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Risk Factors for Infection of Sutured Maxillofacial Soft Tissue Injuries

Hua-Qiu Guo, Xue Yang, Xiao-Tong Wang, Ai-Ping Ji, and Jie Bai

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Abstract

Background: Maxillofacial soft tissue injuries (STIs) are common and frequent in emergency departments. The aim of this study was to analyze factors causing infection of maxillofacial STIs.
Patients and Methods: Patients with maxillofacial STIs who received sutures and had complete medical records were evaluated. Gender, age, American Society of Anesthesiologists (ASA) grade, diabetes mellitus, wound age, wound length, wound contamination, wound type, and sites were analyzed using univariable analysis and binary logistic regression.
Results: There were 3,276 cases included. In the univariable analysis, there was no significant difference in the infection rate between genders or between the wound age groups. In binary logistic regression, age, wound length, wound type, and physician level were risk factors for infection: age of 18–44 years (odds ratio [OR], 2.2; 95% confidence interval [CI], 1.7–2.9), 44–64 years (OR, 3.1; 95% CI, 2.3–4.3), and ≥65 years (OR, 2.6; 95% CI, 1.7–4.1); wound length of 4–8 cm (OR, 1.7; 95% CI, 1.3–2.2) and >8 cm (OR, 2.4; 95% CI, 1.1–5.1); intra-oral wounds (OR, 1.6; 95% CI, 1.1–2.4) and communicating wounds (OR, 3.2; 95% CI, 2.3–4.4); junior specialists (OR, 1.6; 95% CI, 1.2–2.2); and lip (OR, 3.7; 95% CI, 1.1–12.0) and cheek (OR, 4.7; 95% CI, 2.3–17.1) sites. Wound contamination, ASA grade, and diabetes mellitus were not significantly different from wound infection in binary regression analysis.
Conclusions: Age (>18 years old), wound length (>4 cm), intra-oral wounds, communicating wounds, suturing by junior surgeons, and lip or cheek injuries may be risk factors for maxillofacial STI infection. Even if the penetrating wound age exceeds 24 hours, it is meaningful to suture if there is no serious infection. For wounds at high risk of infection, further measures should be considered to reduce the possibility of infection, such as improving the surgical training of junior surgeons and improving the patient's wound care.

Keywords: injury; maxillofacial; soft tissue; wound infection

Maxillofacial soft tissue injuries (STIs) are common and frequent in emergency departments of stomatology hospitals, and they are minor injuries compared with jaw fractures. Therefore, maxillofacial STIs have some different epidemiological characteristics comparing to jaw fractures [1]. Because the face is associated with the perception of beauty and there is the possibility of scarring, maxillofacial STIs can cause not only aesthetic problems but also psychological issues [2]. Maxillofacial STI infection can aggravate the formation of scars, and the aesthetic evaluations of patients with infection are lower [3]. Because of the rich blood supply in the oral and maxillofacial regions, the infection rate is lower than that in other areas. Most of the available studies are aimed at the laceration of all parts of the body, and there are few studies on simple maxillofacial STIs and infection. The bacterial environment and abundant

Department of Oral Emergency, Peking University School and Hospital of Stomatology & National Center of Stomatology & National Clinical Research Center for Oral Diseases & National Engineering Research Center of Oral Biomaterials and Digital Medical Devices & Beijing Key Laboratory of Digital Stomatology & Research Center of Engineering and Technology for Computerized Dentistry Ministry of Health & NMPA Key Laboratory for Dental Materials, Beijing, P.R. China.

blood supply in the oral cavity may make the risk factors for infection different from those of STIs in other parts of the body. Therefore, it is meaningful to evaluate the risk factors for maxillofacial STI infection. Understanding the factors causing infection and taking corresponding measures against these factors are valuable for improving the prognosis of patients.

Patients and Methods

This study was approved by an ethics committee and was conducted under the guidance of international ethical standards (PKUSSIRB-202054051).

From January 1, 2017, to December 31, 2020, all patients with STIs who received sutures in this department were enrolled.

Inclusion and exclusion criteria

The inclusion criteria were as follows: patients with only STIs due to oral and maxillofacial trauma (with or without dental trauma) at the initial visit and patients with all types and severities of maxillofacial STIs that needed suturing. The diagnoses of STIs in the electronic records were as follows: laceration and avulsion, puncture, cutting injury, bite, animal bite, and blast injury. Even if some wound age exceeded 24 hours or the wound had mild infection or necrosis, the physician performed debridement and suturing at the initial visit.

