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ORIGINAL ARTICLE

The role of unfinished root canal treatment in odontogenic maxillofacial infections requiring hospital care

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Abstract

Objectives The aim of this study was to evaluate clinical and radiological findings and the role of periapical infection and antecedent dental treatment of infected focus teeth in odontogenic maxillofacial abscesses requiring hospital care.

Materials and methods In this retrospective cohort study, we evaluated medical records and panoramic radiographs during the hospital stay of patients (n=60) admitted due to odontogenic maxillofacial infection originating from periapical periodontitis.

Results Twenty-three (38 %) patients had received endodontic treatment and ten (17 %) other acute dental treatment. Twenty-seven (45 %) had not visited the dentist in the near past. Median age of the patients was 45 (range 20–88) years and 60 % were males. Unfinished root canal treatment (RCT) was the major risk factor for hospitalisation in 16 (27 %) of the 60 cases (p=.0065). Completed RCT was the source only in 7 (12 %) of the 60 cases. Two of these RCTs were adequate and five inadequate.

Conclusions The initiation of inadequate or incomplete primary RCT of acute periapical periodontitis appears to open a risk window for locally invasive spread of infection with local abscess formation and systemic symptoms. Thereafter, the quality of the completed RCT appears to have minor impact. However, a considerable proportion of the patients had not received any dental treatment confirming the importance of good dental health. Thus, thorough canal debridement during the first session is essential for minimising the risk for spread

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of infection in addition to incision and drainage of the abscess. If this cannot be achieved, tooth extraction should be considered.
Clinical relevance Incomplete or inadequate canal debridement and drainage of the abscess may increase the risk for spread of endodontic infection.

Keywords Acute periapical periodontitis · Dental infection · Dental treatment · RCT · Space infection · Antibiotics

Introduction

Odontogenic infections originate primarily from pulpal or periodontal tissues and from infected tooth sockets after extractions [1]. They can invade locally causing abscess formation or spread haematogenously and may, in both cases, require hospital care [2, 3]. In severe local infections, treatment with systemic antibiotics in combination with surgery is well established [4, 5]. Treatment results are generally favourable, but even death may result due to severe odontogenic infection [6–8].

The most common underlying dental disease in odontogenic infections is periapical periodontitis caused by microbes, which have invaded pulp tissue and the root canal system through dental caries [3, 9–12]. Other possible routes for infection are enamel cracks, tooth and root fractures, open restoration margins, periodontal disease and dental trauma [13–15]. Although periapical periodontitis can be asymptomatic, patients usually seek dental care due to pain [16]. In cases of abscess formation, drainage by incision and extraction are effective modes of treatment. Root canal treatment (RCT) is considered when the tooth is restorable and when no contraindications for RCT are present. It can, however, be technically demanding for a non-specialist, time-consuming and often requires multiple visits for completion. In acute situations, compromises are common due to time and cost limitations [12]. Often the initiation of RCT is postponed and only symptom-related acute dental treatment, such as occlusal adjustment or temporary restorative treatment, is provided with the aim of resolving the pain until a future appointment. Antimicrobial therapy is usually prescribed to support the endodontic treatment or to control the emerging infection [12]. Although the inefficiency of antibiotics without appropriate drainage has been demonstrated in several studies, antibiotics are frequently described instead of endodontic treatment [3, 12, 17, 18].

The aim of this retrospective study was to evaluate the clinical and radiological findings of patients with locally invasive spread of odontogenic maxillofacial infection of periapical source requiring hospital care. We also evaluated the role of chronic periapical infections and endodontic treatment in the course of infection. To our knowledge, this is the first systematic analysis of predisposing factors evaluated in patients hospitalised due to locally invasive spread of odontogenic infection.

