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Risk factors and preventive measures for severe orofacial and neck infections: a three-year observational study

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Abstract

Background The purpose of this study was to identify the risk factors of severe orofacial and neck infections and the factors that could prevent them and reduce their severity.

Methods A three-year prospective observational study was conducted from 8.15.2016 to 8.31.2019 at a tertiary care hospital. 94 patients participated the study. The criteria for inclusion in the study were that the patients were adults with neck and severe orofacial infections that required treatment in hospital. Patients under the age of 18 and patients who did not consent to participate in the study were excluded. The responses to the questionnaire designed for this study were collected, as was supplemental data from medical records. The patient data were analyzed. Length of stay (LOS), intensive care unit (ICU) stay, complications and mortality were used as the main outcome variables, and various pre-admission factors and clinical and laboratory parameters were used as the predictor variables. The method used was univariate analysis.

Results In 79 (84.0%) cases, surgery confirmed an abscess and pus. Age ($p = 0.001$) and underlying diseases ($p = 0.024$) contributed to complications. Bulging of the lateral pharyngeal wall or laryngeal swelling on admission was significantly related to the need for intensive care treatment ($p < 0.001$). The spaces most often involved were the submandibular ($n = 15$; 16.0%), sublingual ($n = 15$; 16.0%) and parapharyngeal ($n = 14$; 14.9%) spaces. Sixty-three cases (67.0%) were of odontogenic origin, and 58.5% of the patients reported having attended previous health care appointments due to an acute dental problem. The patients with odontogenic infections had poor oral hygiene and most likely did not brush their teeth daily ($p = 0.029$). "Dishwater" pus was associated with longer hospitalization ($p < 0.001$), intensive care treatment ($p < 0.001$), and surgical revisions ($p < 0.001$). One lethal outcome (1.1%) was reported.

Conclusion Age and underlying illnesses should be considered complicating factors, and lateral pharyngeal or laryngeal edema should be considered risk factors for ICU treatment. This study also emphasized the preventive role of good dental hygiene and the importance of patients' follow-up treatment after acute dental interventions.

Keywords Orofacial, Deep neck, Odontogenic infection, Abscess

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Background

Severe orofacial and deep neck infections (DNI) can potentially spread through the fascial planes, causing substantial morbidity [1–3]. Their etiology is most often odontogenic, but other causes include pharyngotonsillar infections, sialadenitis, foreign bodies, trauma, congenital cysts, neoplasms, lymphadenitis, and iatrogenic factors such as post-operative infections after dental surgery [4]. Recognizing and eliminating the dental focus, administering parenteral antibiotics, performing incisions and drainage, and frequent intensive care unit (ICU) treatment are essential for a favorable outcome. Due to the risk of airway obstruction, securing the airway with fiberoptic intubation or tracheostomy under local anesthesia is often necessary [3, 4]. Complications such as sepsis, descending necrotizing mediastinitis, or vascular ruptures can be potential causes of lethal outcomes [1, 5–7]. Several predisposing factors such as diabetes, older age, systemic diseases, psychiatric morbidity or dementia, excessive alcohol consumption, and smoking have been mentioned in the previous literature [1, 3, 8, 9]. In addition, similar factors, such as diabetes, vascular and pulmonary diseases, multispace location, age, immunocompromised status, and *Streptococcus Anginosus* have been associated with more severe infection such as longer hospitalization, mediastinal extension, or the need for intensive care [3, 10–13]. However, the significance of contact with primary health care or frequent use of acute dental care is not fully known. Dishwater pus has been previously identified as a risk factor for necrotizing fasciitis (NF). Nevertheless, its importance in less aggressive infections remains unknown [14].

Recent studies have shown that DNIs are an increasing health problem and a considerable burden on the healthcare system, which highlights the importance of investigating possible preventive or aggravating factors [1, 9, 15, 16]. Dental infections can be relatively easily treated if detected at an early stage. Uittamo et al. (2020) reported that 59% of odontogenic emergency care patients had previously attended health care appointments for acute infections. Nevertheless, only a small number of these patients had received appropriate dental treatment before being hospitalized for DNI [17]. Poor dental health and a lack of prior dental treatment have been linked to more severe infections [18]. Conditions such as caries, periodontitis, periapical infections, pericoronitis, and post-extraction infections, mainly localized in the lower molars, are believed to precede severe infections [8]. The limitations of public health dental care also increase the volume and severity of odontogenic infections [19]. Therefore, the objective of this study was to determine the factors that precede infection and cause delays or suboptimal treatment for patients who require hospitalization, and to help direct the limited preventive resources that are available toward high-risk patients. The study hypothesis was that certain clinical parameters and patients' prior health behavior are associated with more severe disease and prolonged treatment.

