. Absent

=>

Appendix 2

Outcome of root fillings completed by undergraduate students, Faculty of Dentistry, University of Tromsø, Norway

Opus No. ☐

Examiner ID: 1 = Linn, 2 = Linn K, 3 = Ragna ☐

Year of student, 1= 4 yr, 2 = 5 yr ☐

Tooth number of FDI system ☐

Diagnose;
1 = vital, 2 = necrotic, 3 = retreatment ☐

Apical status pretreatment, PAI: 1-5 ☐

Date RCT completed (d/m/y) ☐

Number of treatment sessions up to obturation
1 = one session, 2 = two sessions, 3 = > 2 sessions ☐

Time between 1st session and obturation;
1 = within 1 month, 2 = > 1 month ☐

If 2, number of months ☐

Number of canals of treated tooth ☐

Quality evaluation

Quality of filling obturation (tooth);
1 = complete, 2= incomplete apical, 3 = incomplete lateral ☐

4 = incomplete lateral&apical, 5 = no filling, 6 = not assessable

Presence of root filling material in the apical periodontal ligament space;
1 = no, 2 = yes < 1mm, 3 = yes >1mm, 4 = not assessable ☐

Distance of root filling from radiographic apex(mm)
1 = 0-2 mm, 2 = 2-3 mm, 3 = > 2 mm ☐

Furcation perforation;
1 = yes, 2 = no, 3 = not assessable ☐

Lateral perforation;
1 = yes, 2 = no, 3 = not assessable ☐

Apical perforation;
1 = yes, 2 = no, 3 = not assessable ☐

Fractured instrument
1=yes, 2=no, 3=not assessable ☐

Follow-up clinical examination and radiograph

Reason for failure
1= tooth is present, 2= retreatment, 3 = extraction ☐

Symptoms from tooth area
1=yes, 2=no, 3 = fistula ☐

Pain when palpation
1=yes, 2=no ☐

Pain when percussion
1=yes, 2=no ☐

Restoration

1= direct permanent, 2 = indirect permanent (crown/onlay etc)

3 = Temporary, 4 = lost filling

Apical status follow-up, PAI:1-5

Probing depth

1 = no deeper than 4 mm, 2 = > 4 mm

Outcome

1=healed, 2=healing, 3=failure

Appendix 3

Standard of Care in Clinical Endodontics

Patient selection preferences per semester:

6th and 7th semester:

- Pulpal therapies
- Primary endodontics ONLY
- Non-complicated canals ONLY (avoid abrupt curvature)
- Preferable vital cases but non-vital cases also accepted.

8TH semester:

- As before, Primary non-complicated endodontics ONLY.

9th and 10th semester:

- Preferable mostly primary cases
- Retreatment (orthograde, non-complicated, not molars); two cases mandatory.

General guidelines for the treatment sequence:

In ALL cases, regardless of the diagnosis, once the canal treatment is started (first file introduced), the chemo-mechanical preparation should preferable be finished in the same appointment up to the final (previously determined) size, a minimum of #35.

Vital cases

The canals are obturated in the 1st visit, whenever feasible. But make sure that i) canal(s) can be dried (there is no blood or tissue exudates weeping into canal after the last paper point) and ii) time allows a proper obturation.

In case the obturation is postponed, the canal is NEVER left empty, but filled with calciumhydroxide, properly temporized and obturation rescheduled preferable within a WEEK but NOT later than 4 weeks. If longer time (up to 6 months) is planned, the calcium hydroxide must be packed.

Emergency treatment of acute pulpitis:

1) Preferable a pulpectomy (total extirpation of the pulp) is made, the canal is chemo-mechanically prepared and obturated (see above).
2) In molar teeth, if there is shortage of time, a pulpotomy (coronal pulp removal + cotton pellet + temporization) can be done instead, and the canals LEFT UNTOUCHED. In case the tooth is immature (open apex) pulpotomy (coronal pulp removal + Dycal + temporization) will be the final (pulpal) treatment. If the apex is closed, pulpectomy is scheduled ASAP but not later than ONE MONTH.
3) In either case, the tooth is reduced from the occlusion whenever possible, especially molar teeth.

Non-vital cases

The canal is NEVER obturated in the 1st visit, but calciumhydroxide is used as an intracanal medication for a MINIMUM OF 5 DAYS, BUT NOT LONGER THAN 4 WEEKS. Before obturation the tooth must be i) symptom free, ii) eventual sinus tract must have been closed and iii) the canal(s) must be able to get dry.

Emergency treatment of acute periapical abscess:

1) Place rubber dam.
2) Open the tooth and start chemo-mechanical preparation.

