ACTA ODONTOLOGICA SCANDINAVICA
VOLUME 79, 2021
NUMBER 06

Acta Odontologica Scandinavica

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ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iode20

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To cite this article: Jussi Furuholm, Niina Rautaporras, Johanna Uittamo, Mikko Saloniemi & Johanna Snäll (2021) Health status in patients hospitalised for severe odontogenic infections, Acta Odontologica Scandinavica, 79:6, 436-442, DOI: 10.1080/00016357.2021.1876916

To link to this article: https://doi.org/10.1080/00016357.2021.1876916

Published online: 27 Jan 2021.

ACTA ODONTOLOGICA SCANDINAVICA
2021, VOL. 79, NO. 6, 436–442
https://doi.org/10.1080/00016357.2021.1876916

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ORIGINAL ARTICLE

Health status in patients hospitalised for severe odontogenic infections

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ABSTRACT

Objective: Previous findings refer to certain predisposing medical conditions that compound the risk of developing severe and potentially lethal acute odontogenic infections (OI). The objective of this study was to clarify this rationale and infection severity in general.

Material and methods: Records of patients aged ≥18 years requiring hospital care for deep OI were retrospectively investigated. The main outcome variable was need for intensive care unit (ICU) treatment. Additional outcome variable was occurrence of infection complications and/or distant infections. Several parameters describing patients' prior health and recent dental treatment were set as independent variables.

Results: Of the 303 acute OI patients included, 71 patients (23%) required treatment in the ICU, with no significant difference between previously healthy and patients with disease history. OIs originating from teeth in the mandible compared with maxilla had 7.8-fold risk ($p = .007$) for ICU treatment in binary logistic regression analyses. Elevated levels of infection parameters at hospital admission predicted further ICU stay. Infection complications and/or distant infections occurred in 7.6% of patients, of which septicaemia and pneumonia were the most common. The mortality rate was 0.3%. Infection complications and/or distant infections occurred significantly more often in smokers ($p = .001$) and in patients with excessive consumption of alcohol or drugs ($p = .025$), however smoking showed 3.5-folded independent risk for infection complications and/or distant infections ($p = .008$) in logistic regression.

Conclusions: Severe OIs often occur in previously healthy patients. Smokers in particular are prone to the most serious OIs.

ARTICLE HISTORY
Received 18 September 2020
Revised 10 December 2020
Accepted 8 January 2021

KEYWORDS
Odontogenic infection; hospital care; intensive care; septicaemia

Introduction

Odontogenic infections (OI) are usually mild, start locally around a tooth, and remain confined to the alveolar ridge vicinity. However, OIs can sometimes spread to the surrounding tissues and further to the deeper structures of the neck. In terms of clinical research, it is interesting that severe OIs have become more frequent in recent decades [1–5]. Deep neck infections are often caused by odontogenic foci [2,6,7], which may, in the most severe cases, be fatal [8]. Besides the need for treatment in intensive care, OIs may lead to infection complications and distant infections [2,7,9–11]. Like deep neck infections from other origins, severe OIs may spread into deep fascial spaces and even beyond these barriers, resulting in distant infection complications such as cavernous sinus thrombosis, brain abscesses, airway obstruction, mediastinitis, or endocarditis [12–18].

The predisposing circumstances that lead to these possibly life-threatening conditions remain incompletely understood. Inadequate local dental treatment may increase the risk of infection severity [19]. Tooth extractions and root canal treatments are the most common dental procedures preceding these severe infection complications, particularly if not performed *lege artis* [20]. Previously, it has been shown that most patients visit outpatient care for the same symptoms before being admitted to hospital [3,21,22]; thus, diagnosis and effective early treatment of the infection appear to be challenging.

To hinder local or systemic spread of a dental infection, it seems to be of paramount importance to take sufficient control of the infection as early as possible. Early decisive surgical intervention leads to the shortest possible hospital stay [23]; a longer hospital stay seems to be positively related to the number of infected spaces [8,24,25]. Additionally, some patients seem to be at higher risk of requiring hospital care or even care in an intensive care unit (ICU), and a recent study reported several different prognostic factors [22,26,27]. Patients with severe OIs suffering from cardiovascular disease or who abuse drugs or alcohol are more prone to infectious complications [1,9,22]. Previous studies have shown diabetes and mental disorders to elevate this risk [1,28]. Although several studies support the association between diabetes and OIs [29,30], converse associations have also been identified [31]. Failure to recognise a worsening infection at an early

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

state may explain the connection between these diseases and the most severe OIs. This possible connection remains ambiguous. In addition, the potential risk for previously healthy patients of developing a severe OI is less known.

