Infection and Drug Resistance

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ORIGINAL RESEARCH

A Five-Year Retrospective Study of 746 Cases with Maxillofacial Space Infection in Western China

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Purpose: To grasp the current epidemiological situation of maxillofacial space infection and investigate the risk factors contributing to the longer hospitalization of odontogenic space infection in western China.

Patients and Methods: This retrospective study collected the clinical characteristics from 746 hospitalized patients with maxillofacial space infection and investigated the risk factors associated with longer hospitalization. Pearson's chi-square test and multivariable binary logistic regression were performed for statistical analysis.

Results: A total of 438 males and 308 females were included in this study, aging from 1 to 90 years (mean age 48.6 years). 74.9% cases resulted from odontogenic infections, with the submandibular space being the most commonly involved space (53.7%). Advanced age (OR (>60 y:19–60 y:≤18 y) = 3.784:3.416:1, $p < 0.05$), treatment before admission (OR = 2.271, $p < 0.05$) and number of involved spaces (OR (≥4:2–3:1) = 3.204:1.931:1, $p < 0.05$) were closely related to longer hospitalization. Streptococcus being the most frequently found aerobic bacteria (268/615, 43.6%) of all the bacteria isolated was resistant to clarithromycin (91.5%) and erythromycin (92.8%).

Conclusion: Hospitalization time could be longer for patients with the identified risk factors. Streptococcus, as the most common type of aerobic flora, is highly resistant to clindamycin and erythromycin.

Keywords: maxillofacial space infection, epidemiological, odontogenic infections, hospitalization time, risk factors

Introduction

Despite the decreasing prevalence and complications reported, the advancement of diagnostic techniques, and the availability of effective antibiotics, maxillofacial space infection remains a daily challenge for maxillofacial surgeons.[1–4] Severe odontogenic infection that could spread to adjacent anatomical spaces, leading to complications of infections requiring multiple surgeries, intensive care unit hospitalization, tracheotomy, and even death is still the most common emergency in maxillofacial surgery.[2] Delayed and non-standard treatment is often responsible for the occurrence of maxillofacial infection and the aggravation of the condition.[5] China consists of 56 ethnic groups and the west of China is where more than 40 ethnic groups mainly gather. Given that oral medical resources are mainly concentrated in eastern China, patients in the less economically developed regions in western China are less able to cultivate a comprehensive awareness of oral health including early prevention, timely recognition, and prompt and effective intervention for oral diseases as a result of significant differences in the environment, living habits, educational, and cultural levels.[3]

Powerful interventions to treat oral and maxillofacial infections rely on timely diagnosis, elimination of the underlying cause, drainage, and detection of prevailing microorganisms for targeted antibacterial treatment.[1,6] The

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curative effect of antibiotics, as well as other interventions, ultimately depends on the personal condition of patients. The development of the infection is directly related to the patients' immunity, associated pathology, the medication administered prior to presentation to the doctor, the type and virulence of the pathogenic microorganisms, and their adaptation to a world dominated by antibiotics.[5,7] Although dental and oral-maxillofacial infections are common in clinical practice and many studies have already provided recommendations for the administration of antibiotics, there is still no consensus about the ideal approach to these infections.[1,6,8–10] There is a lack of recent data based on large-scale samples of the spectrum of clinical pathogens and the associated antimicrobial resistance for these infections. It is important to consider the geographical area, the standard therapy of each hospital, and the experience of each surgeon prescribing antibiotics empirically for the treatment of these infections to facilitate the regular adjustment of therapy protocols, and the development of guidelines for dental professionals.[1,5,11] The Department of Maxillofacial Surgery, West China Stomatology Hospital of Sichuan University, located in western China, is the longest established maxillofacial surgery unit in China. It has an annual hospitalization capacity of more than 3000 people. Approximately 200 patients per year are hospitalized for maxillofacial infections in this tertiary stomatology center. Treatment recommendations targeted to the regional epidemiological characteristics in this area are a significant reference point for areas or countries with similar geographical and cultural characteristics and those at a similar stage of development.

The present study collected data of general demographic characteristics by reviewing the medical records of 746 patients with oral and maxillofacial space infections hospitalized in our Department of Maxillofacial Surgery during a recent 5-year period to analyze risk factors leading to longer hospitalization and to identify the dominant pathogens and their susceptibility and resistance to common antibiotics.

Materials and Methods

This retrospective study was performed in patients with oral and maxillofacial space infections who were hospitalized in the Department of Maxillofacial surgery, West China Stomatology Hospital of Sichuan University from January 2014 to December 2018.