Patients and methods

Study design

The study material comprised of patients admitted to the Department of Oral and Maxillofacial Diseases, Helsinki University Central Hospital (HUCH) due to odontogenic infection in 2004. All patients hospitalised due to odontogenic infections in the Helsinki and Uusimaa Hospital District (1.4 million inhabitants) in Finland are treated in this referral unit. Hospital admission criteria were threat to airways or vital structures, need for general anaesthesia (examination and/or treatment), septic fever, marked swelling, need for inpatient control of a concomitant systemic disease, and/or need for intravenous antimicrobial treatment. All patients with the need for hospital care for at least 1 day due to periapical periodontal pathology as the source of infection were included in this study. Patients hospitalised due to infection complications following tooth extraction were excluded, as panoramic radiographs of the source of infection were not available for analysis. Patients discharged within 24 h of admittance were also excluded from the study material. The study was approved by the Helsinki University Hospital Research Board (trial number 220363).

Data collection

Patients were identified in the hospital database using the following WHO ICD-10 diagnoses [19]: K04.7 (periapical abscess without sinus), K05.2 (acute periodontitis), K12.2 (cellulitis and abscess of mouth), K14.0 (glossitis), J36 (peritonsillar abscess) and J39.1 (other abscess of the pharynx). The final diagnose was verified from the medical records. Only patients with deep space abscesses were included in the study.

Study variables

Characteristics reviewed were age, gender, characteristics of hospital stay, previous dental events, time interval from primary dental treatment to hospital admission, microbiological findings of the pus samples and blood cultures, antimicrobial therapy prescribed before the hospital admission, source of infection and radiological findings of the source of infection in the preoperative panoramic radiographs. The source of infection is referred to as the focus tooth in this study and the first visit to the dentist due to dental pain or other symptom as the primary dental treatment. Treatment of the locally invasive odontogenic infection at the hospital included extraction of the focus tooth or teeth and intravenous antimicrobial treatment and surgical intervention as incision and drainage. In cases with insufficient response to the given treatment, surgical reoperation was performed and recorded for this study. During hospital stay, resolution of the infection was followed by daily measurements of inflammatory parameters, C-reactive protein (CRP) levels and white blood cell (WBC) counts and body temperature among others. These were recorded in order to evaluate the severity and course of infection during hospital stay. The predictor variables were preceding dental procedure, periapical pathology and antimicrobial therapy. The outcome variables were CRP levels and WBC counts on admission and at maximum, body temperature, source of infection, fascial spaces involved, need for reoperation, need for intensive care and length of stay (LOS).

Patient groups

For the analyses, the patients were divided into three groups according to the primary dental treatment given: endodontic treatment, other symptom-related acute dental treatment or no preceding dental treatment. The first patient group consisted of patients with preceding endodontic treatment with or without systemic antimicrobial therapy. The second patient group consisted of patients who received other non-endodontic dental treatment or symptom-related first aid such as occlusal adjustment or temporary restorative treatment with or without antimicrobial therapy or antimicrobial therapy only. The third patient group comprised patients without any preceding dental procedures in the near past, if the patient did not recall visiting a dentist due to tooth in question or during the past month.

Panoramic radiographs

Preoperative panoramic radiographs of the patients taken on hospital admission at the emergency department of HUCH were analysed [20, 21], and the source of infection was identified. Digitalized (video disc AGFA CRMD 4.0 general; disc reader AGFA CR 75; manufacturer AGFA-GEVAERT; AGFA IMPAX system, Mortsel, Belgium) PM 2002 CC panoramic radiograph device (Planmeca Oy, Helsinki, Finland) was used in the panoramic radiograph imaging of the patients. In addition, a maxillofacial radiologist (KKL) assessed the focus teeth individually and recorded data for periapical findings, carious pulp exposure, restorations, residual carious roots, pulp amputations, furcation lesions, sclerosis, empty or partially ossified tooth sockets and any additional pathological findings. Periapical findings were graded as widening of periodontal space, periapical radiolucency and large well-defined lucency. Teeth with signs of RCT were identified and classified as adequate RCT, inadequate RCT (obturation missing in at least one root, poor quality and/or more than 2 mm short from apex), retreatment (radiological findings indicating signs of removed root filling) or unfinished RCT (radiological findings indicating signs of intracanal medication).