Most recent studies have focussed on deep neck infections in general and included infections other than OIs in the analyses. We aimed to clarify specifically infections of odontogenic origin and designed and conducted a retrospective study to assess the severity of acute OIs in general and to analyse predictors for the most severe OIs. Our study hypothesis was that the most severe OIs are most common in immunocompromised patients.

Materials and methods

Study design

Patient data from all acute maxillofacial infections treated in the Töölö Hospital Emergency Department between the years 2015 to 2018 were retrospectively reviewed. The data was extracted from the electronic patient records by selecting codes for dental diseases and infections and reviewed by two experienced clinicians (NR and JU). Data of patients who required further hospital care for an acute facial or neck infection (or both) were analysed in more detail. Information on the parameters regarding the study variables were collected into a dataset for statistical analyses. The oral and maxillofacial on-duty unit of the Department of Oral and Maxillofacial Surgery, Helsinki University Hospital, Helsinki, Finland, in the Töölö Hospital Emergency Department is the largest maxillofacial emergency unit in Finland and has a catchment area of 1.6 million inhabitants.

Inclusion and exclusion criteria

Patients aged $\geq$18 years and who required treatment and hospital stay for acute OI (i.e. abscess, or cellulitis of facial or neck region of dental origin) confirmed by oral and maxillofacial surgeons were included in the present study. Patients with infection of unknown origin or other than odontogenic focus as a reason for maxillofacial infection were excluded from the analyses.

Study variables

The main outcome variable was need for treatment in an ICU, describing the most severe OIs. Length of stay in the ICU was recorded for the ICU patients, and rest of the variables for all individuals.

Additional outcome variable was occurrence of infection complications (i.e. pneumonia or death during OI treatment) and/or distant infections.

The primary predictors were history of recent dental procedure and preceding antibiotic medication. A dental procedure was considered recent if it was administered as treatment during the same period of symptoms as the reason for referral for hospitalisation.

Secondary predictor variable was localisation of the infection focus (maxilla/mandible). In addition, the precise infection focus tooth was categorised and analysed in the following subgroups: lower third molar, lower second molar, lower first molar, lower anterior, upper third molar, upper second molar, upper first molar, upper anterior.

Additional predictor variables were clinical and laboratory parameters at hospital admission. Association between body temperature, systolic blood pressure, diastolic blood pressure, pulse, C-reactive protein (CRP) values, white blood cell (WBC) counts, and the main outcome were analysed.

Explanatory variables were sex, age, body mass index, smoking, excess consumption of alcohol or regular use of drugs, and history of immunocompromised condition by disease, medications, or both. Consumption limits for excess use of alcohol were $\geq$12 doses per week in women and $\geq$23 doses in men, based on anamnestic information.

Type and rate of distant infections, infection complications, and total morbidity were also reported.

Statistical analysis

We conducted the statistical analyses with software package IBM SPSS for Macintosh (version 25.0, IBM Corp., Armonk, N.Y. USA). Categorical variables were cross-tabulated and analysed with Pearson's chi-squared test or Fisher's exact test if expected values were $<$5. Student's t-test was used to compare differences between study groups in continuous variables. Treatment in ICU, and occurrence of and/or distant infections, were separately selected as dependent variables for multivariate analyses; age was categorised into tertiles and the remaining predictor variables were entered as dichotomous. Body mass index was excluded from binary logistic regression analyses due to missing values. We considered p-values $<$.05 as statistically significant throughout the study.

Ethics approval and consent to participate

The study protocol was approved by the Internal Review Board of the Head and Neck Centre, Helsinki University Hospital, Helsinki, Finland (HUS/58/2020). The study was conducted following the Helsinki Declaration.

Results

A total of 335 patients were examined; 32 were excluded as no definite odontogenic origin of infection could be detected. The final number of OI patients included for analysis was 303.