Inclusion Criteria and Discharge Indications

Inclusion criteria for patients with oral and maxillofacial space infection were as follows: (a) clinical manifestations of typical inflammation – local reddening, swelling, increased skin temperature, spontaneous pain, local dysfunction; (b) fluctuation or pitting edema with obvious tenderness on the surface of the skin in the involved area; (c) pus in the lesion area or gas and abscess detected by computed tomography scan in the maxillofacial space; (d) a complete medical record and a family life history in western China of more than 5 years, and (e) treatment of antimicrobial therapy.

Discharge indications were as follows: (a) clinical symptoms (swelling, pain, fever and dysfunction) significantly improved; (b) inflammatory indicators (white blood cells [WBC] and C-reactive protein [CRP]) returned to the normal range.

Incision and Drainage of Maxillofacial Abscesses

The brief procedure for the operation was as follows: (a) needle aspiration was used to locate the abscess cavity; (b) skin and subcutaneous tissues were cut, followed by blunt separation of the muscle layers along the direction of the needle; (c) blunt dissection was conducted to expand the volume of the abscess cavity; and (d) drainage tubes were placed in the abscess cavity to facilitate the drainage of pus.

Microbiological Detection and Antimicrobial Susceptibility Test

Intraoperative swabs were taken from all included patients to detect the distribution of pathogens and to conduct antibiotic sensitivity experiments. All the samples were transported for prompt processing within 12 hours using transporting medium (Pangtong, Chongqing, China). The K-B (Kirby-Bauer) method and the E-test (Epsilometer test) method were used for drug sensitivity experiments in aerobic and anaerobic bacteria respectively.

Collection of Data

The following data were collected: (a) general demographic characteristics (sex, age, region, ethnic group, and accompanying systemic disease); (b) history of treatment (self-antibiotic administration, treatment before admission, maxillofacial treatment before admission, and course of the disease before admission); (c) admission diagnosis and treatment (pathogenesis, admission white blood cell count, admission temperature, tracheotomy, length of hospitalization, number of infected spaces, distribution of pathogens, and results of antibiotic-sensitivity experiments).

Data Analysis

Descriptive statistics, Pearson's chi-square test and multivariable binary logistic regression analysis were used to analyze data using SPSS25.0 software (IBM Corp., Armonk, NY, USA). Epidemiological correlation analysis was performed using Pearson's chi-square and Fisher's exact tests. Pearson's chi-square test and multivariable binary logistic regression analysis were used to identify risk factors in association with longer hospital stays (≤9 days versus >9 days). Univariate analysis with a chi-square test was conducted to screen out potential factors related to the length of hospital stay; then multivariate logistic regression analysis was used to identify the risk factors associated with a longer hospital stay. A p-value of < 0.05 was considered to be statistically significant for all tests.

Results

General Clinical Characteristics

On the basis of the inclusion criteria, a total of 746 patients with oral and maxillofacial space infection were enrolled in this study, including 438 males (58.7%) and 308 females (41.3%), aging from 1 to 90 years (average age 48.6 years). A total of 166 patients had a history of self-antibiotic administration, and 123 patients had received maxillofacial treatment such as tooth extraction or abscess incision and drainage (Table 1). The average course of disease before admission was 9.8 days, and 20.9% had a course of disease >14 days when visited our hospital.

As shown in Table 1, 11.5% of the patients came from minority areas in western China, and 12.6% were ethnic minorities. However, no significant differences were found between minority areas and non-minority areas in the course

Table 1 Demographic Characteristics of Patients with Maxillofacial Space Infection (n = 746)

Variable	Categories	N (%)
Gender	Male	438(58.7)
	Female	308(41.3)
Age (Year)	≤18	88(11.8)
	19–30	74(9.9)
	>30	584(78.3)
Region	Non-minority areas	660(88.5)
	Minority areas	86(11.5)
Nationality	Han	652(87.4)
	Ethnic minorities (except for Han)	94(12.6)
Accompanied systemic disease	No	588(78.8)
	Yes	158(21.2)
Self-antibiotic administration	No	580(77.7)
	Yes	166(22.3)
Treatment before admission	No	212(28.4)
	Yes	534(71.6)
Maxillofacial treatment before admission	No	623(83.5)
	Yes	123(16.5)
Course of disease before admission (Day)	≤7	425(57.0)
	8–14	165(22.1)
	>14	156(20.9)

Note: Data presented as n (%) for categorical variables.

Table 2 Analytical Results for Different Regions (n = 746)

Variable	Categories	Region		Chi-Square	p value
		Non-Minority Areas (n, %)	Minority Areas (n, %)		
Course of disease before admission (Day)	≤7	383(58.0)	42(48.8)		
	8–14	138(20.9)	27(31.4)		
	>14	139(21.1)	17(19.8)	4.972	0.083
Treatment before admission	No	188(28.5)	24(27.9)		
	Yes	472(71.5)	62(72.1)	0.012	0.911
Maxillofacial treatment before admission	No	554(83.9)	69(80.2)		
	Yes	106(16.1)	17(19.8)	0.467	0.495

Note: Data presented as n (%) for categorical variables.