Patients with complete electronic medical records, including gender, age, physical condition, visit time, chief complaint, examination, diagnosis, attending physician, treatment, and appointment records were included. Patients who needed, in addition to the initial visit, at least one follow-up visit two days or more after suturing to evaluate whether infection occurred.

The exclusion criteria were as follows: patients with incomplete electronic medical records; patients with jaw fractures or serious trauma of other parts of the body; patients who received sutures at other hospitals; patients who had serious wound infections that could not be sutured at the initial visit and sutured at the subsequent visit when the infection was reduced; patients who had only medical records of the first visit or only follow-up records within 48 hours after suture; patients who were American Society of Anesthesiologists (ASA) grade 4 or 5.

Classification

The patients were divided into four groups according to their age: <18 years old, 18–44 years old, 45–64 years old, and ≥65 years old. The patient's physical condition was divided into three categories according to ASA grade: no organic disease (grade 1); mild/moderate systemic disease without functional impairment (grade 2); and organic disease with definite functional impairment (grade 3). Diabetes mellitus status was classified according to the American Diabetes Association (ADA) guidelines. Wound age was divided into 4 groups: less than 8 hours, 8 ~ 16 hours, 16 ~ 24 hours, and above 24 hours.

The physician level was classified as follows: nonspecialist, a practitioner who was trained in maxillofacial surgery but not engaged in surgery; junior specialist, a surgeon who had been engaged in surgical clinical work for two to five years; and senior specialist, a surgeon who had been engaged in surgical clinical work for more than five years.

Wound types were divided into intra-oral mucosal wounds, extra-oral skin/lip wounds, and communicating wounds (the wound penetrated from the extraoral skin/lip to the intraoral mucosa). The trauma sites were divided into the lip, cheek, chin, mandible, tongue, gum, and other parts.

Statistical methods

All data were analyzed with SPSS Statistics, version 21 (IBM Corp, Armonk, NY). First, univariable analysis was used to analyze gender, age, physical condition, diabetes mellitus, wound age, wound length, wound contamination, wound types (intra-oral/extra-oral/communicating wounds), attending physician level, and anatomic site of injury. The Pearson χ^2 test was used ($p \leq 0.05$). Statistically significant factors in univariable analysis were further included in binary logistic regression analysis to identify independent risk factors.

Results

A total of 3,276 cases, 2,147 males and 1,129 females, were eligible for inclusion in the study. In the univariable analysis, there was no significant difference in the infection rate between genders ($p = 0.364$), moreover, there was no significant difference in the infection rate between wound ages ($p = 0.361$). American Society of Anesthesiologist grade ($p < 0.001$), diabetes mellitus status ($p < 0.001$), wound length ($p < 0.001$), wound contamination ($p < 0.001$), type of wound (intra-oral/extra-oral/communicating wound) ($p < 0.001$), physician level ($p = 0.038$), and injury site ($p < 0.001$) were substantially different (Table 1).

Binary logistic analysis showed that there were substantial differences in the following factors: age, 18–44 years (odds ratio [OR], 2.2; 95% confidence interval [CI], 1.7–2.9), 44–64 years (OR, 3.1; 95% CI, 2.3–4.3), and ≥65 years (OR, 2.6; 95% CI, 1.7–4.1); wound length: 4–8 cm (OR, 1.7; 95% CI, 1.3–2.2) and >8 cm (OR, 2.4; 95% CI, 1.1–5.1); type of wound: intra-oral wound (OR, 1.6; 95% CI, 1.1–2.4) and communicating wound (OR, 3.2; 95% CI, 2.3–4.4); physician level: junior specialist (OR, 1.6; 95% CI, 1.2–2.2); sites: lip (OR, 3.7; 95% CI, 1.1–12.0) and cheek (OR, 4.7; 95% CI, 2.3–17.1).

The above factors were independent risk factors for infection (Table 2). Binary logistic regression analysis did not show a significant relationship between ASA grade ($p = 0.531$), diabetes mellitus ($p = 0.111$), wound contamination ($p = 0.155$), and infection (Table 2).

Discussion

Oral and maxillofacial STI is a common and frequent disease in the emergency department of stomatology. Seventy percent of STIs are penetrating wounds and need sutures [1]. There have been few reports on risk factors for infection after suturing penetrating wounds of maxillofacial STIs. Similar studies have mostly focused on body laceration infection and maxillofacial animal bite infection [3–6]. The results of these studies on the relation between age, physical condition, wound length, wound pollution, wound age and infection risk are not consistent.

