Article

Characterization, Management, and Epidemiology of Odontogenic Infections: An Analysis of 103 Cases at a Major Regional Medical Center

Ho-Hyun (Brian) Sun [1, 2, 4], Wenli Yu[1, 2], Sally Sun[2, 3], Sean Lee[1, 2], Vincent Farhood[5], and Payam Afzali[1]

[1] University of California, San Francisco – Highland Hospital
[2] Kaiser Permanente Northern California
[3] University of the Pacific, Thomas J Long School of Pharmacy
[4] Western University of Health Sciences, College of Dental Medicine
[5] University of the Pacific, Arthur Dugoni School of Dentistry
* Correspondence: hsun@westernu.edu

Abstract: Odontogenic infections are infections of the orofacial structures arising from dental disease. Despite its preventability, it exerts a significant burden on healthcare infrastructure worldwide. Our study explored the various different microbiological, social, and epidemiological characteristics of 103 cases of odontogenic infections at our regional center which demonstrated specific predilections for the young and middle-aged, those with diabetes mellitus, African American/Black and Hispanic ethnicities, posterior teeth, left-sided dentition, and male gender. However, nuances and exceptions to these trends were also seen with specific groups that may complicate treatment.

Keywords: odontogenic infection; dental abscess; head and neck infection; dental epidemiology; racial discrepancy; gender discrepancy

1. Introduction

Odontogenic infection (OI) refers to infections of the jaws, alveolar bones, and/or other maxillofacial structures originating from dentition. These infections typically occur when dental caries or trauma lead to introduction of bacterial species into the dental pulp, root canals, and the periapical spaces.[1] OIs are particularly painful and its propensity for causing facial asymmetry makes it an especially prominent disease. A 2017 review found that it was one of the most prevalent and significant causes of head and neck injury that accounted for approximately 36% of all Australian adult emergency room (ER) visits.[2] This has translated to a rate of 1 per 2600 individuals requiring admission and inpatient intervention.[3] Similarly, infection rates in children also remain high and accounts for approximately 47% of all U.S. pediatric ER visits.[4]

Sources indicate that OIs cause up to 57% of deep neck abscesses.[1] OIs can become emergent because of their spread through the fascial planes close to the airway, causing edema and swelling. In particular, bilateral submandibular infections are known as Ludwig's Angina (LA) and is considered a medical emergency owing to a rapid development of upper airway obstruction.[5]

Over 75% of Ludwig's angina cases arise from dental infections, especially in the setting of systemic illnesses like diabetes mellitus type 2 (DM2) or acquired immune deficiency syndrome.[5,6] Its diagnosis requires meticulous examination, patient history, clinical presentation, and radiographic imaging. Differential diagnoses also include non-infectious conditions such as hematoma or tumors which must be ruled out.[7]

Management of OI typically consists of removal of the offending tooth, drainage of any associated abscesses, followed by antibiosis but the individual protocols can vary greatly. Any drained fluids or spaces should be cultured to determine the offending pathogen, which could aid in antibiotic selection.[1] Severe cases may require pre-operative intubation or tracheostomy to protect the airway.[6] In infections already closely approximating the airway, more invasive parapharyngeal approaches should be considered in addition to periodontogenic surgery. Extensive spread into the mediastinum has also been documented.[8] In those suffering from predisposing systemic conditions, additional medical interventions including intravenous antibiotics may be required even for surgically uncomplicated cases. Treatment planning should also encompass treatments for the patient's systemic risk factors such as DM2, which may increase the risk of OI by over 1400-fold.[9]

Appropriate intervention depends on appropriate disease categorization. To better characterize relevant patient factors, a review of the OI cases including history of antibiosis, systemic conditions, age, gender, and their management was conducted.

2. Materials and Methods

A chart review of OI patients was conducted at a regional medical center serving the oral surgery needs of multiple, diverse Northern California counties between January 2019 to June 2020. All patients were treated by HBS, WY, and SL. A diagnosis of OI was made if there was compromised dentition with an identifiable bacterial conduit (such as caries or open dental fracture) as well as a clinical finding of purulent discharge, associated fluctuant swelling, and/or a radiographic finding of a periapical radiolucency whose histopathology demonstrated an inflammatory response without other neoplastic, traumatic, fungal, or autoimmune indicators. Patient demographics were taken including age, gender, American Society of Anesthesiology (ASA) physical status with medical history, ethnicity, location of the OI, gram stain results, duration (if any) of swelling, and pre-operative antibiotic use.