Table 3 Analytical Results for Different Ethnic Groups (n = 746)

Variable	Categories	Ethnic Group		Chi-Square	p value
		Han (n, %)	Ethnic Minorities (n, %)		
Course of disease before admission (Day)	≤7	375(57.5)	50(53.2)		
	8–14	139(21.3)	26(27.7)		
	>14	138(21.2)	18(19.1)	1.923	0.382
Treatment before admission	No	184(28.2)	28(29.8)		
	Yes	468(71.8)	66(70.2)	0.099	0.753
Maxillofacial treatment before admission	No	541(83.0)	82(87.2)		
	Yes	111(17.0)	12(12.8)	1.082	0.298

Note: Data presented as n (%) for categorical variables.

of disease before admission (p = 0.083), treatment before admission (p = 0.911), or maxillofacial treatment before admission in another hospital (p = 0.495) (Table 2). The same result was observed when comparing patients of ethnic minorities and Han patients (accounting for 92% of the Chinese mainland population) ($p > 0.05$) (Table 3).

Admission Diagnosis and Treatment

Pathogenesis

Odontogenic infections were responsible for 74.9% of oral and maxillofacial space infections, with endodontic and periodontal diseases accounting for 73.9%, followed by pericoronitis of the mandibular third molar (15.2%), and tooth extraction (6.4%). Ill-fitting prostheses and other dental causes were classified as other odontogenic infections (4.5%). Glandular infection was the most common cause apart from odontogenic infection (11.0%). Other causes were jaw cysts (3.4%), injury (2.1%), and other pathogenic factors such as radiation osteomyelitis or infected tumors, which were included in other pathogenic factors (2.0%) (Figure 1).

Multiple space infections were found in 548 patients (77.5%) and single facial space infections numbered 198 (22.5%). The masseteric space was most frequently identified as the single space infection (n = 55), and in 39 patients, the specific spaces infected could not be identified relying solely on clinical and laboratory examination. The submandibular space was the most commonly involved space in both multiple affected spaces (n = 332) and all identifiable infection spaces (n = 380), including single and multiple spaces (Figure 2).

Microbiological Findings

Distribution of Pathogens

Pus was collected from the focal zones of 655 patients, and the pathogens were cultured and identified. No

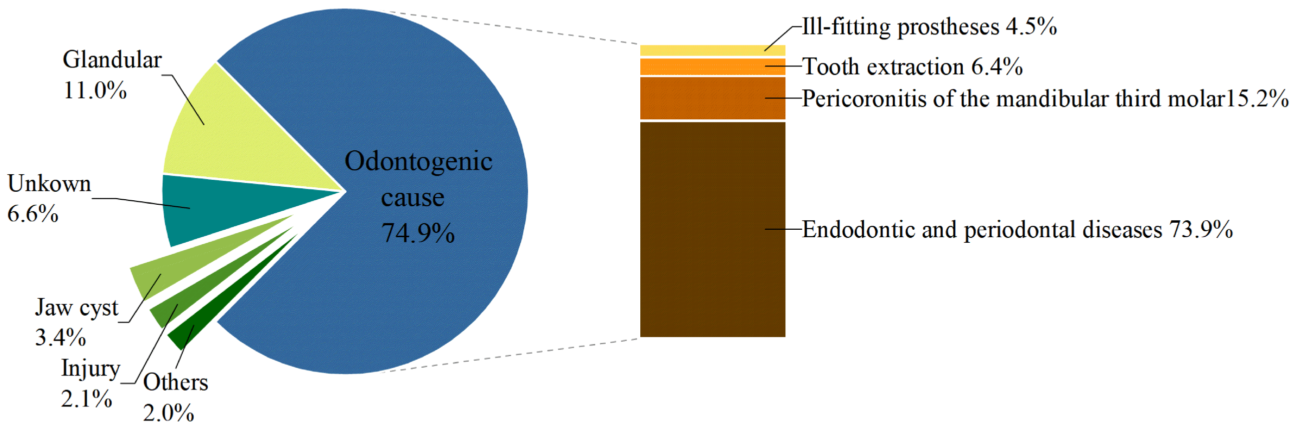

Figure 1 Proportions of etiologic conditions for maxillofacial space infections.