Data analyses

Data were analyzed by using Graph Pad Prism version 4.0 (Graph Pad Inc., San Diego, CA, USA). Depending on the nature of comparison and the normality of the distribution of the data, Kruskal–Wallis with Dunn's multiple comparison tests, one-way analysis of variance with Bonferroni's multiple comparison test, Mann–Whitney *U* test or the chi-square test were used for statistical analysis. Data are presented as mean (± standard deviation), median (range) or number (in percent). The cross tabulations of the specific findings were calculated in relation to number of foci (n) of the patient group. Statistical significance was set at $p<.05$.

Results

In 2004, a total of 101 patients were admitted as inpatients to the hospital due to emerging odontogenic maxillofacial infection with local abscess formation. Preoperative radiographs of the focus teeth taken at the hospital were available for 63 patients. Three patients with pericoronitis and no signs of periapical pathology were excluded from the study. Fifty-nine of the 60 patients were diagnosed with K12.2 and one patient with K04.7. Of the 60 patients who fulfilled the inclusion criteria, 59 had radiologically confirmed periapical pathology as the source of infection, and one patient received acute dental care based on a clinical diagnosis of pulpitis. The median time interval from the primary dental treatment to hospital admission was 4 days (range 0–16) for patients with preceding endodontic treatment and 3 days (range 1–6) for patients with other non-endodontic primary treatment. Diabetes was the most common systemic disease being recorded in six (10 %) patients. Other systemic diseases were found in isolated cases.

Characteristics of the patient groups are presented in Table 1. The number of infection foci per patient in this study material ranged from 0 to 14 with a mean of 1.6 foci per patient. Patients without preceding dental treatment had the highest mean number of infection foci, 2.1 (range 0–14). Periapical findings indicating periapical pathology were also most numerous in this patient group (p=.0118) (Table 2). On average, they had 1.2 focus teeth with periapical pathology, while patients with preceding endodontic treatment had 1.1 and patients with other dental treatment 0.9 focus teeth.

Signs of unfinished RCT of the focus tooth was the most common radiological finding indicative of endodontic treatment in all patient groups as shown in Fig. 1 (p=.0065). At the time of hospital admission, 20 (33 %) of the 60 patients had unfinished RCT that had been initiated due to acute

Table 1 Patient characteristics of the study groups

	All cases (*n*=60)	Endodontic treatment (*n*=23)	Other dental treatment (*n*=10)	No dental treatment (*n*=27)
Gender				
Female	24 (40 %)	7 (30 %)	7 (70 %)	10 (37 %)
Male	36 (60 %)	16 (70 %)	3 (30 %)	17 (63 %)
Age (years)	45 (20–88)	44 (20–88)	31.5 (22–58)	45 (20–87)
Diabetes	6 (10 %)	1 (4 %)	1 (10 %)	4 (15 %)
Lower molar focus	49 (82 %)	21 (91 %)	9 (90 %)	19 (70 %)
Focus (*n*)	97	28	13	56
Foci per patient	1.6 (0–14)	1.2 (1–3)	1.3 (0–3)	2.1 (0–14)

Data are presented as number (in percent) or mean (in range). Kruskal–Wallis with Dunn's multiple comparison tests or one-way analysis of variance with Bonferroni's multiple comparison tests were used for statistical analysis. There were no statistically significant differences between the groups

periapical periodontitis. Four of these were patients with unfinished re-treatment. In 7 (12 %) of the 60 patients, RCT of the focus tooth had been completed. In two (3 %) of these seven cases, the completed RCT was radiologically adequate. Four of the five cases of completed inadequate RCT of the focus tooth were in the patient group without preceding treatment, and one was in the patient group of other dental treatment.

Additional radiological findings are shown in Table 3. Residual carious roots as source of infection were most common in patients without preceding treatment when compared to other patient groups (p=.0003). Temporary restorations were found most frequently in the patient group of endodontic treatment, which was in accordance with the given treatment. There was no significant difference in the prevalence of amalgam and composite restorations between the patient groups.