Methods

A prospective observational study of neck and severe orofacial infections requiring hospitalization and/or surgical treatment of abscesses in adults (aged over 18) was conducted in a tertiary care hospital from 8.15.2016 to 8.31.2019. Patients aged under 18 and those who did not consent to participate in the study were excluded. While hospitalized, the patients completed a structured questionnaire designed for this study by the study group. Some patients completed the questionnaire after their time intensive care, once their condition allowed. The questionnaire elicited information on previous treatments, health behaviors, preceding symptoms, and sociodemographic factors, which are usually not fully reported in patient records. This provided more harmonious data for the study. The collected data were supplemented by clinical data from medical records, such as laboratory and microbiological results. Patient demographics, cause of infection, body mass index (BMI), comorbidities, symptoms, operations, dental hygiene habits, pre-admission dental treatment, smoking status, alcohol consumption, length of hospital stay (LOS), ICU days, complications, and outcomes were analyzed. The outcomes used for the analysis were those that measured overall LOS, prolonged LOS (7 or more days), the need for ICU treatment, prolonged ICU treatment (7 or more days), complications, and revision surgery. Predictor variables like clinical findings and risk factors were compared to outcome variables using univariate analysis.

IBM SPSS Statistics version 27 was used to analyze the data. The Pearson Chi-Square test was used to compare the categorical data of the groups, and Fisher's exact test (two-sided significance) was used to analyze an expected group size of below five with an asymptotic two-sided significance. A p-value of < 0.05 being considered significant. The Mann–Whitney U test was applied to the independent samples to compare the continuous variables of the two groups. The Kruskal–Wallis test was used for comparing multiple groups to the continuous variables. A two-sided p-value of < 0.05 was considered statistically significant. A Spearman's rank-order correlation was applied when non-normally distributed continuous variables were compared (BMI, LOS).

Results

The study population consisted of 96 patients. Two participants did not complete the questionnaire and were excluded, leaving 94 participants. Sixty-four (68.1%) were male and the mean age was 46.4 (18–82). Table 1 specifies the patient demographics and comorbidities. Out of 91 patients, 35 (37.2%) reported smoking. The smokers had an odontogenic infection ($p=0.025$) more commonly than the non-smokers. However, their LOS did not differ significantly ($p=0.084$) because the median was four days for smokers and five days for non-smokers. Complications did not differ either ($p=0.761$). The patients were mostly (53.2%) employed. The educational profile was mainly upper secondary level and three answers were missing. Fifty-two (55.3%) patients had no underlying illnesses. The most often-encountered underlying diseases were hypertension (19.1%), psychiatric diagnosis (11.7%), and diabetes (9.6%). The mean BMI ($n=89$) was 28.2 kg/m^2 and as a continuous variable, BMI did not correlate with LOS ($p=0.231$). A BMI over 30 ($n=26$) did not significantly correlate with the need for ICU treatment ($p=0.135$), complications ($p=0.498$), or overall LOS ($p=0.304$).

Table 1 Patient demographics and comorbidities

	No. of patients ($n=94$)	%
Sex		
Female	30	31.9
Male	64	68.1
Age (mean,range)	46.4 (18–82)	
Sosioeconomics		
Emloyed	50	53.2
Retired	26	27.7
Unemployed	13	13.8
Student	3	3.2
Other	2	2.1
Education (highest)		
Primary school	16	17.0
Upper secondary level	56	59.6
Higher education	19	20.2
Missing	3	3.2
Smoker	35	37,2
BMI (mean,range)	28.2 (15.4–57.3)	
BMI > 30	26	27.7
Comorbidities		
Hypertension	18	19.1
Psychiatric diagnosis	11	11.7
Diabetes	9	9.6
Heart and vascular disease	7	7.4
Lung disease (exc. asthma)	7	7.4
Malignancy (inc. previous)	4	4.3
Heavy alcohol consumption	3	3.2
Immunocompromised	3	3.2
Chronic renal failure	1	1.1
I.v. substance abuse	1	1.1
Healthy	52	55.3
Some or several co-morbidity	42	44.7