Every diagnosis of OI was treated via removal of the offending tooth with concurrent incision and drainage of the associated soft tissue swelling. Patients with signs of airway involvement including swelling of the oropharynx, oral floor elevation, dyspnea, difficulty tolerating secretions, and tracheal deviation were treated under general anesthesia with endotracheal intubation for airway protection and admitted for intravenous antibiosis. All outpatient individuals who were not prescribed antibiotics within the past three days were prescribed a week's dose of an oral beta-lactam antibiotic (amoxicillin 500mg TID, penicillin VK 500mg TID-QID, or cefalexin 500mg QID) unless proven allergic, at which point they were prescribed clindamycin 300mg QID for 7 days. All patients were followed for a minimum of one week after discharge.

3. Results

A total of 102 patients were included in the review with an age range of 19 to 72. One patient was diagnosed with two concurrent cases of OI for a total of 103 cases. 62 patients (60.8%) were male

and 40 patients (39.2%) were female. 34 (33.%) patients self-identified as African American/Black, 31 (30.4%) as Hispanic, 21 (20.6%) as non-Hispanic white, 11 (10.8%) as East Asian/Pacific Islander, 4 (3.9%) as Middle Eastern, and 1 (0.98%) as South Asian. Age distribution showed 2 (2.0%) in their second decade, 23 (22.5%) in their third, 28 (27.5%) in their fourth, 20 (19.6%) in their fifth, 17 (16.7%) in their sixth, 10 (9.8%) in their seventh, and 2 (2.0%) in their eighth.

The ASA classifications ranged from one to four with 45 (44.1%) patients ASA class one, 44 (43.1%) ASA class two, 11 (10.8%) ASA class three, and 2 (2.0%) ASA class 4.

Table 1: ASA classifications according to ethnicity. Highlight denotes most common classification.

	AA/Black	Hispanic	White	EA/PI	Mid-Eastern	South Asian
ASA 1	14 (41.2%)	17 (54.8%)	8 (38.1%)	5 (45.5%)	1 (25%)	0 (0%)
ASA 2	16 (47.1%)	11 (35.5%)	11 (52.4%)	3 (27.3%)	2 (50%)	1 (100%)
ASA 3	3 (8.8%)	2 (6.5%)	2 (9.5%)	3 (27.3%)	1 (25%)	0 (0%)
ASA 4	1 (2.9%)	1 (3.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	34	31	21	11	4	1

The African American/Black, White, and Middle Eastern patients were most frequently ASA class two, while Hispanic and East Asian/Pacific Islander patients were most frequently ASA class one. The most common systemic conditions were DM2 (17 patients), hypertension (14 patients), asthma (8 patients), hyperlipidemia (5 patients), iron deficiency anemia (3 patients), and anxiety (2 patients).

Table 2: Order and frequency of the most common systemic comorbidities

Condition	Frequency
Diabetes 2	17 (16.7%)
Hypertension	14 (13.7%)
Asthma	8 (7.8%)
Hyperlipidemia	5 (4.9%)
Anemia	3 (2.9%)
Anxiety	2 (2.0%)

Overall, the African American/Black patients were evenly divided into 50% female and 50% male. The Hispanic and non-Hispanic White groups consisted predominantly of male patients at 71.0% and 76.2%, respectively. In contrast, patients identifying as East Asian/Pacific Islander were predominantly female at 63.6% of total. The average ages were 39.82 years in the African American/Black group, 49.82 years in the East Asian/Pacific Islander group, 38.452 years in the Hispanic group, and 40.76 years in the non-Hispanic White group. Data from the other ethnic groups were not included as they accounted for less than 5 individuals combined and were insufficient for appropriate statistical comparison.

A total of 90 cases (88.2%) were discovered in the premolar/molar regions and 13 cases (12.7%) were found at or anterior to the canines. Using the dental midline as a spatial marker, 34 cases were in the lower left quadrant, 29 cases in the upper left, 24 in the upper right, and 16 in the lower right.