Table 2 Periapical findings and endodontic treatment of the focus teeth

	All cases (*n*=60)	Endodontic treatment (*n*=23)	Other dental treatment (*n*=10)	No dental treatment (*n*=27)
Focus (*n*)	97	28	13	56
Periapical findings	66	25*	9	32
Widening of periodontal space	14	6	2	6
Periapical lucency	46	16	7	23
Large periapical lucency	10	4	0	6
Completed RCT	7	2	1	4
Adequate	2	2	0	0
Inadequate	5	0	1	4
Unfinished re-treatment	4	3	1	0
Unfinished RCT	16	16	0	0
Pulp amputation	3	2	0	1

Data are presented as number of the specific finding. The chi-square test was used for statistical analysis. The cross tabulations of the specific findings are calculated in relation to number of foci (*n*) of the patient group

*p=.0118

All patients in this study presented with similar local and systemic symptoms, such as dental pain, swelling, reduced opening of the mouth or fever. The characteristics of the hospital stay are shown in Table 4. The median LOS was 3 days (range 1–14) for all patients. Patients without preceding treatment had the longest LOS (median 5 days, range 1–13) and patients with preceding endodontic treatment had the shortest LOS (median 2 days, range 1–14) (p=.0412). Twenty-two of the 60 patients (33 %) were in the need of intensive care with a median length of 3 days (range 1–8). The need of reoperation was highest among patients without preceding treatment (22 %) compared to patients with preceding endodontic and other dental treatment (4 and 10 %, respectively). Patients without preceding treatment had the highest CRP levels and WBC counts on admission when compared to other patient groups (p=.0093 and p=.0466, respectively). In addition, the maximum CRP levels during hospital stay were the highest in this patient group (p=.0012). All these differences in hospital stay were greatest between patients with preceding endodontic treatment and those without any preceding dental treatment.

The ongoing systemic antimicrobial therapy at the time of hospital admission is presented in Table 5. Thirty-seven (62 %) of the 60 patients were not receiving antibiotic therapy at the time of hospital admission. When antibiotics had been prescribed, penicillin V in combination with metronidazole was the most common antimicrobial therapy in all patient groups. The antibiotics prescribed were in accordance with local recommendations [22].

In 44 (73 %) of the 60 patient cases, a pus sample for microbiological diagnostics had been taken. The proportion of aerobic and anaerobic, gram-positive and gram-negative bacteria reported from the abscess samples is shown in Table 6. Patients without preceding dental treatment had been reported with anaerobic gram-negative bacteria in 41 % of the cases in contrast to 17 % of patients with preceding endodontic treatment. Over half of the patients with preceding endodontic treatment or other dental treatment had been reported with aerobic gram-positive bacteria in their pus samples (55 and 53 %, respectively) compared to patients without a preceding dental procedure (33 %). Mixed flora was reported in 7 (58 %) of the 12 cases in endodontic treatment group, six (67 %) of the nine cases in other dental treatment group and in 11 (48 %) of the 23 cases in no preceding dental treatment group.

The microbiological findings of the pus samples are presented in Table 7. Alfa/nonhaemolytic streptococci had been identified in 8 (67 %) of the 12 patient cases in