3) In some cases the pus can come out via the tooth by itself. You may also facilitate the drainage by increasing the apical foramen size up to size #25, but not larger. DO NOT try to push the pus through the tooth, but use tiny suction tips.
4) Wait until there is no more pus/exudation from the canal (this will take several minutes up to half an hour) and then continue the preparation up to the final size. Irrigate copiously (a lot!) with 2,5% sodium hypochlorite (NaOCl).
5) When getting the canal clean and dry, irrigate with EDTA and dry with paper points, place calciumhydroxide as an intracanal dressing. Temporize. Never expose the tooth to the saliva contamination by leaving it open.
6) Assess the need for incision of the abscess. Mature, fluctuating abscesses are opened, unless emptied already during the tooth preparation process. After incision, ensure the drainage with suturing a piece of rubber into the wound.
7) The antibiotics is prescribed only in case of i) generalized symptoms such as fever, fatigue and/or ii) the swelling has spread beyond the immediate vicinity of the tooth.
8) The tooth is reduced from the occlusion whenever possible, especially molar teeth.

Emergency treatment of acute apical periodontitis without abscess:

1) Chemo-mechanical preparation of ALL canals until desired final size (minimum #35).
2) Calciumhydroxide as intra-canal medication.
3) Temporization
4) The tooth is reduced from the occlusion whenever possible, especially molar teeth.

Irrigation/medication schemes

For irrigation, 2,5% NaOCl solution is used copiously (10 mL/canal) throughout the entire chemo-mechanical preparation. In non-vital cases EDTA and Chlorhexidine are also used.

Vital cases

The chemo-mechanical preparation is started with filling the canal/cavity with 2,5% NaOCl. No endodontic instruments are used dry. Thereafter the canal is irrigated each time between the files. Thereafter the canal is dried with paper points and routinely filled in the same visit with gutta-percha.
In case the obturation is postponed (see above), the canal is filled with calcium hydroxide and tooth is temporized. At the second visit the calcium hydroxide is removed by rinsing with 2,5% NaOCl and circumferential filing with master file, and root filled with gutta-percha.

Non-vital cases

All non-vital cases are treated as *infected*, hence special protocol is needed to eradicate the bacteria also from the dentinal tubules with intracanal dressing with calcium hydroxide (CH).

First visit

After the chemo-mechanical preparation and final irrigation with 2,5% NaOCl, the canal is filled with 17% ethylene-di-tetra acetic acid (EDTA) solution for 2 minutes to remove the smear layer. Thereafter the canal is dried with paper points and filled with CH and the tooth is temporized. In retreatment cases, Klorhexidin 1mg/ml (blue line) is used to rinse off the EDTA and kept for a minimum of 2 minutes, and dried before placing the intracanal dressing.

Second visit

After the calcium hydroxide has been rinsed off with 2,5% NaOCl (and the preparation size eventually increase by one step), the EDTA is placed for 2 minutes, and thereafter rinsed off with

Klorhexidin 1mg/ml (blue line), which is left for the entire time for master cone fit check-up radiographic procedures. Thereafter, the canal is dried with paper points and filled with gutta-percha.

Treatment step-by-step

1. Diagnosis and treatment planning
    a. Make sure that there is a GENERAL treatment plan where the particular tooth in question is included. In an acute case, where the above mentioned general plan is not available, make sure that the tooth is RESTORABLE.
    b. Follow a step-by step DIAGNOSTICS & THERAPY chart (ANNEX 1), even in cases that may not turn out to be treated endodontically.
    c. To assess the periapical health, a recent periapical radiograph is needed. OPG is a good adjunct, but NEVER acceptable as the only preoperative radiograph. Take eccentric projections, when appropriate (ANNEX 2) Take at least **two projections** whenever you are unsure of the findings.
    d. If the pre-treatment prognosis (section 5, in Annex 1) turns out to be UNFAVORABLE, the tooth is NOT treated in the student clinic. Reconsider also the treatment in cases with questionable prognosis.
    Inform the patient of the suggested treatment plan, including details of planned periodontal and restorative procedures (section 6, Annex 1). Inform also of the consequences of leaving the tooth without treatment. **CHECK (1) & SIGN IN "DIAGNOSTICS & THERAPY" CHART (ANNEX 1)**.
    e. Transfer the essential information of the approved diagnostic chart (also negative finding) to OPUS, but keep the chart with you during the entire endodontic treatment until the final restoration of the tooth. Write down in <opus the patient's acceptance (or refusal) to have the suggested treatment. **CHECK (and sign in OPUS by code).**
2. Preparation of the patient to the treatment
    a. Always briefly explain what and why you are doing.
    b. Cover the patients shoulders with plastic apron (on top use the standard apron)
    c. Cover the patients eyes with glasses (preferable dark, large enough)
    d. Never pass any syringe, sharp instrument, or light beam from the operating lamp over the patient's eyes.
3. Local Anesthesia
    a. Local anesthesia is offered to the patient in ALL endodontic procedures, including obturation visit. In non-vital cases, if there is no special reason to indicate anesthesia, the patient may refuse of having it. Vital cases are NOT started without a proper, *verified* anesthesia.
    b. Infiltration anesthesia is given *both* on buccal and lingual/palatal sides.
    c. In lower jaw a mandibular block is ALWAYS given. The sharp/dull test is ALWAYS performed on the lip, and the procedure is NOT started until the patient cannot tell them apart.
    d. In acute cases, if there are difficulties to reach the pulp, the following procedures MUST be tried i) intra-ligament injection (Peri-press) and ii) intra-pulpal injection.
4. Cavity opening before entering to the pulp
    - Outline form – is projection of the internal tooth anatomy onto the external root structure
    - Convenience form – allows modification of the ideal outline form to facilitate unstrained instrument placement.