Overall, infection numbers were approximately equal on the maxillary and mandibular arches (51.5% maxillary vs 48.5% mandibular) but more common on the left side (61.2%) of the mouth.

Figure 1: Anteroposterior distribution of odontogenic infections

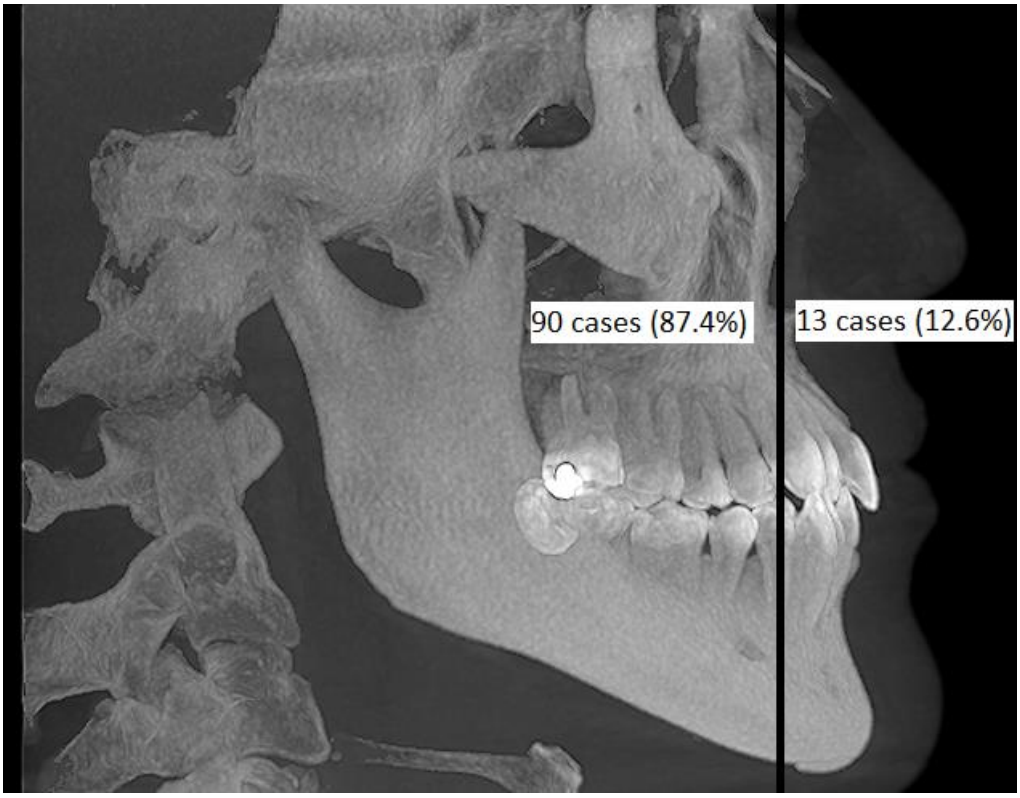
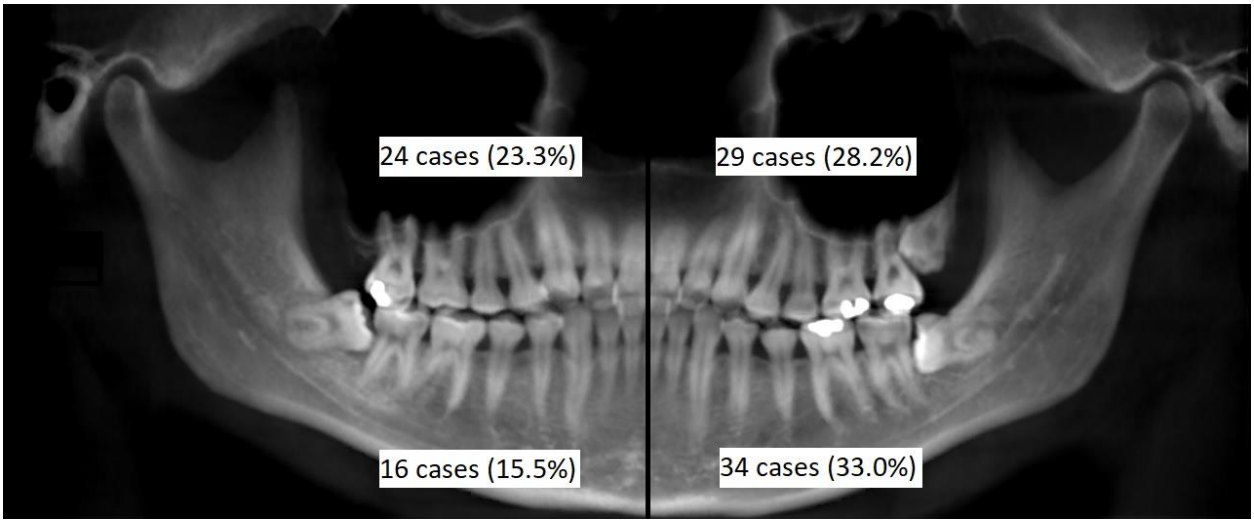