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Table 1. Cases and Maxillofacial Soft Tissue Injury Characteristics and Their Association with Infection Rate

	n (%)	Non-infection (%)	Infection (%)	χ^2	p
Gender					
Male	2,147 (65.5)	1,827 (85.1)	320 (14.9)	0.825	0.364
Female	1,129 (34.5)	974 (86.3)	155 (13.7)		
Age[a]					
<18 y	1,474 (45.0)	1,357 (92.1)	117 (7.9)	111.486	<0.001
18–44 y	1,121 (34.2)	928 (82.8)	193 (17.2)		
45–64 y	444 (13.6)	333 (75.0)	111 (25.0)		
≥65 y	237 (7.2)	183 (77.2)	54 (22.8)		
ASA grade					
Grade 1	2,993 (91.4)	2,592 (86.6)	401 (13.4)	35.402	<0.001
Grade 2	226 (6.9)	164 (72.6)	62 (27.4)		
Grade 3	57 (1.7)	45 (78.9)	12 (21.1)		
Diabetes mellitus					
No	3,198 (97.6)	2,748 (84.9)	450 (14.1)	19.856	<0.001
Yes	78 (2.4)	53 (67.9)	25 (32.1)		
Wound age					
<8 h	2,984 (2984)	2,552 (85.5)	432 (14.5)	3.203	0.361
8–16 h	175 (5.3)	153 (87.4)	22 (12.6)		
16–24 h	28 (0.9)	25 (89.3)	3 (10.7)		
>24 h	89 (89)	71 (79.8)	18 (20.2)		
Wound length					
<4 cm	2,732 (83.4)	2,383 (87.2)	349 (12.8)	40.701	<0.001
4–8 cm	508 (15.5)	394 (77.6)	114 (22.4)		
>8 cm	36 (1.1)	24 (66.7)	12 (33.3)		
Wound contamination					
No	2,437 (74.4)	2,123 (87.1)	314 (12.9)	20.012	<0.001
Yes	839 (25.6)	678 (80.8)	161 (19.2)		
Communication					
Extra-oral	980 (29.9)	902 (92.0)	78 (8.0)	113.439	<0.001
Intra-oral	1,314 (40.1)	1,156 (88.0)	158 (12.0)		
Communication	982 (30.0)	743 (75.7)	239 (24.3)		
Attending physician level					
Senior specialist	1,239 (37.8)	1,061 (85.6)	178 (14.4)	6.520	0.038
Junior specialist	517 (15.8)	424 (82.0)	93 (18.0)		
Non-specialist	1,520 (46.4)	1,316 (86.6)	204 (13.4)		
Sites					
Tongue	63 (1.9)	60 (95.2)	3 (4.8)	52.191	<0.001
Gum	173 (5.3)	164 (94.8)	9 (5.2)		
Mandible	33 (1.0)	31 (93.9)	2 (6.1)		
Chin	323 (9.9)	294 (91.0)	29 (9.0)		
Cheek	121 (3.7)	95 (78.5)	26 (21.5)		
Lip	2,399 (73.2)	2,001 (83.4)	398 (16.6)		
Others	164 (5.0)	156 (95.1)	8 (4.9)		
Total	3,276 (100.0)	2,801 (85.5)	475 (14.5)		

ASA = American Society of Anesthesiologists; SD = standard deviation.
[a]Age: average ± SD: 5.4 ± 22.7 years old. Maximum, 90 years old; minimum, 1 year old.

Several studies have shown that increased age is a risk factor for an increase in laceration infection [7,8]. Children are more prone to maxillofacial laceration, and their infection rate is lower than that of adults. In this study, it was also found that adults were more likely to be infected than children and adolescents under the age of 18. The mechanism of the effect of age on infection was not clear. This may be related to the inflammatory response affected by age [9] and may also be related to hypoxia caused by insufficient local blood perfusion in elderly patients [10]. The influence of physical condition on STI infection is controversial [11,12]. In this study, the increased infection rate caused by age seemed to have nothing to do with the physical condition aggravated by age. With facial injury caused by high-impact trauma, those aged older than 60 years with underlying diseases, including diabetes mellitus, showed a higher proportion of infection [13]. However, in this study, with mild trauma such as STIs, patients with underlying diseases (ASA grade 2/3) did not show a higher infection rate. Notably, the finding as to whether diabetes mellitus increased infection of STIs was different in the literature [3,8,14]. Diabetes mellitus was also not a risk factor for infection in this study.