- Caries removal – Removing caries permits i) the development of an aseptic environment before entering the pulp chamber, ii) allows assessment of restorability before treatment, iii) provides sound tooth structure for adequate provisional restoration.
- Unsupported tooth structure removal – ensures a coronal seal during and after treatment – cut the cusps of molars and premolars!
  - Naturally, this does not apply if "optimal size" access cavity only has been cut, and the marginal ridges are intact.
- Reducing the tooth from the occlusion – promotes the healing in the periapical tissues by eliminating the stress caused by biting forces.

N.B.! Complex restorations may have changed the coronal landmarks used in canal location. In difficult cases the access can be prepared without the rubber dam in place. This provides visualization of the tooth shape, orientation, and position of in the dental arch. When the canal or chamber is located, the rubber dam is applied. Until the rubber dam is in place, files cannot be used, not even in treating emergencies.

a. Before starting any procedure, make sure that you are acquainted with the equipment used in endodontics (ANNEX 3)
b. Before beginning the access the preoperative radiographs should be assessed to determine the degree of case difficulty.
c. For ceramic crowns/onlays use always diamonds, for metal crowns special trans-metal burs may be used.
d. Remove ALL caries, until sharp explorer does not stick to dentin. Note that discolored dentin does not need to be removed.
e. Consider all previous fillings a risk for leakage. Use dye test if intention to leave them.
f. Assess the need for build-up. Use composite.
g. Assess the need for cutting the cusp(s). The risk for fracture increases whenever the bucco-lingual width of an MOD cavity exceeds 1/3 of the entire cusp to-cusp width. Reduce 1,5 -2mm. Use wax to check if needed. When in doubt – cut.
h. Start access opening with a cutting tip bur in turbine hand piece, always with water cooling.
i. When predetermined depth is reached, the endodontic explorer is used to search for an exposure of pulpal horn/cavity. If not found, ask for ASSISTANCE. **CHECK (2)**

5. Rubber dam
   a. There will be NO endodontic treatments without rubber dam.
   b. To avoid putting the dam on a wrong tooth, the dam is placed after the initial cavity opening (turbine bur phase) but before entering the pulp chamber.
   c. Only in special cases where the alignment of the tooth is difficult to estimate, in agreement with the instructor or a specialist, the placing of dam may be postponed after the access cavity preparation, latest when the canal orifices have been found.
   d. Write down to patient journal OPUS the code of the clamp. If, for any reason, a clamp is replaced by other means (e.g. Wedjet) make a statement of this to OPUS.
   e. If the tooth does not stand the clamp, clamp the distal tooth, or clamp on the oral mucosa, after giving anesthesia and informing the patient (Int Endod J, (7) 2004).
   f. Cover both the mouth and the nose!
   g. Disinfect the working field (rubber + tooth including access cavity) by Klorhexidinsprit 5mg/ml Etanol 56% (red line) for 1 minute.
6. Access opening
   a. When the pulp is exposed, in molars and premolars change to non-cutting tip bur (Endo-Z) in blue hand-piece to remove the roof of the pulp chamber. Use endo explorer to check that all dentine overhangs are removed.

b. Sharp endodontic explorer is used for detection of the canal orifice.
c. Use always x2,5 magnifying loops. Dye staining, fiber-optic-trans-illumination (FOTI) and ultrasonic device may also facilitate the location of the orifices.
d. Avoid gouging. When canal(s) are located, fill in excessive gouging with glass ionomer, if needed. **CHECK (3) AND SIGN IN ENDODONTIC TREATMENT CHART (ANNEX 4).**