The basic patient characteristics are reported in Table 1. Most patients were male (56%) and mean age was 47 years. Smoking was more common in males than females (33% vs. 21%, $p = .024$); this was also observed for alcohol or drug abuse (13% vs. 4%, $p = .005$). Altogether 71 patients (23%) were treated in the ICU. Duration of ICU treatment ranged from $<$1 to 32 days (mean 4.5 days, median 3 days). The reason for postoperative ICU stay was narrowed laryngeal space

Table 1. Descriptive characteristics of the patients with odontogenic infection.

	All, $N = 303$ (100%)	Females, $n = 134$ (44%)	Males, $n = 169$ (56%)	Percentages, females vs. males	p-Value*
Age (years): mean (SD), range	47 (18.2), 18–100	49 (20.6), 18–100	45 (15.9), 19–86		NS
Body mass index[a], $n = 253$: mean (SD), range	26.4 (5.52), 13.4–47.8	26.4 (6.56), 14.5–47.8	26.3 (4.56), 13.4–41.3		NS
Smoking					.024
yes	83 (27%)	28 (21%)	55 (33%)	34% vs. 66%	
no	220 (73%)	106 (79%)	114 (67%)	48% vs. 52%	
Excess consumption of alcohol/drugs					.005
yes	27 (9%)	5 (4%)	22 (13%)	19% vs. 81%	
no	276 (91%)	129 (96%)	147 (87%)	47% vs. 53%	
Immunocompromised[b]					NS
no	246 (81%)	108 (81%)	138 (82%)	44% vs. 56%	
yes	57 (19%)	26 (19%)	31 (18%)	46% vs. 54%	
diabetes	27 (9%)	10 (7%)	17 (10%)	37% vs. 63%	NS
yes	71 (23%)	26 (19%)	45 (27%)	37% vs. 63%	NS
no	232 (77%)	108 (81%)	124 (73%	47% vs. 53%	

Values are frequencies and percentages if not otherwise mentioned.
*Differences between females and males were tested with chi-square for categorical variables, or t-test for continuous variables. NS: non-significant, p-value $>.05$.
[a]Data of body mass index was available for 111 females and 142 males.
[b]Immunocompromised: immunologically compromised condition due to disease history including diabetes, or medication.

for the deep infection in all these patients. It was estimated in collaboration between oral and maxillofacial surgeons and anaesthesiologists. All options for airway management (i.e. conventional intubation, fiberoscopic intubation, tracheostomy) were available throughout the hospital stay.

No statistically significant differences were observed between the study groups in the explanatory background variables regarding the main outcome, treatment in the ICU (Table 2). Of all 303 patients, 128 (42%) were documented as generally healthy; for ICU-treated patients the proportion of generally healthy was 45% and for non-ICU-treated 41%, and the difference was statistically not significant.

Compared with non-ICU patients, OIs that required ICU treatment were significantly more often associated with teeth in the mandible than in the maxilla ($p = .001$). The most common teeth recorded as origins of infection were the lower second molars (Table 3).

Body temperature, pulse, CRP levels, and WBC counts at hospital admission were significantly higher in the ICU patients versus non-ICU patients ($p < .01$; Table 4).

After adjusting for the explanatory variables and the primary and secondary variables, binary logistic regression showed a 7.8-fold increased risk ($p = .007$) of admission to ICU treatment for OIs originating from teeth in the mandible compared with maxilla. No significant associations were detected for different types of local dental treatment prior to hospital admission in univariate or binary logistic regression analyses.

Infection complications and/or distant infections were detected in 23 (7.6%) of all 303 patients (Table 5). Septicaemia ($n = 12$; 4.0%) and pneumonia ($n = 11$; 3.6%) were the two most common diagnoses. All patients with pneumonia ($n = 11$) were treated in the ICU. Pneumonia was diagnosed in 15% of all 71 ICU-treated patients, Endocarditis, necrotising fasciitis, and urosepsis were observed in individual cases. None of the patients had infection spread to the mediastinum. Infection complications and/or distant infections occurred significantly more often in smokers vs. non-smokers (57% vs. 25%, $p = .001$) and in patients with excessive consumption of alcohol or drugs vs. patients without excessive consumption (22% vs. 8%, $p = .025$). After adjusting for the explanatory variables and the primary and secondary variables, binary logistic regression showed a 3.5-fold increased risk ($p = .008$) of infection complication and/or distant infection for smoking. No significant associations were detected for different types of preceding local dental treatment. One patient (0.3%) died during infection treatment period in hospital; this patient had prior dilated cardiomyopathy, history of excessive alcohol consumption, and suffered from kidney dysfunction and pneumonia.