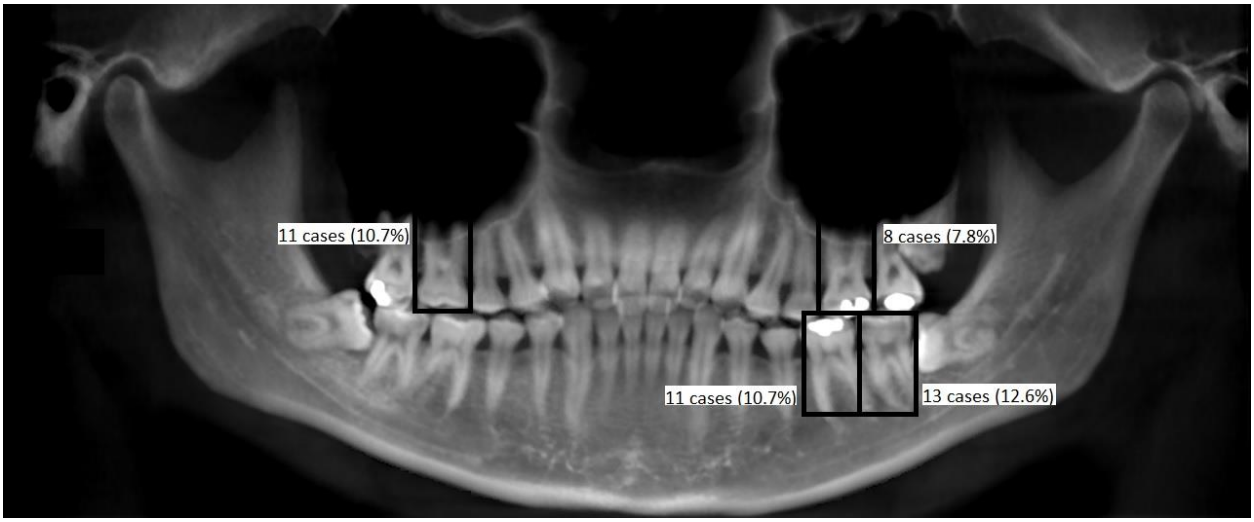
Figure 2: Distribution of odontogenic infections by oral quadrant.



Note that the patient in this radiograph is congenitally missing tooth #1

The tooth with the highest number of OI was #18 (left mandibular second molar) with 13 cases followed by #19 (left mandibular first molar) and #14 (left maxillary first molar) with 11 cases each and #3 (right maxillary first molar) with 8 cases. There were no cases of OI in either of the maxillary third molars (#1, #16), the two mandibular central incisors (#24, 25), the right mandibular third molar (#32), the left mandibular first premolar (#21), and the right mandibular lateral incisor (#26).

Figure 3: Location and frequency of the most infected dentition



A total of 5 patients required treatment in the operating room followed by admission and in-hospital surveillance. Patients were admitted if there was evidence of airway involvement or OI recurrence in the setting of known systemic risk factors such as diabetes or immunosuppression. 4 out of 5 admissions involved the lower left quadrant (3 cases involving #18 and one involving #17) and one involved the right mandibular canine (#27). Gram stains from each case showed three patients with streptococcal organisms, one case of Hemophilus, and another with no identifiable organisms. All streptococcal organisms were found in ASA class one patients.