The majority, i.e., 67.0% ($n=63$) of the patients had an odontogenic etiology of infection. Of these infections, 17% ($n=11$) were categorized as dental post-operative infections. The second most common infection was pharyngotonsillar infection, at 23.4% ($n=22$). Other identified causes were two sialadenitis, one lymphadenitis, a neoplasm, an otogenic infection, and cervical penetrating trauma. Three infections remained unknown. Patients with odontogenic infections were significantly more likely not to brush their teeth daily ($p=0.035$). Level of education was also associated with dental habits. The more highly educated patients were significantly more likely to brush their teeth daily than the primary- ($p=0.005$) or secondary-/intermediate-level educated patients ($p=0.004$).

Table 2 illustrates the presenting symptoms. To find possible predictive complaints, patients with a more severe clinical course were compared to the others. A more severe clinical course was defined as prolonged LOS (≥ 7 days) or the need for intensive care. Bilateral neck swelling ($p=0.005$), torticollis ($p<0.001$), and swelling or redness on the chest ($p=0.003$) were associated with a longer LOS. Bulging of the lateral pharyngeal wall ($p<0.001$) and laryngeal swelling ($p<0.001$) were significantly related to the need for ICU treatment, but dental pain and facio-buccal swelling were negatively linked. The mean duration of symptoms before hospitalization was 4.3 days and the median was 3 days (range 1–20 days; SD 3.32) and this did not differ in terms of education level ($p=0.852$) or socioeconomic status ($p=0.594$). Table 3 shows a comparison of the clinical presentation of healthy patients and patients with comorbidities. Dysphagia ($p=0.003$) and laryngeal swelling ($p=0.046$) were observed more often in patients without comorbidities.

Dental appointments and oral health care were examined using a questionnaire, which is partly presented in Table 4. Of the patients, 45.7% reported having undergone regular dental check-ups, and only 29.8% had seen their dentist in the past 12 months. Thirty-two (34%) patients also reported having experienced symptoms in the focus area in the past. Previous health care appointments due to an acute dental problem were reported by 55 (58.5%) patients, 54.5% of whom ($n=30$) reported being advised to seek additional treatment after the emergency appointment. However, 19 (63.3%) patients stated that they did not seek this recommended

Table 2 Clinical presentation on admission and associations to more severe clinical course

	n	%	7 days or longer LOS *p*-value	ICU treatment *p*-value
Neck pain	72	76.6	0.066[a]	0.343[a]
Neck swelling	70	74.5	0.062[a]	1.000[a]
bilateral	6	6.4	0.005[a]	0.070[a]
Sore throat	70	74.5	0.222[a]	0.062[a]
Dysphagia	56	59.6	0.634[b]	0.034[b]
Trismus	53	56.4	0.823[b]	0.752[b]
Swelling of the floor of the mouth	38	40.4	0.944[b]	0.634[b]
bilateral	7	7.4	0.334[a]	0.019[a]
Fever	36	38.3	0.778[b]	0.412[b]
Faciobuccal swelling	34	36.2	0.231[b]	*0.004[b]
Bulging of the lateral pharyngeal wall	32	34.0	0.211[b]	< 0.001[b]
Redness of the neck	32	34.0	0.211[b]	0.904[b]
Dental pain	30	31.9	0.163[b]	*0.011[b]
Laryngeal swelling	20	21.3	0.348[a]	< 0.001[a]
Torticollis	17	18.1	< 0.001[a]	0.012[a]
Dyspnea	7	7.4	0.109[a]	0.109[a]
Hoarseness	5	5.3	0.207[a]	0.042[a]
Swelling or redness on the chest	5	5.3	0.003[a]	0.040[a]