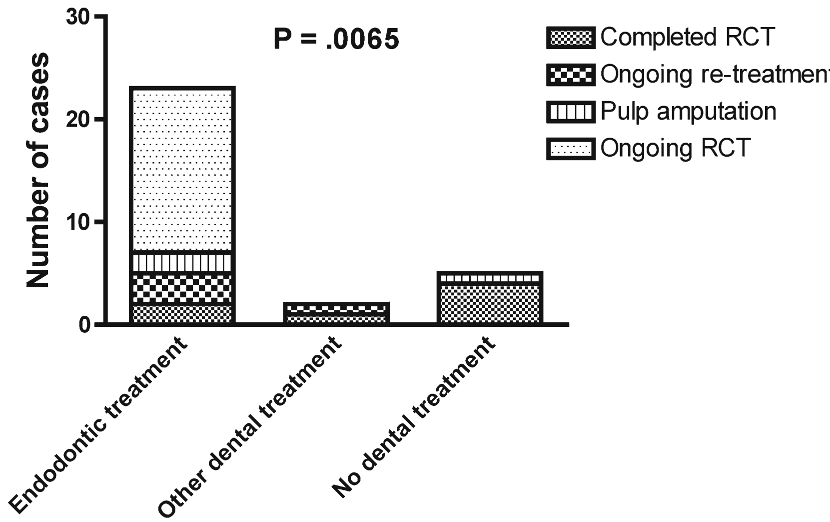

Fig. 1 The type and status of endodontic treatment of the dental foci documented at hospital admission, if any. Unfinished root canal treatment (RCT) was the major risk factor for hospitalisation (p=.0065). The chi-square test was used for statistical analysis

endodontic treatment group and eight (89 %) of the nine cases in other dental treatment group compared to 4 (17 %) of the 23 cases in no dental treatment group (p=.0008). *Prevotella* spp. were reported significantly less often in the patient group with preceding endodontic treatment compared to the group without preceding dental treatment or the group with other dental treatment (17, vs. 61 and 56 %, accordingly, p=.0397). Coagulase negative staphylococci were reported in 23 % of the samples and *Staphylococcus aureus* in 9 % of the samples. Yeasts were identified in 3 (25 %) of the 12 cases in endodontic treatment group, three (33 %) of the nine cases in other dental treatment group, and 7 (30 %) of the 23 cases in no dental treatment group. In addition, two patients in the group of patients without preceding dental treatment had had positive blood cultures from which *Veillonella* spp. and *Lactobacillus catenaforme* had been isolated.

Table 3 Additional radiological findings of the focus teeth

	All cases (n=60)	Endodontic treatment (n=23)	Other dental treatment (n=10)	No dental treatment (n=27)
Focus (n)	97	28	13	56
Carious pulpal exposure	19	2	5	12
Residual carious root	35	2	4	29*
Amalgam restoration	18	5	3	10
Composite restoration	15	6	4	5
Temporary restoration	8	7	1	0
Missing restoration	5	3	0	2
Empty tooth socket	2	1	1	0
Sclerosis	23	7	3	13
Furcation lesion	6	1	1	4

Data are presented as number of the specific finding. The chi-square test was used for statistical analysis. The cross tabulations of the specific findings are calculated in relation to number of foci (n) of the patient group

*p=.0003

Discussion

In this study, unfinished RCT initiated due to acute periapical periodontitis was the most common finding in patients hospitalised due to locally invasive spread of infection with local abscess formation and systemic symptoms. It appears that the type and quality of the primary endodontic treatment undertaken on teeth with acute periapical periodontitis are essential in order to initiate the resolution of the infection. In Finland, the acute symptomatic cases with or without periapical periodontitis are almost exclusively treated over multiple visits with inter-appointment intracanal calcium hydroxide medication, and single-visit endodontic treatment is rare [23]. Even after well-performed debridement, the antimicrobial effect of calcium hydroxide is limited [24]. However, exacerbation of the infection is more likely to result from suboptimal canal debridement due to the lack of time in the first aid situation. It is therefore questionable if the single-visit approach, i.e. completion of RCT in one session, would have prevented the invasive course of infection, as the evidence of either technique resulting in better immediate post-operative outcome is lacking [25–27].