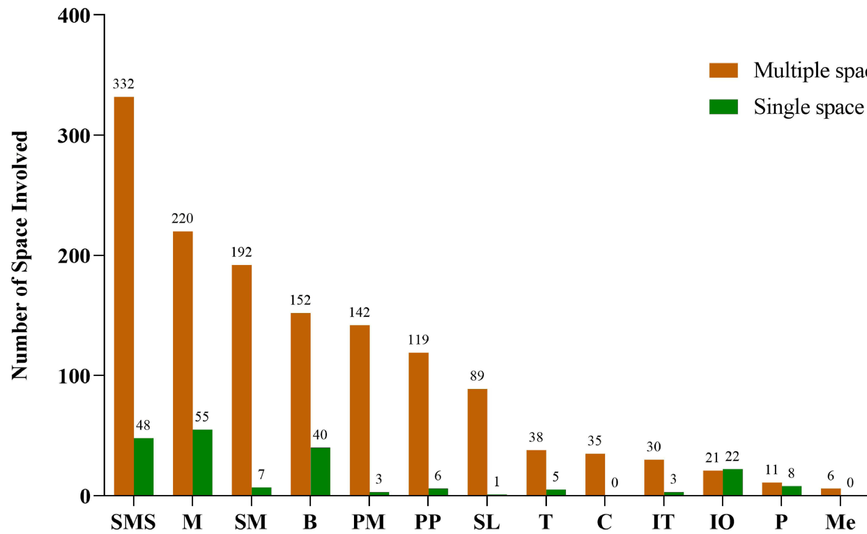

Figure 2 Comparison of the distribution of the identified spaces between multiple space infections and single space infections.
Abbreviations: SMS, submandibular space; M, masseteric space; SM, submental space; B, buccal space; PM, pterygomandibular space; PP, parapharyngeal space; SL, sublingual space; T, temporal space; C, cervical space; IT, infratemporal space; IO, infraorbital space; P, parotid space; Me, mediastinum.

microorganisms were cultured in 25.5% of cases (167/655), and pathogens were positively identified in 74.5% (488/655) of patients' specimens. In 325 cases, only aerobic bacteria were isolated, while in 36 cases, only anaerobic bacteria were detected (Figure 3). Mixed infections with aerobic and anaerobic bacteria were found in 127 patients. From all these 488 microbiome-positive cases, 163 anaerobic and 452 aerobic bacterial strains were isolated.

One hundred twenty-five mixed bacterial strains (125/615, 20.3%) were isolated from aerobic flora (Figure 3), with Streptococcus being the most common (268/615, 43.6%), followed by Staphylococcus (24/615, 3.9%). Additionally, a total of 20 strains of Klebsiella were detected (20/615, 3.3%), including 19 strains of *Klebsiella pneumoniae* (19/615, 3.1%). Many other bacteria such as *Acinetobacter baumannii, Haemophilus influenzae*, and *Haemophilus parainfluenzae* were discovered in small numbers in secretions from the focal zones (15/615, 2.4%). Among the anaerobic flora, Prevotella (113/615, 18.4%) was isolated most frequently, with *Prevotella intermedia* being most commonly found (62/615, 10.1%).

Microbiological Sensitivity Characteristics

Drug sensitivity experiments were performed on 215 aerobic strains, including *Streptococcus* spp. (166), *Staphylococcus* spp. (14), and *Klebsiella* spp. (20). The resistance patterns of these three main aerobic bacteria are shown in Figure 4. *Streptococcus* spp. isolates had the highest resistance to clindamycin and erythromycin (91.5% and 92.8% respectively)