Regarding more serious maxillofacial trauma, such as fractures, delay to theater could increase the post-operative infection rate [15]. However, for STIs, the concept of the golden period has been gradually abandoned [16–19]. In

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Table 2. Cases and Maxillofacial Soft Tissue Injury Characteristics Retained in the Logistic Regression Model That Are Associated with Wound Infection

	n *(%)*	*Infection (%)*	*Non-infection (%)*	p	*OR (95% CI)*
Age					
<18 y	1,474 (45.0)	1,357 (92.1)	117 (7.9)	<0.001	1.0
18-44 y	1,121 (34.2)	928 (82.8)	193 (17.2)	<0.001	2.2 (1.7- 2.9)
45–64 y	444 (13.6)	333 (75.0)	111 (25.0)	<0.001	3.1 (2.3– 4.3)
≥65 y	237 (7.2)	183 (77.2)	54 (22.8)	<0.001	2.6 (1.7– 4.1)
ASA grade					
Grade 1	2,993 (91.4)	2,592 (86.6)	401 (13.4)	0.531	1.0
Grade 2	226 (6.9)	164 (72.6)	62 (27.4)	0.399	1.2 (0.8– 1.8)
Grade 3	57 (1.7)	45 (78.9)	12 (21.1)	0.671	0.8 (0.4– 1.8)
Diabetes mellitus					
No	3,198 (97.6)	2,748 (84.9)	450 (14.1)		1.0
Yes	78 (2.4)	53 (67.9)	25 (32.1)	0.111	1.6 (0.9– 3.0)
Wound length					
<4 cm	2,732 (83.4)	2,383 (87.2)	349 (12.8)	<0.001	1.0
4–8 cm	508 (15.5)	394 (77.6)	114 (22.4)	<0.001	1.7 (1.3– 2.2)
>8 cm	36 (1.1)	24 (66.7)	12 (33.3)	0.037	2.4 (1.1– 5.1)
Wound contamination					
No	2,437 (74.4)	2,123 (87.1)	314 (12.9)		1.0
Yes	839 (25.6)	678 (80.8)	161 (19.2)	0.155	1.2 (0.9– 1.5)
Communication					
Extra-oral	980 (29.9)	902 (92.0)	78 (8.0)	<0.001	1.0
Intra-oral	1,314 (40.1)	1,156 (88.0)	158 (12.0)	0.002	1.6 (1.1– 2.4)
Communication	982 (30.0)	743 (75.7)	239 (24.3)	<0.001	3.2 (2.3– 4.4)
Attending physician level					
Senior specialist	1,239 (37.8)	1,061 (85.6)	178 (14.4)	0.003	1.0
Junior specialist	517 (15.8)	424 (82.0)	93 (18.0)	<0.001	1.7 (1.2– 2.2)
Non-specialist	1,520 (46.4)	1,316 (86.6)	204 (13.4)	0.460	1.1 (0.9– 1.4)
Sites					
Tongue	63 (1.9)	60 (95.2)	3 (4.8)	<0.001	1.0
Gum	173 (5.3)	164 (94.8)	9 (5.2)	0.581	1.5 (0.4– 5.7)
Mandible	33 (1.0)	31 (93.9)	2 (6.1)	0.775	1.3 (0.2– 8.9)
Chin	323 (9.9)	294 (91.0)	29 (9.0)	0.105	2.9 (0.8–10.2)
Cheek	121 (3.7)	95 (78.5)	26 (21.5)	0.017	4.7 (2.3–17.1)
Lip	2,399 (73.2)	2,001 (83.4)	398 (16.6)	0.033	3.7 (1.1–12.0)
Others	164 (5.0)	156 (95.1)	8 (4.9)	0.911	1.1 (0.3– 4.4)

OR = odds ratio; CI = confidence interval; ASA = American Society of Anesthesiologists.

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many studies, it was considered that wound age had no effect on the infection rate of laceration [18,19]. Although it is important to see a physician as soon as possible after trauma to reduce the infection rate [17], in everyday practice, wounds are sutured regardless of the elapsed time [18]. It is recommended that head and neck STIs be sutured within 24 hours of occurrence [20]. In this study, there were no differences in infection between different wound age groups. Notably, the infection rate of maxillofacial STIs with an age of over 24 hours was not different from that for other wound ages. Therefore, we suggest that even if the penetrating wound age exceeds 24 hours, debridement and suturing are valuable if there is no serious infection.