Based on our results, the unfinished and inadequate RCT appears to open a risk window for locally invasive spread of infection with a median delay of 4 days. Thus, the dentist should have an aggressive approach in order to gain control of the spreading infection. Thorough canal debridement with incision and drainage of the abscess during the first session is essential in order to minimise the risk for spread of infection. If this cannot be achieved, tooth extraction with appropriate patient instructions and follow-up should be

Table 4 Characteristics of the hospital stay

	All cases (n=60)	Endodontic treatment (n=23)	Other dental treatment (n=10)	No dental treatment (n=27)	p
Length of stay (days)	3 (1–14)	2 (1–14)	3.5 (1–10)	5 (1–13)	.0412[a]
Need for intensive care	20 (33 %)	4 (17 %)	5 (50 %)	11 (41 %)	ns
Length of intensive care (days)	3 (1–8)	2 (1–4)	3.5 (1–6)	3 (1–8)	ns
Need for reoperation	8 (13 %)	1 (4 %)	1 (10 %)	6 (22 %)	ns
CRP (mg/L) on admission	113 (5–516)	74 (5–227)	86.5 (22–202)	128 (40–516)	.0093[a]
CRP (mg/L) at maximum	143 (11–516)	101 (11–358)	148.5 (41–375)	178 (79–516)	.0012[a]
WBC (10^3/μL) on admission	11.8 (6.4–24.4)	11.1 (6.4–22.2)	10.6 (6.4–17.9)	15.2 (7.3–24.4)	.0466
WBC (10^3/μL) at maximum	12.8 (6.4–27.9)	11.2 (6.4–22.2)	10.6 (6.5–17.9)	15.2 (7.3–27.9)	ns
Body temperature (°C) on admission	37.1 (36.0–38.5)	36.9 (36.2–37.9)	36.9 (36.0–38.4)	37.0 (34.5–38.5)	ns
Body temperature (°C) on maximum	37.5 (36.5–39.9)	37.5 (36.5–38.2)	37.5 (36.7–39.8)	37.8 (36.6–39.9)	ns

Data are presented as number (in percent) or median (range). Kruskal–Wallis with Dunn's multiple comparison tests or chi-square test was used for statistical analysis

CRP C-reactive protein, *WBC* white blood cell

[a] Dunn's multiple comparison test: endodontic treatment vs. no treatment

considered. Patients with preceding endodontic or other dental treatment had 1.2 and 1.3 infection foci, respectively, compared to 2.1 foci in patients without preceding treatment, reflecting the overall dental health. Thus, in most cases RCT was initiated with a reasonable aim of achieving and/or maintaining good dental health. It is well described that locally invasive odontogenic infections most often originate from lower molars. RCT of these teeth is often rather challenging for non-specialists providing the acute care, which together with anatomical risk factors of the submandibular space contributes to the risk of spread of the infection. Accumulation of risk factors for spread of infection should trigger revision of the treatment plan and consideration of tooth extraction.

Table 5 Ongoing antimicrobial therapy as recorded at hospital admission

	All cases (n=60)	Endodontic treatment (n=23)	Other dental treatment (n=10)	No dental treatment (n=27)
No antimicrobial therapy	37	9	3	25
Penicillin V	5	3	1	1
Penicillin V + metronidazole	8	7	1	0
Clindamycin	1	0	0	1
Roxythromycin	4	1	3	0
Roxythromycin + metronidazole	1	1	0	0
Cephalexin	1	1	0	0
Cephalexin + metronidazole	1	0	1	0
Metronidazole	1	1	0	0
Doxycycline	1	0	1	0

Considering the number of RCTs completed every year and the cumulative number of completed RCTs in the population, patients with completed RCT as the focus tooth were underrepresented in this study material. Spread of infection from a tooth with completed RCT even with chronic periapical periodontitis was unexpectedly rare in our hospital district. It is not known what proportion of all initiated RCTs are re-treatments or primary RCTs. However, the small number of re-treatments in this study material seems reasonable. Re-treatment is a time-consuming procedure with a more uncertain prognosis compared to primary RCT and may not be easily initiated in acute situations [28]. The overall success of endodontic treatment has been shown to be as good as 91 % in a study by Imura et al.; the success rate being higher for primary RCT than for re-treatment [28]. In our hospital district (1.4 million inhabitants), it can be estimated based on the registers of Kela, The National Insurance Institution of Finland that approximately 50,000 teeth received RCT in 2004. Based on this estimation, the proportion of patients developing a severe infection requiring hospital care can be calculated to be less than 0.2 %. Therefore, severe infection complications following endodontic treatment are rare. The quality of RCT has not been associated with the incidence of persisting periapical periodontitis, although good quality supports healing [15]. Similarly, in our study, the quality of the completed RCT seemed to have little impact on the risk for flare-up. However, as these complications may be fatal, understanding the potential predisposing factors would be beneficial.