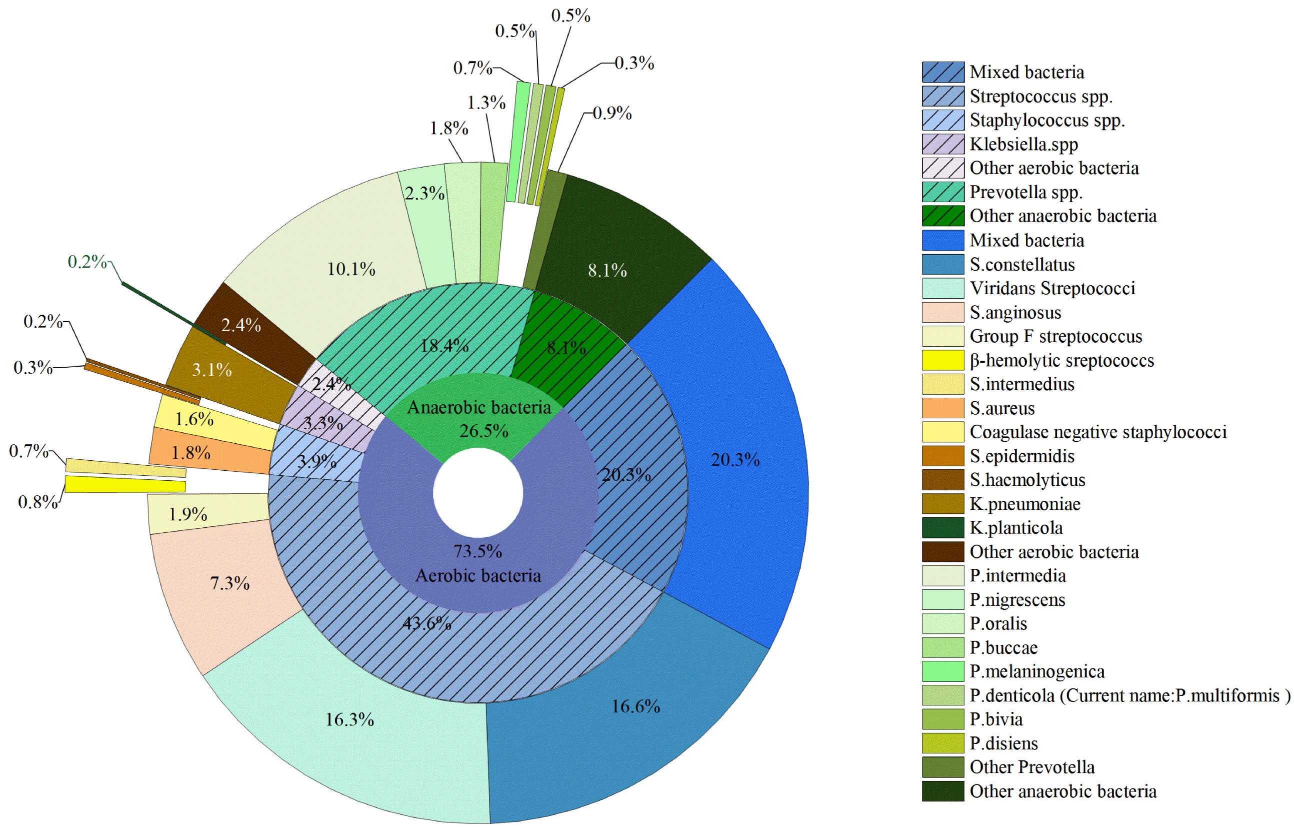

Figure 3 Proportional distribution of microorganisms from 488 patients with positive pathogen identification.

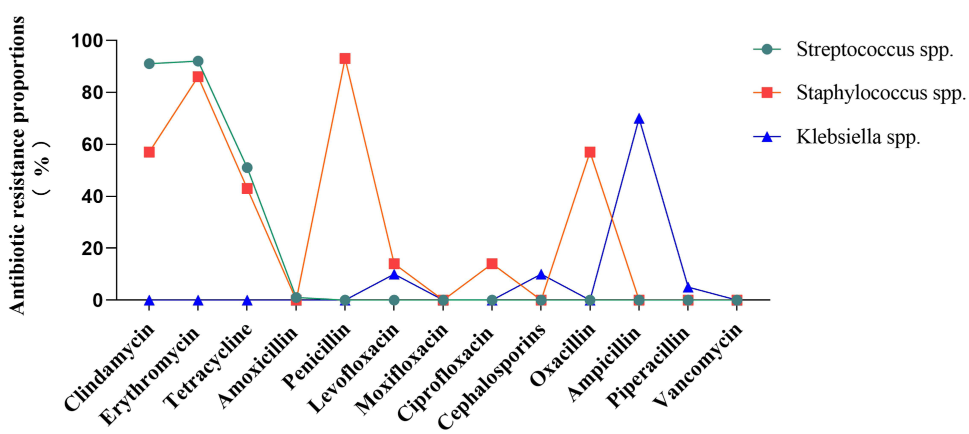

Figure 4 Antibiotic resistance characteristics of main aerobia.

while resistance to amoxicillin (1.2%), penicillin (0.6%), and cephalosporins (0.6%) was substantially lower. The sensitivity of Streptococcus to vancomycin, levofloxacin and moxifloxacin was 100%.

Penicillin had the highest resistance proportion in *Staphylococcus* spp. (92.9%), followed by erythromycin (85.7%) and clindamycin (57.1%). For moxifloxacin and vancomycin, the sensitivity proportions were as high as 100%. Of all the antibiotics tested for drug sensitivity, *Klebsiella* spp. was relatively highly resistant to ampicillin (70%), while the resistance to cephalosporin (10%), levofloxacin (10%), and piperacillin (5%) was relatively low.