Discussion

This study clarified infection severity in hospitalised OI patients. We hypothesised that the most severe OIs—requiring treatment in an ICU—are most common in immunocompromised patients. Our hypothesis was not confirmed. Surprisingly, underlying disease, sex, or older age did not predispose patients to more severe infection. The typical hospitalised patient with severe OI is a previously healthy patient without notable infection predisposing history and has infection spread from the mandibular lower molar. Half of the hospitalised patients had attended outpatient care and received recent treatment before being sent to hospital; however, no clear relationship could be detected between different types of preceding local infection treatment and infection severity.

Immunocompromised patients (e.g. those with HIV or diabetes) are prone to acquire co-infections and more severe OIs [32,33]. Although greater body mass index (BMI) is also associated with more frequent ICU admission [34], this was not confirmed in the present study. It should be noted that only a fifth of patients in the present study population had a history of diseases that predispose to infections. Previously healthy patients were as likely to require ICU treatment as

Table 2. Difference in body mass index, and associations between explanatory variables and treatment in the intensive care unit (ICU).

	All, $N = 303$	ICU, $n = 71$ (23%)	Non-ICU, $n = 232$ (77%)	Percentages, ICU vs. non-ICU	p-Value*
Age: mean (SD), range	47 (18.1), 18–100	45 (16.6), 18–88	47 (18.7), 18–100		NS
Sex					NS
females	134 (44%	26 (37%)	108 (47%)	19% vs. 81%	
males	169 (56%)	45 (63%)	124 (63%)	27% vs. 73%	
Body mass index, $n = 253$[a]: mean (SD), range	26.4 (5.52), 13.4–47.8	26.8 (5.31), 18.1–43.6	26.2 (5.59), 13.4–47.8		NS
Smoking					NS
yes	83 (27%)	25 (35%)	58 (25%)	30% vs. 70%	
no	220 (73%)	46 (65%)	174 (75%)	21% vs. 79%	
Excess consumption of alcohol/drugs					NS
yes	27 (9%)	9 (13%)	18 (8%)	33% vs. 68%	
no	276 (91%)	62 (87%)	214 (92%)	22% vs. 78%	
Immunocompromised[b]					NS
no	246 (81%)	61 (86%)	185 (80%)	25% vs. 75%	
yes	57 (19%)	10 (14%)	47 (20%)	18% vs. 82%	
diabetes	27 (9%)	7 (10%)	20 (9%)	26% vs. 74%	NS

*Association of independence was tested with chi-square for categorical variables. Difference between groups was tested with t-test for age and body mass index. NS: non-significant, p-value > 0.05.
[a]Data of body mass index was available for 111 females and 142 males.
[b]Immunocompromised: immunologically compromised condition due to general disease including diabetes, or medication.

Table 3. Associations between infection site and treatment prior to hospital care and treatment in the intensive care unit (ICU).

	All, $N = 303$	ICU, $n = 71$ (23%)	Non-ICU, $n = 232$ (77%)	Percentages, ICU vs. non-ICU	p-Value*
Maxilla	46 (15%)	2 (3%)	44 (19%)	4% vs. 96%	.001
Mandible	257 (85%)	69 (97%)	188 (81%)	27% vs. 73%	
Maxilla					NS
third molars	8 (17%)	0	8 (18%)	0 vs. 100%	
second molars	3 (7%)	0	3 (7%)	0 vs. 100%	
first molars	12 (26%)	1 (50%)	11 (25%)	8% vs. 92%	
anterior	23 (50%)	1 (50%	22 (50%)	4% vs. 96%	
Mandible					NS
third molars	71 (28%)	22 (32%)	49 (26%)	31% vs. 69%	
second molars	95 (37%)	28 (41%)	67 (36%)	29% vs. 71%	
first molars	61 (23%)	13 (19%)	48 (26%)	21% vs. 79%	
anterior	30 (12%)	6 (8%)	24 (13%)	20% vs. 80%	
Preceding recent dental treatment					
no	155 (51%)	33 (46%)	122 (53%)	21% vs. 79%	NS
yes	148 (48%)	38 (54%)	110 (47%)	26% vs. 74%	
extraction	115 (78%)	33 (87%)	82 (75%)	29% vs. 71%	NS
rct[a]	25 (17%)	3 (8%)	22 (20%)	12% vs. 88%	
incision	5 (3%)	1 (3%)	4 (4%)	20% vs. 80%	
incision & extraction	3 (2%)	1 (2%)	2 (1%)	33% vs. 67%	
Preceding antibiotics					NS
yes	138 (46%)	34 (48%)	131 (56%)	21% vs. 79%	
no	165 (54%)	37 (52%)	101 (44%)	27% vs. 73%	