7. Negotiate the canal
   a. During the entire preparation irrigate the canal adequately (5-15 ml/tooth/session) with 2,5% NaOCL. Never prepare a dry canal.
   b. Use dull (but do not have to be side-vented), flexible needles 30 G .
   c. Never squeeze the tip against the canal walls.
   d. First, irrigate and fill the entire access cavity with 2,5% NaOCl. NEVER use any files DRY in the canal.
   e. Insert a small K-file into the canal using watch-winding motion (path finding). Usually start with #15, if it gets stuck, use #10, or #08, respectively. Do not push to avoid ledging.
   f. Use only intact high-quality files. Scrutinize the flutes before inserting file into canal
   g. If you expect the canal to be curved (most of the cases), PRECURVE the TIP of the file in the direction of the anticipated curvature. Note that only stainless steel files can be precurved.

8. Determine the working length
   a. Choose and write down to the Endodontic Treatment Chart (ANNEX 4) the reference point and make a drawing when appropriate (to be kept in patients files until the treatment is finished). Note that is done AFTER the cusps are cut).
   b. Separately for each canal, use the standardized abbreviations for each canal.
   c. Use first Apex-locator and verify the result with a radiograph (indikatorbilde). Routinely use file size #15K (in molars smaller files are not visible; in anterior teeth #10 may be used. Even in larger canals do NOT use sizes bigger than #25K (NiTi if curved) to avoid further damage in case of over extension.
   d. An acceptable INDIKATORBILDE with Corrected Working Length (CWL) is a must to continue. Do not hesitate to take another radiograph, if the file or apex is not clearly visible. Remember to explain the need for another radiograph to the patient.
      a. In the OPUS, describe the findings in all radiographs (interpretation) and the appropriate measures to make corrections, if any. **CHECK (4) AND SIGN IN ENDODONTIC TREATMENT CHART (ANNEX 4).**

9. Prepare a glide path to size #20
   a. Regardless of the preparation method (hand/rotary) prepare a glide path with hand files (#20K, or #20Niti-K) to the working length.
   b. Use all NiTi-K-files in a Balanced Force motion.
   c. When size #20 is reached, check the need for further coronal flaring to establish a STRAIGHT LINE ACCESS. If needed, use rotary instruments in brushing movement to enlarge the canal orifice, GG-burs, or circumferential filing with K-files.
   d. Check again the Corrected Working Lengths (CWL) with Apex-locator, and make amendments to the chart and OPUS, if needed. **CHECK**
10. Chemo-mechanical preparation
   a. Irrigate with 2,5% NaOCl (see paragraph 7a-c).
   b. Select the method for enlargement.
   c. Do not use rotary, if you have not passed the simulation tests or you do not feel confident.
   d. Make sure your instructor is familiar with the method you choose.

e. In curved canals, from size #25 onwards, do NOT use anything but nickel titanium (Niti-K-files, Protaper hand files, or ProTaper).
f. Whenever feasible, keep the rule that in elective cases (not acute) the chemo-mechanical preparation of the canal should be finished in one session. Thus, better leave e.g. one canal entirely to another session, than leave the preparation half-ways.
g. Prepare the canal to minimum size of #35 in the FIRST VISIT.
h. If there is any hesitation whether the CWL has been reached, take master-file radiograph. **CHECK (5) AND SIGN IN ENDODONTIC TREATMENT CHART (ANNEX 4).**
i. In case of iatrogenic **procedural error** during the access cavity or chemo-mechanical preparation the student should do the following without delay: i) identify the problem ii) inform he the clinical instructor, iii) inform the patient iv) **contact specialist from IKO** (Rita Kundzina in the first place), and if that is not possible, contact TkNN and v) document the incidence into OPUS before the session is over. Especially in case of perforations it is important to proceed to the closure ASAP.

11. Temporization
a. Do not leave cotton pellet into the cavity
b. Use Cavit in the deep parts of the cavity and place IRM on the top, if appropriate.
c. Make sure that the total layer of temporary material between the canal and saliva is at least 3 mm.
d. If 3 mm is not achieved otherwise, place the Cavit deeper to the canal.
e. Consider resin enforced glass ionomer filling as a temporary, in case there is a risk of fracture /loss of the filling.