[*] negative predictive value

[a] Fisher's exact test

[b] Pearson Chi-Square test

Table 3 Comparison of the clinical presentation in healthy and comorbid patients

	Comorbidity (*n* = 42)	Healthy (*n* = 52)	*p*-value
Neck pain	31 (73.8%)	41 (78.8%)	0.566[a]
Neck swelling	33 (78.6%)	37 (71.2%)	0.412[a]
bilateral	2 (4.8%)	4 (7.7%)	0.688[b]
Sore throat	28 (66.7%)	42 (80.8%)	0.119[a]
Dysphagia	18 (42.9%)	38 (73.1%)	**0.003**[a]
Trismus	22 (52.4%)	31 (59.6%)	0.482[a]
Swelling of the floor of the mouth	15 (35.7%)	23 (44.2%)	0.403[a]
bilateral	3 (7.1%)	4 (7.7%)	1.000[b]
Fever	13 (31.0%)	23 (44.2%)	0.188[a]
Faciobuccal swelling	15 (35.7%)	19 (36.5%)	0.934[a]
Bulging of the lateral pharyngeal wall	11 (26.2%)	21 (40.4%)	0.149[a]
Redness of the neck	15 (35.7%)	17 (32.7%)	0.759[a]
Dental pain	14 (33.3%)	16 (30.8%)	0.791[a]
Laryngeal swelling	5 (11.9%)	15 (28.8%)	**0.046**[a]
Torticollis	6 (14.3%)	11 (21.2%)	0.390[a]
Dyspnea	3 (7.1%)	4 (7.7%)	1.000[b]
Hoarseness	2 (4.8%)	3 (5.8%)	1.000[b]
Swelling or redness on the chest	3 (7.1%)	2 (3.8%)	0.653[b]

[a] Pearson Chi-Square test

[b] Fisher's exact test

follow-up treatment. The most common reasons were fear of the dentist ($n=9$), financial issues ($n=4$), and difficulty obtaining follow-up care ($n=2$), which were also common reasons for not having regular dental check-ups (Table 4).

An infection requiring hospital admission was diagnosed by an on-call otorhinolaryngologist or an oral and maxillofacial surgeon based on clinical, laboratory, and imaging findings. Seventy-one (75.5%) patients had undergone magnetic resonance imaging (MRI) ($n=45$; 47.9%), contrast-enhanced computed tomography (CT) ($n=8$; 8.5%), or both ($n=18$; 19.1%). In one case (1.1%), ultrasound had been used and in one case (1.1%) cone-beam CT. Repeated imaging (CT or MRI) at follow-up was considered necessary in 20 (21.3%) cases. Orthopantomography (OPG) was available in 78 (83.0%) cases. Lower molars accounted for 59.4% and upper molars 18.8% of the causative teeth. Dental imaging findings were specified in 68 cases and periapical infection was diagnosed in 54 cases, caries in 19, and pericoronitis in 7. In six cases, the teeth were decayed to the root. Some patients ($n=22$) showed multiple findings. A total of 42 patients had poor dental health according to radiological and clinical findings, and this was significantly more common in the odontogenic subgroup of infections ($n=37$; $p=0.002$), as expected. The dental status of 11 (11.7%) patients could not be determined from the patient records.

The main affected neck space was recognized in 88 (93.6%) cases. The most involved spaces were the submandibular ($n=15$; 16.0%), sublingual ($n=15$; 16.0%) and parapharyngeal ($n=14$; 14.9%) spaces. The masticator space ($n=11$; 11.7%), buccal space ($n=10$; 10.6%), and Ludwig's angina were occasionally found as bilateral submandibular and sublingual spaces ($n=4$; 4.3%). Other spaces reported were the submental ($n=3$), carotid space ($n=2$), the base of the tongue ($n=2$), the parotid region ($n=2$), the clavicular fossae ($n=1$), and the paratracheal ($n=1$) and retropharyngeal ($n=1$) spaces. The infection was categorized as multilocular ($n=7$; 7.4%) if the main space could not be identified from the several affected spaces. Nevertheless, based on imaging, more than one space was considered affected in 41 (43.6%) cases.

The questionnaire elicited information on treatment before hospitalization. Forty-four (46.8%) patients had been to a dentist, 24 (25.5%) to a general practitioner or other physician, 16 to a nurse (17.0%), and 6 patients did not specify. Thirty-six (38.3%) patients had been

Table 4 Dental care appointments and oral health habits

	n	%	
1. Regular dental check-up[a]			
Yes	43	45.7	
No	50	53.2	
2. If yes, frequency			
Every half year	3	7.0	% of 43
Once a year	25	58.1	
Once in every two year	9	20.9	
Rarely	11	25.6	
Never	0	0.0	
3. Reason for no regular dental care check-ups			
Fear of dentist	26	52.0	% of 50
Financial issues	12	24.0	
Difficulty accessing treatment	9	18.0	
Lack of time	7	14.0	
Other	9	18.0	
4. When was the last time you had a dental check-up?			
Less than a year ago	47	50.0	
1–2 years	19	20.2	
3–4 years	7	7.4	
more than 4 years	20	21.3	
5. How often do you make an appointment for dental care due to an acute problem?			
4 times a year or more frequently	2	2.1	
2–3 times a year	2	2.1	
Once a year	3	3.2	
Less than once a year	87	92.6	
6. Do you brush your teeth daily?			
Yes	69	73.4	
No	25	26.6	

[a] One missing value

prescribed antibiotics before admission; 22 cases had undergone dental extraction, 5 root canal treatment, 1 calculus removal, and 3 light tooth smoothing. Forty-three had pain medication and 12 had had throat swabs.