Factors Prolonging Hospitalization

Risk factors affecting the length of hospital stay were analyzed for 427 hospitalized patients with odontogenic maxillofacial space infection, revealing that the average length of hospitalization was 9 days. The results of Pearson's chi-square test are shown in Table 4. There was a significant age-related difference in the length of hospitalization for patients aged 19–60 years and patients older than 60 years, compared with the youngest patients (≤18 years) (χ^2 = 9.893, p = 0.007). The hospital stay was significantly longer for patients with underlying systemic diseases than for patients without systemic conditions (χ^2 = 4.402, p = 0.036). Patients who received treatment before admission had significantly longer hospitalizations than those who did not (χ^2 = 7.682, p = 0.006). Hospitalization was significantly longer in patients with more anatomical spaces involved (χ^2=17.801, p < 0.001). Patients with a longer course of disease before admission tended to be hospitalized for longer (χ^2 = 7.344, p = 0.025), and there were also statistically significant differences in the length of hospital stay according to admission WBC (χ^2 = 10.092, p = 0.006), admission temperature (χ^2 = 12.328, p = 0.004), and tracheotomy (χ^2 = 6.762, p = 0.009).

Multivariable binary logistic regression analysis was performed to identify factors associated with longer hospital stays. The results indicated that advanced age (OR (>60 y:19–60 y:≤18 y) = 3.784:3.416:1), treatment history at another hospital before admission (OR = 2.271), and a large number of involved spaces (OR (≥4:2–3:1) = 3.204:1.931:1) were closely related to longer hospitalization of patients with odontogenic maxillofacial space infection (Table 5).

Table 4 Results of Univariate Analysis (n = 427)

Variable	Categories	Hospitalization Length		Chi-Square	p value
		≤9day n (%)	>9day n (%)		
Age (Year)	≤18	39(13.5)	5(3.6)		
	19–60	155(53.6)	81(58.7)		
	>60	95(32.9)	52(37.7)	9.893	0.007
Gender	Male	158(54.7)	85(61.6)		
	Female	131(45.3)	53(38.4)	1.825	0.177
Self-antibiotic administration	No	223(77.2)	112(81.2)		
	Yes	66(22.8)	26(18.8)	0.883	0.347
Accompanied systemic disease	No	237(82.0)	101(73.2)		
	Yes	52(18.0)	37(26.8)	4.402	0.036
Treatment before admission	No	74(25.6)	19(13.8)		
	Yes	215(74.4)	119(86.2)	7.682	0.006
Course of disease before admission	≤7	185(64.0)	86(62.3)		
(Day)	8–14	71(24.6)	24(17.4)		
	>14	33(11.4)	28(20.3)	7.344	0.025
Tracheotomy	No	284(98.3)	129(93.5)		
	Yes	5(1.7)	9(6.5)	6.762	0.009
Admission temperature (°C)	36–37.2	203(70.2)	77(55.8)		
	37.3–38	55(19.0)	44(31.9)		
	38.1–39	27(9.3)	11(8.0)		
	>39	4(1.4)	6(4.3)	12.328	0.004
Admission WBC (*10^9/L)	≤10	112(38.8)	39(28.3)		
	11–20	147(50.9)	82(59.4)		
	>20	30(10.4)	17(12.3)	10.092	0.006
Number of infected space	1	85(29.4)	19(13.8)		
	2–3	145(50.2)	70(50.7)		
	≥4	59(20.4)	49(35.5)	17.801	<0.001

Note: Data presented as n (%) for categorical variables.
Abbreviation: WBC, white blood cell.

Table 5 Results of Multivariable Binary Logistic Regression Analysis (n = 427)

Variable	Categories	Hospitalization Length		OR	95% CI	p value
		≤9day n (%)	>9day n (%)			
Age (Year)	≤18	39(13.5)	5(3.6)	1		
	19–60	155(53.6)	81(58.7)	3.416	1.228–9.507	0.019
	>60	95(32.9)	52(37.7)	3.784	1.312–10.913	0.014
Admission temperature (°C)	36–37.2	203(70.2)	77(55.8)	1		
	37.3–38	55(19.0)	44(31.9)	2.258	1.332–3.826	0.002
	38.1–39	27(9.3)	11(8.0)	1.011	0.446–2.292	0.979
	>39	4(1.4)	6(4.3)	4.388	1.102–17.471	0.036
Admission WBC (*10^9/L)	≤10	112(38.8)	39(28.3)	1		
	11–20	147(50.9)	82(59.4)	1.371	0.820–2.293	0.229
	>20	30(10.4)	17(12.3)	0.937	0.415–2.114	0.875
Accompanied systemic disease	No	237(82.0)	101(73.2)	1		
	Yes	52(18.0)	37(26.8)	1.392	0.799–2.426	0.243
Treatment before admission	No	74(25.6)	19(13.8)	1		
	Yes	215(74.4)	119(86.2)	2.271	1.243–4.149	0.008
Course of disease before admission (Day)	≤7	185(64.0)	86(62.3)	1		
	8–14	71(24.6)	24(17.4)	0.833	0.470–1.478	0.533
	>14	33(11.4)	28(20.3)	1.948	1.045–3.632	0.036
Tracheotomy	No	5(1.7)	9(6.5)	1		
	Yes	284(98.3)	129(93.5)	2.446	0.727–8.229	0.148
Number of infected space	1	85(29.4)	19(13.8)	1		
	2–3	145(50.2)	70(50.7)	1.931	1.049–3.556	0.035
	≥4	59(20.4)	49(35.5)	3.204	1.627–6.308	0.001

Note: Data presented as n (%) for categorical variables.
Abbreviations: CI, confidence interval; OR, odds ratio; WBC, white blood cell.