12. Obturation
a. Take ALWAYS a master-cone RADIOGRAPH
b. A shortage of 0.5 mm is accepted, as condensation with sealer will squeeze the cone in place.
c. Take eccentric projections if needed to illustrate all canals.
CHECK (6) AND SIGN IN "ENDODONTIC TREATMENT CHART (ANNEX 4).
d. Take ALWAYS an obturation check RADIOGRAPH.
i. The rubber dam still on
ii. The rests of the cones already cut and maximal lateral and vertical condensation performed. **CHECK (7) AND SIGN IN ENDODONTIC TREATMENT CHART (ANNEX 4).**
e. After temporization, or after the final restoration (if it is placed within a week) take a final post operative radiograph (SLUTTBILDE)
f. With the same ordinary film holder that you used in the pre-op x-ray, as these are compared when assessing the healing.
g. To verify the 3mm thickness of coronal seal. **CHECK (8) AND SIGN TWICE: BOTH CHARTS (ANNEXES 1, 4)**

13. Final restoration
a. Whenever possible (anteriors being exceptions), the final restoration is postponed with a minimum of one week for i) not disturbing the initial periapical healing with occlusal loading ii) to make sure the tooth is symptomless before further restorative measures are taken.

14. Recall all endodontic treatments
a. Preferable after 6 months, but latest after 1 year

b. If assessed fully healed (or vital case with no changes) -> no need for further check-ups.
c. If there is partial, but not full healing, follow-up the case up to 4 years.
d. If there are changes in the vital case after 6 mo, consider retreatment.
e. If there is NO healing after 6 mo, follow-up another 6 months.
f. If there is NO healing after 1 year, consider retreatment.
g. Remember to document the findings and consideration into OPUS.

15. Set up a quality standard for your treatments, not a time limit!

Documentation

From each case, both in internal (IKO) and external clinics, if endodontic procedures have been considered and/or performed, the step-by step chart "Endodontic Diagnostics & Therapy" (ANNEX 1) should be filled in.

1. In case the endodontic examination did NOT lead to endodontic procedures, the chart (ANNEX 1), signed by the instructor, with paper copies of ALL the diagnostic radiographs attached to it, is anyway handed over to Associate Professor Rita Kundzina without delay (either personally, or in her mail box on the 4th floor).
2. In the actual endodontic treatment cases, the Endodontic Treatment Chart (ANNEX 4) is also filled in. After finishing the treatment, this chart should finally be signed by the instructor, paper copies of all radiographs should be attached to it, and both charts (ANNEXES 1 and 4) should be handed over to Associate Professor Rita Kundzina without delay (either personally, or in her mail box on the 4th floor). When in extern practice, documents from all cases can be handed out when returning to the institute (no need for mailing them). Note that in case the patient has several teeth under consideration for endodontic treatment, the chart is filled in separately for each tooth.
3. The pertinent information from both charts is transferred to the OPUS system.

List of Annexes (see separate files)

1. Step-by step chart "Endodontic Diagnostics & Therapy" (ANNEX 1)
2. Eccentric projections in endodontic radiography (ANNEX 2)
3. Endodontic Equipment in IKO (ANNEX 3)
4. Endodontic Treatment Chart (ANNEX 4)

See Next Page: Check list in brief (mixed English and Norwegian!)

Sjekkliste endo

At briefing:

- Student informerer om endobehandling
- Godkjent general behandlingsplan: the tooth is planned to be restored
- Aktuelt apikalbild (evt. flere), if applicable
- Utfylt "Endodontic Therapy"-skjema, if applicable
- Consider PATIENT SELECTION: undergraduate? which year?

1. SJEKK (chair side)
   - "Endodontic Diagnostics & Therapy"-skjema filled in: VL's signature
   - Consider PATIENT SELECTION latest now; evt. referral
   - Transfer av relevanta informationer til OPUS
     - Findings, Diagnosis, Prognosis, Tx Plan; sign electronically

2. SJEKK
   -Forberedelser av pas.: dekke pas. med plastikkduken, beskyttelsesbriller til pas.
   - Anestesi
   - Kofferdam (routinely)
   - Påbegynt cavumprep før pulpatak fjernes + okkl. reduksjon

3. SJEKK
   -Cavumprep (evt. i lag med veileder)
   -Kanallokalisasjon
   -"Straight line access"
   - Kofferdam (each case)

4. SJEKK
   -Bestemme arbeitslengde (apexlokator + rtg.) -> dokumentere i OPUS

5. SJEKK
   - "Straight line access"
   - Kjemo-mekanikal prep til minimum 35

6. SJEKK
   -Masterpointbilde

7. SJEKK
   -Rotfylling + fjernet overskutt deep enough
   -Obturation check X-ray with Kofferdam

8. SJEKK
   -Sluttbildet within 1 wk: min. 3 mm coronal seal

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