Visible contamination, injury deeper than the subcutaneous tissue, and the presence of a foreign body are all associated with an increased risk of infection [8]. A foreign body and devitalized tissue or tissue of uncertain viability increases the likelihood of an inflammatory response and infection [20,21]. However, some parts of the body have complex tissue levels [3,20], which effect the operator's exploration and cleanliness of foreign bodies. Soft tissue infection in the maxillofacial region, which has thin, soft tissue, is more conducive to the exploration and removal of foreign bodies and visible contamination. Additionally, the rich blood supply of maxillofacial soft tissues reduces the rate of infection [8]. In this study, although the infection rate of wounds with foreign bodies and visible contamination was different from that of uncontaminated wounds in univariable analysis, binary logistic analysis did not find visible contamination to be an independent risk factor for infection. When the wound was debrided according to the treatment standard, the infection rate was not affected by the original pollution state.

The bacterial wound flora and the local condition of the wound are inter-related. Wound infection is the result of the relation between wound condition and bacterial invasion [12]. Most bacteria isolated from infected fields persist around cutaneous fields and pharyngeal bacteria [22]. For clean-contaminated wounds, the post-operative infection rate may reach 10% [23]. The intra-oral environment is a bacterial environment. Although wounds may be debrided and sutured in time, the infection rate of intra-oral wounds is higher than that of extra-oral skin wounds. Research on craniofacial reconstructive procedures found that implantation through

a transoral route was correlated with a substantial risk of post-operative infection, further elucidating the role of oral contamination in post-operative infection [24]. Therefore, peri-operative oral care is considered important in reducing the infection rate [22].

In addition, this study found that the infection rate of communicating wounds that penetrated extra-orally to intra-orally was higher than that of intra-oral wounds. Communicating wounds are relatively heavy and deep, and the pollutants are more difficult to clean. Under the combined action of bacteria gathering under the blood scab of the skin wound and the bacterial intra-oral environment, communicating wounds are more likely to cause infection [25]. Therefore, it is recommended that nursing measures be taken to reduce the infection rate of communicating wounds. In addition to peri-operative oral care, topical antibiotic agents should be applied to the skin, the primary healing wounds should be cleansed of scab tissue and residues of the surgical disinfectant after 24 hours, a protective dressing should be applied, and a moist wound environment should be maintained; these strategies have been shown to be effective in preventing wound infection involving skin [23,26]. The lip and cheek regions with thin, soft tissue that is more easily penetrated had a higher infection rate than other parts in this study. This was basically consistent with another study [27].

At our institution, the pre-triage nurse determines the receiving physician according to the maxillofacial STI. If the injury was serious, a professional surgeon (junior or senior) performed the examination and suturing. The study found that the infection rate of STIs sutured by senior surgeons was lower than that of junior surgeons. The impact of physician experience and technology on infection was the same as that reported in other studies [28,29]. Good technique during surgery for incision or laceration closure is much more important than any manipulation of the wound [28]. The infection rate was related to the personnel performing the repair, suggesting differences in wound preparation and repair techniques between emergency departments and surgical personnel [29]. In addition to differences in wound treatment and suture skills, senior surgeons are more experienced in post-operative wound management, such as local use of antibiotic agents/ointment, wound drainage, and timing and number of patient follow-up visits. Whether the above factors affect the wound infection rate has not been further studied, which is a limitation of this study. Further research is planned to more thoroughly examine discuss more detailed factors in further research to that may guide clinical treatment.

Conclusions

This study analyzed the infection rate after suturing maxillofacial penetrating STIs. Increased age, longer wound length (>4 cm), intra-oral and communicating wounds, and lip or cheek sites increased the infection rate. No difference was found regarding gender, physical condition, diabetes mellitus, wound age or contamination. Even if the penetrating wound age exceeds 24 hours, it is meaningful to suture if there is no serious infection. For wounds at high risk of infection, further measures should be considered to reduce the possibility of infection, improving the surgical training of junior surgeons, and improving the patient's wound care.

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Author Disclosure Statement

No conflicting financial interests exist.

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Address correspondence to:
Dr. Jie Bai
Department of Oral Emergency
Peking University School and Hospital of Stomatology
No. 22, Zhongguancun South Avenue, Haidian District
Beijing 100081
P.R. China

E-mail: jiebai1999@163.com

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