Table 5 shows whether the variables affected LOS. Non-odontogenic origin was associated with longer LOS ($p=0.032$). No significant differences were found in terms of smoking, BMI over 30, extraction at the hospital, or comorbidity. However, if the first health care-related contact had been a dentist, this seemed to lead to shorter LOS ($p=0.014$). Education level ($p=0.902$) or socioeconomic status ($p=0.299$) did not affect LOS. As the median LOS was four days, seven days or more can be classed as prolonged LOS ($n=17$; 18.1%). The median overall LOS was six days among the diabetic patients and four days among the non-diabetics, but this difference was not statistically significant ($p=0.439$).

The mean C-reactive protein (CRP) value on admission was 139 mg/L and the median was 127 (range 3–339; SD 81.8). The mean white blood cell count was 15.0×10^9/L and the median 14.1 (range 4.0–27.0; SD 5.0). Higher CRP values on admission were associated with a need for surgical revisions ($p=0.006$) and complications ($p=0.005$), but not comorbidities ($p=0.479$), whereas blood white cell counts were not associated with any of these variables ($p=0.722$; $p=0.147$; $p=0.979$). CRP on admission ($p=0.001$) was associated with prolonged LOS (7 days or more), but white blood cell count ($p=0.198$), age ($p=0.473$), sex ($p=0.741$), and comorbidities ($p=0.195$) were not.

All the patients received empirical parenteral antimicrobial therapy, which was later specified on the basis of microbiological findings and drug susceptibility testing. The most commonly used empirical antibiotics were cefuroxime combined with metronidazole (46.8%), or penicillin combined with metronidazole (37.2%). Pus samples were available for 72 (76.6%) patients and unspecified mixed flora were the most common finding, $n=51$ (70.8%). The most common pathogens found were the *Prevotella* species, 30 (41.7%); viridans group streptococci (including the *Streptococcus Anginosus* group), 29 (40.3%); and the *Fucobacterium* species, 7 (9.7%). Polymicrobial growths were noted in 50 (69.4%) samples.

A neck incision and surgical drainage +/− intraoral incision was made in 39 (41.5%) cases. An intraoral incision was sufficient for 53 (56.4%) patients, 28 (29.8%) of which were made under only local anesthesia. An abscess and pus were found in surgery in 79 (84.0%) cases, of which five were dishwater pus cases. Ten cases had no pus or unclear findings and cellulitis was described in five cases. Dishwater pus was described as foul odorous, clearer, or darkish serous exudate, which differed from the denser yellowish pus more frequently encountered. The etiology was tonsillopharyngeal in three patients and odontogenic in two of these patients. This type of dishwater pus seemed to be associated with the need for ICU treatment ($p<0.001$), prolonged ICU stay ($p=0.031$), revision surgery ($p<0.001$) and longer overall LOS ($p<0.001$), but not with complications ($p=0.503$).

Sixty-eight patients (72.3%) underwent dental extraction—46 (48.9%) of these extractions were at the hospital and 22 (23.4%) before admission. On average, 2.6 teeth had been removed and the median was 1 (range 1–13; SD 2.82). The number of removed teeth negatively correlated with daily brushing of the teeth ($p=0.026$). The mean LOS was shorter (5.3 vs. 6.1 days) if the tooth was extracted before hospitalization but did not reach statistical significance. Surgical revision was necessary in 10 (10.6%) cases. The odontogenic subgroup of patients with good oral health ($n=24$; 39% of all odontogenic cases) was analyzed to determine whether poor dental health slowed down the healing

Table 5 Effect of variables on length of stay (LOS)