There were significant differences in the microbiological findings between patient groups. Aerobic bacteria were the most common finding in patients with preceding endodontic treatment, whereas in patients without preceding dental treatment anaerobic bacteria, especially gram-negative

Table 6 Proportion of aerobic and anaerobic, gram-positive and gram-negative bacteria in pus samples (n=125)

	All cases	Endodontic treatment	Other treatment	No dental treatment
Number of patients with pus samples	(n=44)	(n=12)	(n=9)	(n=23)[a]
Number of findings per patient group	(n=125)	(n=29)	(n=30)	(n=66)
Aerobic gram-positive bacteria	54 (43 %)	16 (55 %)	16 (53 %)	22 (33 %)
Aerobic gram-negative bacteria	9 (7 %)	3 (10 %)	4 (13 %)	2 (3 %)
Anaerobic gram-positive bacteria	21 (17 %)	5 (17 %)	4 (13 %)	12 (18 %)
Anaerobic gram-negative bacteria	41 (33 %)	5 (17 %)	9 (30 %)	27 (41 %)

Data is presented as number (in percent) of findings per patient group and number of isolates per patient group. Pus samples were not taken in 16 (27 %) of the 60 patients

[a] Two samples were reported as mixed oral flora

anaerobes were predominant. Thus, RCT appears to efficiently reduce the proportion of anaerobes in the root canal system and subsequently in the periapical periodontal lesions. Interestingly, staphylococci were reported in over 30 % of the pus samples and *S. aureus* in 9 % of the samples. These pathogens are not covered by the standard choice of antibiotics, namely penicillin or amoxicillin. Two patients in the group of patients without preceding dental treatment had *Veillonella* spp. and *L. catenaforme* isolated from their blood cultures. The virulence of these bacteria is not considered to be generally very high but they may reflect the nature of dental bacteraemia.

Diabetes was the only medical condition predisposing to infections (identified in six patients). Patients with diabetes were mainly (four/six) found in the patient group without preceding dental treatment. In addition, these patients had

Table 7 Bacteria isolated from the pus samples of 44 patients

	All cases	Endodontic treatment	Other treatment	No dental treatment
Number of patients with pus samples	(n=44)	(n=12)	(n=9)	(n=23[a])
Median (range) number of isolates per patient	3 (1–6)	2 (1–5)	3 (2–6)	3 (1–6)
Aerobic gram-positive bacteria				
Alfa/nonhaemolytic streptococci	20 (45 %)	8 (67 %)	8 (89 %)	4 (17 %)*
Betahaemolytic streptococci	10 (23 %)	4 (33 %)	3 (33 %)	3 (13 %)
Microaerophilic streptococci	6 (14 %)	0	2 (22 %)	4 (17 %)
Staphylococcus aureus	4 (9 %)	1 (8 %)	2 (22 %)	1 (4 %)
Coagulase negative staphylococci	10 (23 %)	3 (25 %)	1 (11 %)	6 (26 %)
Moraxella spp.	1 (2 %)	0	0	1 (4 %)
Enterococcus spp.	1 (2 %)	0	0	1 (4 %)
Aerobic gram-negative bacteria				
Apatogenic *Neisseria* spp.	5 (11 %)	2 (17 %)	2 (22 %)	1 (4 %)
Haemophilus parainfluenzae	2 (5 %)	1 (8 %)	1 (11 %)	0
Klebsiella pneumoniae	1 (2 %)	0	0	1 (4 %)
Serratia marcescens	1 (2 %)	0	1 (11 %)	0
Anaerobic gram-positive bacteria				
Anaerobic gram-positive cocci	3 (7 %)	0	0	3 (13 %)
Peptostreptococcus spp.	5 (11 %)	1 (8 %)	0	4 (17 %)
Micromonas micros	5 (11 %)	1 (8 %)	3 (33 %)	1 (4 %)
Actinomyces spp.	1 (2 %)	1 (8 %)	0	0
Lactobacillus spp.	2 (5 %)	1 (8 %)	1 (11 %)	0
Propionibacterium spp.	5 (11 %)	1 (8 %)	0	4 (17 %)
Anaerobic gram-negative bacteria				
Veillonella spp.	2 (5 %)	0	0	2 (9 %)
Anaerobic gram-negative rods	5 (11 %)	0	1 (11 %)	4 (17 %)
Prevotella spp.	21 (48 %)	2 (17 %)	5 (56 %)	14 (61 %)**
Porphyromonas spp.	1 (2 %)	0	1 (11 %)	0
Fusobacterium spp.	12 (27 %)	3 (25 %)	2 (22 %)	7 (30 %)