Discussion

This study reviewed 746 medical records of patients with maxillofacial space infection hospitalized during a five-year period. A total of 615 individual species of pathogens were identified and their antibiotic sensitivity examined. This research, based on a three-A stomatological hospital in western China with a wide radiation range and a large number of patients with a family life history in western China (92% of all the patients), was representative of the region and the stage of epidemiological development, as well as the highly diverse nature of the microbiome associated with maxillofacial space infection.

Data from the same research institution showed that 48.1% of patients had used antibiotics before admission.[12] According to our clinical observations, patients with oral diseases tend to arbitrarily take antibiotics such as penicillin, cephalosporin, and metronidazole. This indiscriminate use of antibiotics may not only mask symptoms of the disease, causing patients to be less vigilant and possibly resulting in a crisis, but also increases the drug resistance of the bacteria. Streptococcus showed high resistance to clindamycin, erythromycin and tetracycline in this study, and Staphylococcus was highly resistant to penicillin. These findings differed from those reported in other regions. Farmahan et al showed that 64.1% of bacteria in positive swabs were sensitive to penicillin,[13] and Rega, Aziz and Ziccardi[14] stated that viridans streptococci exhibited high susceptibility to clindamycin (86.3%) and erythromycin (83.4%) in research performed in New Jersey. Research carried out in Germany found that 84.6% of the Streptococcus isolates were susceptible to clindamycin and *Staphylococcus aureus* was resistant to clindamycin (83.4%), erythromycin (76.5%), and levofloxacin (83.4%).[15] A report from the China Antimicrobial Resistance Surveillance System stated that the resistance rate of *Staphylococcus aureus* to clindamycin decreased over the period of 2014–2019. The detection rate for Streptococcus decreased from 4.3% to 1.6% in 6 years. However, the resistance of *Streptococcus pneumoniae* to erythromycin and clindamycin remained at a high level (94.0–95.6% and 88.4–91.4%, respectively from 2014 to

2019), which is similar to our results.[16] A study from Lithuania reported that penicillin can be successfully used for empirical treatment, leaving clindamycin and stronger antibiotics as reserve treatment options.[1] Yet in a developing country like China, systematic review and policy change on non-prescription antimicrobial use and the control of drug prescriptions are still required.[17,18]

It should be noted that there were no effective data on drug resistance to anaerobes. The mode of pus collection meant that most anaerobes would not survive because of contact with oxygen during collection; however, we speculated that the small amount of anaerobes may also be related to self-medication of antibiotics such as metronidazole (being active to anaerobic bacteria) before admission. Some reports stated that odontogenic infections are mainly caused by anaerobic bacterial strains, and that aerobic and facultative anaerobic bacteria may have lower pathogenicity.[9,18] Given the significant regional differences in the drug resistance of anaerobic bacteria, drug sensitivity testing of anaerobes should be carried out in western China to provide targeted guidance on the use of antibiotics in the future.

After abscess incision and drainage, patients still need ongoing symptomatic treatment, and long hospitalization times place a heavy burden both on patients and social security.[19–21] Our data shows that with an average hospitalization time of 9 days, patients aged >60 years were 3.784 times more likely to have a longer hospitalization than those aged ≤18 years (Table 5), possibly due to age-related changes in patients' health condition.[1,22,23] Older patients with systemic diseases are more likely to obtain poor therapeutic effect, a long treatment cycle, and greater possibility of serious complications.[1,24] However, according to our data, the presence of systemic diseases is not included as an independent risk factor associated with longer hospitalizations. The reason may be that the author's institute is a stomatological hospital, so patients with serious systemic complications often need to be transferred to a general hospital for further treatment. Without complete medical records, the statistical analysis results and clinical practice may differ from other studies.[12,23,25,26] The patients transferred to the general hospital should ideally be followed up to obtain more complete original medical records to provide a more comprehensive grasp of the factors affecting the length of stay of maxillofacial space infection and its prognosis.