Variable	n	%	LOS (mean)	LOS (median)	*p*-value*
All**	93		5.88	4	
Smoking	35	38.9	5.00	4	0.084[a]
No smoking	55	61.1	6.58	5	
First contact to health care					
Dentist	44	48.9	4.95	4	0.014[a]
Other	46	51.1	7.02	5	
BMI > 30	25		5.4	5	0.304[b]
BMI < 30	63		6.08	4	
Extraction at hospital	46	67.6%	6.13	4	0.889
Extraction before the admission	22	32.4%	5.27	4	
Comorbidity	41	44.1%	6.73	5	0.284
No comorbidity	52	55.9%	5.21	4	
Odontogenic	62	66.7%	5.13	4	0.032
Non-odontogenic	31	33.3%	7.47	5	

* Mann–Whitney-U test

** One missing value

[a] 4 missing values

[b] 6 missing values

process. The poor oral health subgroup had more need for revision surgery ($n=4$) than the good oral health group ($n=0$), although it did not reach statistical significance ($p=0.147$).

ICU treatment was needed in 17 (18.1%) cases, a mean of 4.9 days and a median of 5 days (range 1–12). Six (6.4%) patients were at the ICU for seven days or more. Age was not associated with the need for ICU treatment itself ($p=0.569$), but this period of prolonged intensive care (seven days or more) was observed ($p=0.024$) among elderly patients, the median age being 64.5 and 45 years in these groups, respectively. The odontogenic subgroup had five patients (29.4%) in ICU, and the non-odontogenic group had 12 (70.6%). Hyperbaric oxygen therapy (HBO) was administered once a day as an adjunct to ten (10.6%) patients, for an average of six days (range 3–10 days). Tonsillectomy was performed on 19 (20.2%) patients. It is noteworthy that these patients required ICU treatment significantly more frequently than those with other, mainly odontogenic infections ($p<0.001$). A tracheostomy was required in four cases and fiberoptic intubation in 25, representing 37% of the 66 patients requiring general anesthesia.

Twelve (12.8%) patients had complications, and two patients had multiple complications. The most common complication was sepsis ($n=6$; 6.4%) followed by an orocutaneous fistula ($n=3$; 3.2%). Other complications in this population were isolated incidences, including stroke, gastrointestinal bleeding, heart attack, pneumothorax, and one lethal outcome. Age was a clear risk factor for complications ($p=0.001$), as was any underlying disease ($p=0.024$).

Discussion

This study had a prospective cohort of 94 patients, hospitalized for orofacial or neck infections. The findings of our study clarify that poor oral health and oral hygiene habits are predisposing factors for severe orofacial and neck infections, and that laryngeal swelling and thoracic symptoms are also associated with treatment requiring intensive care and longer times in hospital. Retrospective studies have dominated the published literature, and this prospective follow-up study is, to our knowledge, one of the largest studies of orofacial and neck infections to date.

Our case series had a clear male predominance (68.1%), like several other published series [1, 4, 17, 20, 21]. It can be assumed that the poor dental health of males may contribute to this finding [22]. Odontogenic infection was significantly more common among patients who were not committed to daily dental hygiene; an obvious result that highlights the potential for preventing these infections. A recent population-based study has also confirmed the association between chronic periodontitis and DNI [23]. A significant number of patients (58.5%) reported using acute dental care services before admission, and four (4.3%) patients reported using these services even twice or more per year. The hypothesis was that intensifying the follow-up and overall treatment of these high-risk

patients might help reduce severe infections. If the first health care-related contact as a dentist, LOS seemed to be shorter ($p=0.014$). Nevertheless, some milder dental infections (only local anesthesia procedures were needed in 29.8% of the cases) may have been included in the analysis, showing shorter LOS. In our previous study, early extraction significantly reduced LOS [1]. The present study evaluated whether active treatment with a dental focus before admission could shorten LOS. A slightly shorter LOS was found, but it did not reach statistical significance, possibly due to the limited number of patients. The association between non-odontogenic origin and longer LOS was confirmed, which is in concordance with previous studies [24].