Table 3: Demographics of patients with airway signs requiring admission

Age	Site (Tooth)	Gender	ASA Status	Comorbidities	Ethnicity	Cultured Organism(s)
49	#27	Female	ASA 3	Congestive heart failure, Atrial fibrillation	African American/Black	Hemophilus parainfluenzae
30	#18	Male	ASA 1	None	Hispanic	None
59	#18	Male	ASA 1	None	Non-Hispanic White	Streptococcus viridans species
29	#17	Male	ASA 1	None	Hispanic	Streptococcus viridans species
28	#18	Female	ASA 2	Hypertension, Diabetes 2	Asian/Pacific Islander	None

Among the admitted patients, three were ASA class one, one was ASA class two with hypertension and DM2, and one was ASA class three with compensated congestive heart failure. All but one site was in the lower left quadrant, with tooth #18 being infected in three out of five cases. Three patients were male, all of whom were ASA class one. Overall, the admitted patients were young with three patients between 28-30 years of age, one 49 years of age, and another 59 years of

age. There was a relatively even ethnic distribution with one patient each identifying as Asian/Pacific Islander, non-Hispanic white, and African American/Black and two patients identifying as Hispanic.

Out of 103 cases, 10 samples were successfully cultured. 6 out of 10 cultures demonstrated Viridans streptococci species. 2 out of 10 cultures were positive for Eikenella corrodens, 1 was positive for Hemophilus parainfluenzae, and another showed Staphylococcus epidermidis. There were 4 samples each from Hispanic and non-Hispanic White individuals, and in both groups 3 cases were of Viridans streptococci. One Hispanic and one non-Hispanic White individual with a Viridans streptococcus infection required admission. There was a single sample of Hemophilius parainfluenzae from the African American/Black group – who also required admission - and a single sample of Eikenella corrodens from the East Asian/Pacific Islander group.

Table 4: Distribution and patient characteristics for cultured bacteria

Age	Site (Tooth)	Gender	ASA Status	Comorbidities	Ethnicity	Cultured Organism(s)
28	#17	M	ASA 1	None	Hispanic	Staphylococcus epidermidis
39	#3	M	ASA 3	Chronic Kidney disease, Atrial flutter	Non-Hispanic White	Eikenella corrodens
44	#30	F	ASA 2	Anemia	East Asian/Pacific Islander	Eikenella corrodens
49	#27	F	ASA 3	Congestive heart failure, Atrial fibrillation	African American/Black	Hemophilus parainfluenzae
22	#18	M	ASA 1	None	Non-Hispanic White	Streptococcus viridans
62	#18	M	ASA 2	Hypertension, Diabetes 2	Hispanic	Streptococcus viridans
59	#18	M	ASA 1	None	Non-Hispanic White	Streptococcus viridans
28	#2	M	ASA 2	Schizophrenia, Hip agenesis	Non-Hispanic White	Streptococcus viridans
29	#17	M	ASA 1	None	Hispanic	Streptococcus viridans
49	#5	M	ASA 4	Epillepsy, Diabetes 2, Hypertension, End stage renal disease, Hyperlipidemia	Hispanic	Streptococcus viridans

4. Discussion

Odontogenic infections pose not only a potential risk to individual patients but a significant public health burden to healthcare institutions worldwide. Between 2010 and 2011, 91% of American adults aged 20 to 64 had dental caries, of which 27% have not been treated. Unfortunately, certain ethnic groups appear to be at greater risk of burden than others. The rate of untreated decay is higher in individuals of Hispanics and African American/Black ethnicities at 36% and 42%, respectively.[10]

Our data also demonstrates disproportionately larger rates of OI in populations identifying as Hispanic or African American/Black. While the surrounding community is reportedly 23.6% African American/Black, 33.0% of our patients identified as the same. Similarly, 26.9% of the

community identified as Hispanic compared of 30.4% of our patients. This contrasts with those who identified as non-Hispanic White or East-Asian/Pacific Islander, who made up 28.2% and 16.3% of the community compared to 20.6% and 10.8% of those infected, respectively.[11] Both our data and public health records point to an overrepresentation of the African American/Black and Hispanic communities in the rates of odontogenic infections.