*Association of independence was tested with chi-square. NS: non-significant, p-value > 0.05.
[a]rct: root canal treatment. Associations between primary predictors and treatment prior to hospital care. Odontogenic foci were categorised into groups: third molars, second molars, first molars, and anterior teeth including premolars, canines and incisors.

Table 4. Differences between study groups by treatment in the intensive care unit (ICU) in blood pressure and clinical and laboratory infection parameters.

	All, $N = 303$	ICU, $n = 71$	Non-ICU, $n = 232$	p-value*
Body temperature, $n = 302$	37.4 (0.72)	37.7 (0.64)	37.3 (0.73)	.001
Systolic blood pressure, $n = 285$	139 (22.1)	140 (24.4)	139 (21.4)	NS
Diastolic blood pressure, $n = 285$	83 (12.6)	82 (15.5)	84 (11.6)	NS
Pulse, $n = 283$	90 (18.0)	96 (19.2)	88 (17.2)	.002
C-reactive protein level (mg/L) (median)	144 (90.4)	214 (111.6)	123 (70.4)	<.001
White blood cell count (10^9/L), $n = 302$	12.9 (4.63)	15.8 (5.71)	12.0 (3.85)	<.001

Results are expressed as means (and standard deviations).
*Statistical significance of difference was determined with t-test. NS: non-significant, p-value $> .05$.

patients with an immunocompromised condition. It is plausible that patients with underlying disease are well-monitored and treated for dental infection foci at an early stage and thus these infections are appropriately managed. This phenomenon may lead to otherwise generally healthy people to be at an equal risk for requiring intensive care because of an OI, as observed in our study. On population level, this risk should be recognised.

Severe OIs can cause severe consequences such as distant infections or even death. In the present study, infection

Table 5. Infection complications and distant infections of 303 patients with acute odontogenic infections.

	n (% of 303)
Any infection complication or distant infection[a]	23 (7.6)
Septicaemia	12 (4.0)
Pneumonia	11 (3.6)
Endocarditis	2 (0.7)
Necrotising fasciitis	2 (0.7)
Embolic renal infarction	1 (0.3)
Urosepsis	1 (0.3)
Death	1 (0.3)

[a]4 patients had more than one associated infection.

complications and/or distant infections occurred in 7.6% of patients, with septicaemia and pneumonia being the most common types. For these infection complications and/or distant infections, smoking was a statistically significant predisposing factor. A study by Weise et al. [19] indicated a rate of 3.3% for septicaemia in patients with OI, which is concordant with our results. However, when assessing the other consequences, our results showed notably lower complication rates (Table 5) than previously observed even though nearly a quarter (71 of 303) of patients required ICU care. In a recent study of deep neck infections by Velhonoja et al. [2], more than a fifth of patients (22%) developed infection complications. The most common infection complications were also severe; these included necrotising fasciitis (6.5%) and pneumonia (5.8%). A total of 4.7% were blood-culture positive and even 4.3% had life-threatening mediastinitis. However, only 45% of deep neck infections were of dental origin. Other sources of deep neck infection should be considered. Tonsillar or salivary gland infections or infections due to foreign bodies, trauma, or malignancy may create challenges in differential diagnostics. Necrotising fasciitis of the head and neck is reported to have a yearly incidence of 2 per 1 million inhabitants [35]. In a literature review by Gunaratne *et al.* [36], 47% of cervical necrotising fasciitis cases were assessed to be odontogenic. The rate for necrotising fasciitis was 0.7% in this study. Previously, Tapiovaara *et al.* [7] observed that OI is the most common aetiology for deep neck infections with increased risk for mediastinal involvement. In their study, 12 of 25 patients (48%) who developed mediastinitis as a result of deep neck infections were assessed to be of dental origin. None of the patients developed mediastinitis in the present study. The mortality rate was also low in the present study; only one (0.3%) patient died during hospital stay. Hence, OIs can usually be limited to the upper neck when treated promptly. Early infection detection and effective infection care (including abscess drainage and focus tooth extraction) are necessary to avoid further infection complications. Thus, a maxillofacial surgeon's assessment, identification of the focus tooth, and surgical infection care are necessary if there is suspicion of OI aetiology.