Wang et al. (2003) have shown in multiple regressions that patients of older age with neck swelling, trismus, underlying diseases, or complications have longer LOS [25]. The median LOS was two days longer (six days vs. four days) among diabetics. However, the difference did not reach statistical significance in the present study, probably due to the small sample size. Many studies have confirmed a more severe clinical course among patients with diabetes, as has an meta-analysis by Hidaka et al. [26, 27]. Other studies have postulated that pharyngotonsillar or parapharyngeal DNI have a worse prognosis [10, 24]. In this study, bilateral neck swelling, torticollis, and swelling or redness on the thoracic area in the primary presentation were associated with a longer LOS. These are severe symptoms and indicate an advanced stage of the disease. The bulging of the lateral pharyngeal wall, swelling of the larynx, and hoarseness were significantly associated with ICU treatment, which is understandable because of their obvious relation to airway problems. This study also confirmed that dysphagia, bilateral swelling of the floor of the mouth, and torticollis are related to ICU treatment. Previous studies have shown that breathing difficulties are frequently linked to ICU treatment [10, 21]. Dental pain and facial swelling were negatively linked to the need for ICU treatment; this is likely due to the group of patients with only locally advanced dental infections and a good overall prognosis. Interestingly, the symptoms at presentation of otherwise healthy patients and those with underlying illnesses did not differ significantly, except in the cases of dysphagia and laryngeal swelling, which were more common among patients without comorbidities.

Multidisciplinary treatment is frequently needed for managing severe infections. ICU treatment was needed in 18.1% of the cases, which is comparable to the 21% reported by Buckley et al. [9]. Another study reported that among DNI patients with neck incisions, 40% needed ICU treatment [20]. A significantly greater number of patients treated under general anesthesia needed fiberoptic intubation (37%) than the 17.9% reported by Riekert et al. (2019), but higher percentages (49%) have been published by Flynn et al. in 2006. [21, 28]. The tracheostomy rate of anesthetized patients was 6.1% ($n=4$), two with the primary airway method and two during the ICU stay. Riekert et al. have documented a primary tracheostomy rate of 0.8%, and Boscolo-Rizzo et al. a rate of 2.2% However, others have reported higher overall rates of 13–17% among patients requiring neck incisions [1, 20]. Weise et al. (2019) stated that all the 16 odontogenic infection patients with septic progression in their study had undergone a tracheostomy (3.3%) [2]. This highlights the importance of a well-planned airway management protocol for these patients.

Age was a risk factor for complications ($p=0.001$) and prolonged ICU stay ($p=0.024$), which was consistent with the previous literature: Older age has been documented as contributing to complications and longer hospitalization [1, 3, 4, 29]. The association between comorbidities and complications has also been found earlier [2, 4, 19]. Obesity has previously been linked to ICU treatment and septic progression of odontogenic infection [2, 21]. It has been hypothesized that obesity can aggravate disease progression, but in the present study, BMI did not significantly correlate with the need for ICU treatment, complications, or overall LOS, which is possibly due to the limited number of patients.

In 2015, Alotaibi et al. reported that mandibular odontogenic infections were associated with longer hospital stays and ICU treatment [30]. Fu et al. stated in 2018 that lower third molar infection, dysphagia, and a CRP of over 150 were clinical predictors of the need for intensive care [15]. In our data, mandibular molar infections, mostly periapical, were the most common cause of odontogenic infection requiring hospitalization, similar to earlier reports [8, 18]. The anatomical pathway in the molar region, especially the second or third, can enable the infection to spread directly to the submandibular space, which means a higher risk of severe infection and further dissemination [31]. In the odontogenic subgroup, 7.9% needed ICU treatment, which is similar to the 6.3% reported by Riekert et al. in 2019, but lower than the 33% reported by Seppänen et al. for hospitalized odontogenic infections in 2011 [18, 21].

The previous literature has linked dishwater pus to NF, which is rarely seen in the head and neck region [14]. However, tissue necrosis or impaired circulation were not mentioned in the cases in the present study, and NF was not diagnosed. A risk of evolving necrotizing infection was likely, and the data suggest that more attention should be paid to patients in whom dishwater pus was found in surgery, as this was clearly associated with a more severe clinical course such as ICU treatment,

longer LOS, and revisions. Nonetheless, it is notable that four of these five patients received HBO therapy and that all of them left hospital with no sequelae. Further studies with more patients should be conducted to evaluate whether more aggressive treatment protocols are warranted for these patients.

Higher CRP on admission was associated with the need for surgical revisions, complications, and prolonged LOS, which is in accordance with previous studies linking higher CRP to ICU treatment and longer LOS [21, 32]. Overall, complications were found among 12.8% of the patients and 1.1% mortality, which are plausible rates when compared to previous reports of 7–22% and 0.3–1.83%, respectively [1, 3, 4, 9]. MRI was part of the imaging protocol in 63 cases (67.0%). Recently, retropharyngeal edema has been confirmed to be a significant predictor of a more severe illness, and this may help in clinical decision-making among suitable patients [33].