In this study, we used a traditional drainage method after incision; that is, placing the drainage tube after regular postoperative flushing of pus from the cavity. Several studies have proven that the vacuum sealing drainage (VSD) technique can shorten the hospitalization time of patients with severe space infection in the head and neck.[27–30] However, because simple negative pressure cannot solve problems such as the formation of a secondary pus cavity, further studies are needed to verify the clinical effect of this technique.

Multiple space infection is also a risk factor for longer hospitalization for patients with odontogenic infection. Widespread infection results in a greater local and systemic response, which necessitates a longer treatment time.[2,20,31] For patients with multiple space infections, it is important to strengthen the management of the disease and shorten the treatment cycle effectively while ensuring the treatment effect.[1,31]

A risk factor that is seldom reported is the history of external hospital treatment before admission. According to our data (Table 1), 71.6% of all patients enrolled had been treated in other medical institutions before admission. However, up to 83.5% were not managed in accordance with the principles of treatment of the early stages of odontogenic space infection (Table 1). This is indicative of the lack of oral health care knowledge in western China. Many patients were treated initially through self-administrative treatment which could have contributed to a delay in treatment. Additionally, indiscriminate use of antibiotics could contribute to the risk of bacterial resistance to antibiotics and the development of multi-drug resistant bacteria. This may explain why the history of external hospital treatment before admission as an independent risk factor prolonged the length of hospitalization for maxillofacial infections. In fact, if patients with odontogenic infection, whether resulting from periodontitis or pericoronitis of the third molar, underwent regular dental treatment and rational use of antibiotics in the early stage of symptoms, then further aggravation could be controlled effectively, even when the disease has already progressed to an alveolar abscess.[2,20] Strengthening the operation of remote medical consultations and vigorous development of the referral system of the primary medical institutes can significantly reduce the incidence of severe odontogenic infection, improve the treatment effect, and shorten hospitalization times.

As a multi-ethnic country, in addition to the Han majority, there are 55 ethnic minorities in China, accounting for 8% of the total population of Chinese mainland. Forty-four ethnic minority groups are gathered in western China, accounting for 22% of the population in this area and 75% of the ethnic minority population in China. The distribution of dental disease and the need for services differs greatly among regions and nationalities due to diversity in socioeconomic situations and cultural backgrounds.[25,32,33] Kailembo et al[32] stated that higher education was protective of an unmet need for oral health care in China. Most regions in the vast and sparsely populated area of western China have relatively backward economies, low levels of education, and limited medical care due to the uneven distribution of medical and educational resources. However, according to our findings, the better-educated Han people, who account for 78% of the population in western China and 88.5% of people living in non-minority areas (Table 1), showed no obvious advantage in their awareness of oral health care. The lack of knowledge about oral health is universal in this area (Tables 2 and 3). As a populous country representing a developing economy, China has undergone rapid economic development which has led to increasing per capita incomes and advanced public health care. Yet inequalities in wealth and health have widened in recent decades, and medical resources are directed more towards eastern and central China.[3,33] As a result of reforms to the Chinese health insurance system, access to affordable health care for residents of rural and urban areas has been somewhat improved;[32] however, the policies relating to dental prevention and insurance reimbursement for preventive services is still inadequate.[34]

The effectiveness of current oral preventive methods has been proven by evidence-based research. The emphasis should be placed on promoting health rather than preventing diseases. Oral health education through community and clinical practice will play a leading role in future public health programs.[35] Although improvement in economic and educational levels and optimization of resource allocations cannot be achieved overnight, the acquisition of oral health care knowledge can be achieved with powerful public health campaigns and preventive interventions. Areas or countries with similar cultural and geographical characteristics or those at a similar stage of development should remain vigilant and increase the intensity of public health education campaigns. Notwithstanding, policy changes for stomatological resource reallocation may also be required to develop a better health care system.

Conclusion

Clindamycin, erythromycin, and penicillin should be used cautiously as first-line antibiotics in clinical situations in western China. Studies to determine bacterial resistance and associated adjustment of treatment protocols should be regular and continuous. Advanced age, history of treatment at an external hospital before admission, and multiple involved spaces predicted longer hospitalizations. Areas with similar cultural and geographical characteristics and other countries at a similar stage of development should heed the importance of education about preventive oral health care measures. Our findings can act as a reference for the adjustment of health care system reform in other regions.

Abbreviation

WBC, white blood cell.

Data Sharing Statement

The data that support the findings of this study will be available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

This study was conducted in accordance with the principles of the Helsinki Declaration (2013) and approved by the Institutional Ethics Committee of West China Hospital of Stomatology, Sichuan University. Informed consent was obtained from all the patients. We also obtained permission with written informed consent from parents/legal guardian of patients under 18 years old.

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Disclosure

Peihan Wang and Yanling Huang are co-first authors. The authors have declared that no competing interests exist.

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