Compared to the surrounding adult population, our patients were overall younger with 22.5% in their 20s (compared to 15.7% in the community), 27.5% in their 30s (18.2% in the community), 19.6% in their 40s (13.9% in the community), and 16.7% in their 50s (12.2% in the community). The OI patients were also more likely to be male than female especially in the Hispanic and non-Hispanic White groups – who were both more than 70% male - compared to the community ratio of 52% female.[11] This is in contrast to past investigations which showed that both female and older patients are at greater risk of dental caries because of differences in salivary composition and flow rate, dietary habits, and social roles as well as loss of hygiene dexterity at old age.[12] However, studies also show that women are more likely to seek care at earlier stages of symptoms.[13] Since OIs may be regarded as exacerbations of dental disease, we may infer that women were more likely to receive definitive care before simple dental caries evolved into a regional infection. Similarly, the widespread availability of socialized medical insurance for the geriatric age groups may also afford them ready access to preventive care prior to the development of OIs.

As may be expected, patients with DM2 were also overrepresented in our patient population. Approximately 17% of our patients were diagnosed with DM2, compared with the overall rate of 7.9% in the surrounding community. Interestingly, the patients with other common comorbidities were much less likely to present with OIs, with 13.7% positive for hypertension (compared to over 60% in the community), 8.8% for asthma (14.2% in the community), and 4.9% for hyperlipidemia (27.9% in the community).[14] This may suggest that individuals with diagnosed chronic conditions are either 1) under better surveillance for conditions including odontogenic disorders and/or that 2) those with perceived threats to their health engage in better oral preventive measures. Unlike DM2, these conditions also do not directly suppress the immune response to infections, odontogenic or otherwise.

The distribution of OI site differed according to ethnicity as well. In both Hispanic and African American/Black groups, the rate of infection in the anterior dentition was under 7%, though the rate in the non-Hispanic White and East Asian/Pacific Islander groups were more than doubled at 19.0% and 36.4%, respectively. This may indicate a more even anteroposterior distribution of OIs in the non-Hispanic White and East Asian/Pacific Islander groups, though the exact significance of this discrepancy is unclear. The cultured microbes in our population were predominantly of the Viridans streptococci species, which remains consistent with literature.[15]

Likewise, the Hispanic and African American/Black individuals were more likely to incur OIs on the left sides of their mouths (67.7% and 67.6%, respectively) while the East Asian/Pacific Islander individuals saw left-sided infection 27.3% of the time and the non-Hispanic White individuals had a relatively equal left-right distribution (57.1% left-sided). The maxillary versus mandibular distributions were approximately equal in all four aforementioned ethnic groups regardless of laterality. While the cause for this is difficult to ascertain, it may be associated with increased stigma associated with left-handedness especially in some East Asian cultures. A study of congenitally left-handed Japanese students showed that less than 2% used their left hands to eat or write, and as recently as 2006, a survey in Taiwan indicated a 45.7% rate of left-to-right handedness

conversion.[16,17] Right-handed toothbrushing has traditionally been associated with better left-sided oral hygiene as a result of improved angling and more natural movements of the brush head. In fact, a 1987 study of British children indicated that individuals who brush with their right hands presented with additional plaque and gingivitis on the right-sided dentition.[18]

Interestingly, East Asian/Pacific Islander patients with OI tended to be those of the female gender, those who were older, and those with greater comorbidities. OI patients from this group were about 10 years older on average, with individuals predominantly in the 5th and 6th decades of their lives while the other groups consisted primarily of those in the 3rd and 4th decades. Furthermore, the infected East Asian/Pacific Islander individuals were less healthy with 27.3% in ASA category three or greater. The rate of the same were only 11.8% in the African American/Black group, 9.7% in the Hispanic group, and 9.5% in the non-Hispanic White group. In general, infectious diseases more readily affect those with compromised health statuses. However, out data suggests that OI affects proportionately greater numbers of relatively healthy, young African American/Black, Hispanic, and non-Hispanic White individuals than it does East Asian/Pacific Islander individuals. Further study is needed to determine the exact cause of this discrepancy.