This study confirmed that poor oral health and oral hygiene habits are linked to severe orofacial and neck infections. On average, 46% of Finnish men and 77% of women report brushing their teeth twice a day [22]. According to the data, the teeth-brushing habits of the hospitalized orofacial and neck infection patients were related to their level of education, which is line with the findings regarding the oral health of the Finnish population, in which those with basic education rated their teeth and their oral health more poorly than those with higher education [22]. Moreover, patients with a lower level of education were more likely to be hospitalized for odontogenic infection [17]. Of the patients in the present study, 29.8% had seen their dentist in the last 12 months. This percentage is lower than the average in the data from the 2000 Oral Health in the Finnish Adult Population survey, in which 52% of all participants had undergone a dental examination in the past year [22]. Fear of the dentist seemed to be a major issue in avoiding dental care.

One focus of this study was odontogenic infections, which in many cases could be prevented. This study confirms that some risk factors can be managed in order to reduce the incidence of these severe infections. The importance of early detection and treatment with a dental focus can hardly be overestimated. Previous studies have shown that advanced odontogenic infections, such multiple space infections and airway problems, incur significantly higher costs [34]. A cost analysis of hospitalized patients is beyond the scope of this article, but proper access to dental health services and oral health education should be seen as an important preventive measure that could decrease the substantial cost of surgery and potentially long hospitalization. Early detection of signs of severity is crucial for preventing complications. Identifying these patients in primary care is sometimes challenging. Transmitting information and awareness to primary care health workers could help avoid devastating complications. Awake fiberoptic intubation or tracheostomy under local anesthesia when needed has proven to be an effective way of treating difficult airway problems among these patients. Moreover, cross-sectional imaging plays a crucial role in the planning of surgical treatment for severe orofacial and neck infections. Bulging of the lateral pharyngeal wall, laryngeal swelling, dysphagia, torticollis, and bilateral swelling of the floor of the mouth, hoarseness, and swelling or redness on the chest area were associated with a need for ICU treatment. Patients presenting with some of these symptoms should be carefully evaluated and the option of ICU treatment considered. Dishwater pus without evidence of avascular necrosis of the skin or fascia could be a warning sign of evolving necrotizing infection, and the possible progression of the disease should be carefully assessed during follow-up and treated with radical surgical debridement if NF is diagnosed [6, 14].

Limitations and strengths

One of the main limitations of this study is possible selection bias. Only patients who had granted their written consent were included, and thus some patients did not participate. This limited number of patients also directly affects the results of statistical analysis. The prospective nature of this study, the questionnaire, and the checklist for the ENT and OMF surgeons on-call created for the study strengthen the equality of the data. No power analysis or formal sample sizes were estimated at the beginning of the study due to a lack of studies with similar objectives. However, sample sizes of 100 patients are mostly considered sufficient for summarizing the categorical and continuous variables in the descriptive burden of illness studies, and therefore enrollment was extended by one year [35]. Because no previous validated questionnaire was available, the form used for data collection was compiled by the study group for this specific study, in the Finnish language, and thus lacks validation.

Conclusions

Severe cervicofacial infections remain a challenge for prompt diagnosis and disease management. Despite multidisciplinary treatment, potentially fatal complications still occur. It is important to pay specific attention to patients with underlying illnesses or those presenting with laryngeal symptoms, torticollis, dysphagia, or signs of inflammation on the chest. This study emphasizes the preventive role of good dental hygiene and the need for follow-up treatment of patients after acute dental care. Dishwater pus was associated with a more severe course of illness in a small group of patients. Close monitoring

of these patients is recommended, and further studies are needed to confirm whether more efficient treatment methods should be considered for them.

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Authors' contributions
As a detailed description of each author's substantive contribution, we confirm that JV, ML, TS, IK, and HI made substantial contributions to the conception and design of the study and the analysis and interpretation of the data, and that JV, ML, SH, and NA contributed to the acquisition, analysis and interpretation of the data. All the authors were involved in drafting the manuscript and/or critically revising its important intellectual content. As the corresponding author, I confirm that the manuscript has been read and approved for submission by all the named authors.

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Data availability
The datasets generated and/or analyzed during the current study are not publicly available due to privacy reasons, but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Informed consent was obtained from all the participants and/or their legal guardian(s). Ethical Approval for the study (TO6/036/16) was obtained on 2.16.2016 from the ethics committee of the VSSHP (Hospital District of South-West Finland). The study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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