In this study, tooth extraction was performed in 38.0% of patients prior to hospital admission. Nevertheless, abscess incision was combined with tooth extraction in only 3 patients. In general, most tooth extractions were performed during an acute or subacute condition. Thus, our results raise the question of when a tooth extraction alone is insufficient as treatment for OI or if infection spread is not identified at a sufficiently early stage. On the other hand, even though prompt OI care is known to require simultaneous tooth extraction [23,37], it is often not made in time [21]. In addition, the extraction itself may in some cases predispose the patient to infection spread. Although prophylactic antibiotic use should be targeted to patients who would derive benefit, evidence-based data on the use of antibiotics in conventional extractions is somewhat contradictory [38,39]. The overall oral health of the patient is also important, as patients with poor dental health have been shown to be at higher risk for a stronger systemic response of an OI [20]. More detailed information on the clinical condition before tooth extraction, the prophylactic antibiotics used, and the extraction circumstances are required to make further conclusions. Even though tooth extraction often preceded hospitalisation in the present study, this was not associated with more severe infections.

Root canal treatments (RCTs) may increase the risk for spread of endodontic infection if not completed [40]. In our material, 8.3% of hospitalised patients had received a recent RCT. However, only 3 of the 25 patients who had a recent endodontic procedure as an acute infection care required ICU treatment. No association was found between recent RCTs and severe OI. Suboptimal RCT may lead to chronic apical periodontitis [41,42], which can become acute even decades later [43]. With 27% of the adult population presenting teeth with apical periodontitis, the magnitude of this potential risk should not be neglected [44]. Acute OIs may arise from several types of dental infections, such as pericoronitis, periodontitis or apical periodontitis. However, in our retrospective study precise information on these subtypes were only partly available. Further studies focussing on the specific infection types in hospitalised patients would bring an interesting addition to contemporary literature.

The typical signs of OI are pain, restricted mouth opening, and local swelling. In the present study, CRP levels and WBC counts at hospital admission were significantly associated with more severe infection, consistent with previous studies [21,34]. A spreading OI may cause generalised findings such as elevated levels of body temperature and increased heart rate, which also predicted further ICU treatment in the present study. Therefore, the question arises whether these easily measurable clinical parameters should be evaluated earlier. For example, dentists at referral units could evaluate OI patients' general condition, blood pressure, heart rate, and body temperature in addition to clinical findings to support the assessment of infection severity.

Consistent with previous reports, we observed a distinct and significant difference in the prevalence of mandibular molars versus all other teeth as the origin of the most severe infections [3,20,45]. In particular, the third and second lower molars were highly represented in our material. The roots of these teeth are anatomically situated more lingually, which creates a pathway for infection spread. Acknowledging this elevated risk when treating infections of this area with local dental procedures at outpatient care could enhance the probability of preventing some of the most severe infections

from developing and improve detection of spreading OIs at an early stage.

The retrospective design of this study has some limitations. Detailed descriptions of the patients' preceding treatment, symptoms, and clinical findings prior to hospital admission were partially deficient. However, the observational nature of the present study offered the possibility to investigate a large and representative sample of patients with severe OIs. Further studies with more elaborate records of the confounding factors are required to clarify the risks for the most severe OIs.

Conclusions

Deep OIs often occur in previously healthy patients and are associated with lower molars. Septicaemia is the most common infection complication followed by pneumonia. However, other distant infections are relatively rare even in deep OIs when the focus is detected at the beginning of hospital stay and surgical treatment includes comprehensive surgical infection care. Smokers are at significantly higher risk for more complicated OIs than non-smokers.

Disclosure statement

The authors declare that they have no competing interests.

Funding

The study was not supported by any funding source. JS was funded by the Paulo Foundation and JS, JU and NR by Helsinki University Hospital fund.

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