The current study is not without its limitations. The study relies on self-reports from its patients and certain biases or errors may be incorporated in accounting for ethnicity and health status. The investigators attempted to minimize errors in ASA classification via a thorough examination of patient physiology, vital signs, and surgical history, and medications. The primary care physician was contacted in cases where uncertainties were present in the patient's history. In addition, some patients reported administration of antibiotics by the referring dentist, physician, or emergency care provider prior to evaluation. Though unlikely, pre-evaluation antibiotics may alter the course of OI to cause unexpected biases in patient presentation.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Robertson D, Smith AJ. The microbiology of the acute dental abscess. Journal of Medical Microbiology. 2009;58(2):155–62.

[2] Vytla S, Gebauer D. Clinical guideline for the management of odontogenic infections in the tertiary setting. Australian Dental Journal. 2017;62(4):464–70.

[3] Wang J, Ahani A, Pogrel MA. A five-year retrospective study of odontogenic maxillofacial infections in a large urban public hospital. International Journal of Oral and Maxillofacial Surgery. 2005 Sep 1;34(6):646–9.

[4] Graham DB, Webb MD, Seale NS. Pediatric emergency room visits for nontraumatic dental disease. Pediatric dentistry. 2000;22(2):134–40.

[5] Moreland LW, Corey J, McKenzie R. Ludwig's Angina: Report of a Case and Review of the Literature. Archives of Internal Medicine. 1988 Feb 1;148(2):461–6.

[6] Chou YK, Lee CY, Chao HH. An upper airway obstruction emergency: Ludwig angina. Pediatric Emergency Care. 2007;23(12):892–6.

[7] Nubiato Crespo A, Takahiro Chone C, Santana Fonseca A, Montenegro MC, Pereira R, Altemani Milani J. Clinical versus computed tomography evaluation in the diagnosis and management of deep neck infection. Sao Paulo Medical Journal. 2004;122(6):259–63.

[8] Diamantis S, Giannakopoulos H, Chou J, Foote J. Descending necrotizing mediastinitis as a complication of odontogenic infection. International Journal of Surgery Case Reports. 2011;2(5):65–7.

[9] Ko HH, Chien WC, Lin YH, Chung CH, Cheng SJ. Examining the correlation between diabetes and odontogenic infection: A nationwide, retrospective, matched-cohort study in Taiwan. PLoS ONE. 2017;12(6):1–13.

[10] Dye B, Thornton-Evans G, Li X, Iafolla T. Dental caries and tooth loss in adults in the United States, 2011-2012. NCHS data brief. 2015 May;(197):197.

[11] United States Census Bureau. Quick Facts - Oakland City, California [Internet]. 2019 [cited 2020 Oct 25]. Available from: https://www.census.gov/quickfacts/oaklandcitycalifornia

[12] Martinez-Mier EA, Zandona AF. The impact of gender on caries prevalence and risk assessment. Dental Clinics of North America. 2013;57(2):301–15.

[13] Thompson AE, Anisimowicz Y, Miedema B, Hogg W, Wodchis WP, Aubrey-Bassler K. The influence of gender and other patient characteristics on health care-seeking behaviour: A QUALICOPC study. BMC Family Practice. 2016;17(1):1–7.

[14] Conduent Healthy Communities. Oakland Community Dashboard [Internet]. Healthy Alameda County. 2020 [cited 2020 Oct 25]. Available from:

http://www.healthyalamedacounty.org/?module=indicators&controller=index&action=indicatorsearch&doSearch=1&showComparisons=1&l=132167

[15] Gill Y, Scully C. Orofacial odontogenic infections: Review of microbiology and current treatment. Oral Surgery, Oral Medicine, Oral Pathology. 1990;70(2):155–8.

[16] Shimizu A, Endo M. Handedness and Familial Sinistrality in a Japanese Student Population. Cortex. 1983;19(2):265–72.

[17] Meng L. The rate of handedness conversion and related factors in left-handed children. Laterality. 2007 Mar;12(2):131–8.

[18] Addy M, Griffiths G, Dummer P, Kingdom A, Shaw WC. The distribution of plaque and gingivitis and the influence of toothbrushing hand in a group of South Wales 11–12 year-old children. Journal of Clinical Periodontology. 1987 Nov 1;14(10):564–72.