The data is presented as number (in percent) of patients with the specific bacteria per patient group or median (range) number of isolates per patient. The chi-square test was used for statistical analysis of the patient groups. Pus samples were not taken in 16 (27 %) of the 60 patients

*p=.0008; **p=.0397

[a] Two samples were reported as mixed oral flora

poorer dental health as reflected by a higher number of infection foci compared with other patients. All other patients were generally in good health.

Ten patients received other symptom-related dental treatment in the form of restoration, occlusal adjustment or systemic antimicrobial therapy. However, all these patients had dental pain and teeth with periapical lucency indicating the need for RCT or tooth extraction. Five of these ten patients had submandibular swelling in addition to dental pain. Yet they received primarily only systemic antimicrobial therapy without dental treatment, thus delaying resolution of the infection. The same trend has also been noted in previous studies [29, 30]. According to systematic literature review and meta-analysis, antibiotics do not offer additional benefit in addition to drainage (either through the root canal or incision) in localised acute periapical abscess [5, 18, 31]. Antibiotics should be reserved for the cases with systemic complications and those patients who are medically compromised [5, 18, 31]. The results of our study do not support extensive use of antibiotics in addition to endodontic treatment or extraction in the early course of infection.

There are some limitations to this study. Firstly, due to the retrospective study model, preoperative panoramic radiographs were not available for all patients. Therefore, focus analysis of patients with preceding tooth extraction due to periapical periodontitis could not be done. Secondly, the incidence and the risk for hospital admission due to locally invasive spread of infection following endodontic treatment could not be accurately evaluated, as the study material comprised only patients with locally invasive infection after failed dental treatment or in its absence. In addition, the primary dental care medical records were not available for analysis and the systemic symptoms were poorly documented in the medical records. Therefore, the data available do not allow for an estimation of whether or not RCT was performed in adequate fashion before placement of the root canal medication and temporary filling or if the choice of antimicrobial therapy were appropriate in relation to the diagnosis. Finally, the course of infection leading to hospitalisation comprises various steps and has a number of risk factors, including the immunological status of the patient. Thus, the significance of the preceding dental treatment in the course of infection varies from patient to patient.

Conclusion

The initiation of primary RCT of acute periapical periodontitis appears to open a risk window for locally invasive spread of infection with local abscess formation and systemic symptoms. Thereafter, the quality of the completed RCT appears to have little impact on the risk for flare-up. Thus, the dentist should have an aggressive approach in order to gain control of the infection. Thorough canal debridement with incision and drainage of the abscess during the first session is essential in order to minimise the risk for spread of infection. If this cannot be achieved and there are signs of spreading infection, tooth extraction with appropriate patient instructions and follow-up should be considered. This is especially important in case of patients with numerous periapical findings and residual carious roots since poor dental health constitutes the major risk for locally invasive odontogenic infections.

Conflict of interest The authors declare that they have no conflict of interest.

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