Original Article

Risk factors for the occurrence of infection in patients with oral squamous cell carcinoma after restorative reconstruction and its impact on recurrence and quality of life: a retrospective cohort study

Miaomiao Shen[1#], Weilan Shan[1#], Siyi Lv[2], Kuan Cai[1], Xuan Chen[1], Zhengyun Xu[1], Mingjin Gao[1], Guodong Wang[1]

[1]Department of Stomatology, Second Affiliated Hospital of Naval Medical University, Shanghai, China; [2]Department of Stomatology, School/Hospital of Stomatology, Lanzhou University, Lanzhou, China

Contributions: (I) Conception and design: M Shen, W Shan; (II) Administrative support: G Wang, M Gao; (III) Provision of study materials or patients: M Shen, W Shan; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Mingjin Gao, PhD; Guodong Wang, PhD. Department of Stomatology, Second Affiliated Hospital of Naval Medical University, No. 415, Fengyang Road, Huangpu District, Shanghai 200003, China. Email: 787250017@qq.com; wangguodong@smmu.edu.cn.

Background: Worldwide, there are approximately 300,000 new cases of oral squamous cell carcinoma (OSCC) and 100,000 deaths each year. The complexity of oral and maxillofacial structures leads to a high risk of surgical infection such as radical tumor resection and free flap reconstruction. Previous studies have shown that diabetes mellitus, previous radiotherapy, oral-neck communication, etc. are risk factors for postoperative infection, but the influence of time on prognosis has not been clarified in detail. This study supplements this aspect and provided a reference for improving the quality of life of patients.

Methods: We retrospectively analyzed a total of 168 patients who developed OSCC from July 2014 to September 2019. According to the inclusion and exclusion criteria of this study, the general data questionnaire designed by ourselves was used to sort out the general characteristics and clinical data of the subjects. The *t* test, Chi-square test and binary logistic regression were used for statistical analysis. Surgical site infections (SSI) are defined as infections associated with surgical procedures. The quality of life was evaluated by the 36-Item Short Form Survey (SF-36) score. A 3-year follow-up was conducted by telephone, Email and outpatient review.

Results: Among the 168 patients, the total number of postoperative infections was 22 (13.1%). Binary logistic regression analysis showed that body mass index (BMI) (OR =0.029, P=0.039), American Society of Anesthesiologists (ASA) classification (OR =21.443, P=0.042), preoperative radiotherapy (OR =19.993, P=0.022), Jaw resection status (OR =29.665, P=0.021), Perioperative transfusion (OR =29.148, P=0.020), preoperative white blood cell count (OR =1.763, P=0.017), albumin level (OR =0.853, P=0.033) were independent influencing factors between the two groups (P<0.05). Except for the social functioning and role-emotional dimensions, all dimensions of SF-36 in patients with infection were significantly lower than those without infection.

Conclusions: The incidence of postoperative infection after restorative and reconstructive surgery for OSCC deserves the attention of clinicians. For high-risk infected persons, relevant anti-infection measures should be taken early against the infectious source, and the possibility of nosocomial infection should be attached great importance in clinical work. After discharge, patients should also actively do follow-up, education and other related work to reduce the incidence of postoperative infection.

Keywords: Oral squamous cell carcinoma (OSCC); postoperative infection; prognosis; repair and reconstruction

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Introduction

Oral cavity cancer (OCC), a type of head and neck cancer, ranks 16th in mortality among malignancies worldwide and is a growing problem in global public health. OCC refers to malignant tumors of the oral cavity, including secondary sites in the oral cavity (1). More than 90% of OCC tumors originate from squamous tissues and therefore are widely known as oral squamous cell carcinoma (OSCC) (2,3). In fact, squamous cell carcinoma is the most common malignancy in the oral cavity and one of the 10 most common cancers worldwide (4,5).

According to Global Cancer Statistics (GLOBOCAN) estimates, the global age-standardized incidence rate of oral and oropharyngeal cancer was approximately 6/100,000 in 2012, with higher rates in Western countries and an age-standardized incidence rate of approximately 11/100,000 in the United States (6). A study has shown that the incidence of OSCC is higher in men than in women, with about 5.8 cases per 100,000 people in men compared to about 2.3 in women (3). In recent years, with the increasing advancement of medical technology and the general increase of people's health awareness, the diagnosis and treatment rate of OSCC has increased significantly. Survival rate for OSCC can vary depending on the anatomical location of each subsite, the staging, grading, diagnosis, and treatment (7). The rate of diagnosed cases and deaths also varies by geographic location, with the highest diagnosis rate (64.2%) and highest mortality rate (73.3%) in Asia, and the lowest diagnosis rate (1.3%) and lowest mortality rate (0.56%) in Oceania (8).

Usually, OSCC presents as a localized lump or ulcerative erosion, which may cause lump rupture, bleeding, and pain in severe cases. If the mass develops further, it may invade the tongue muscle and cause tongue movement disorder; if it invades the teeth, it may cause loose teeth, among other issues (9). Because OSCC is characterized by strong local infiltration, a high rate of early lymph node metastasis, and a high risk of recurrence, immediate radical tumor resection and cervical lymph node dissection with free-flap repair are critical in the treatment of OSCC, as this can remove the focal tissue and inhibit disease progression (10). In principle, the combination of surgical resection and postoperative radiotherapy is another effective treatment for OSCC (11).

The oral and maxillofacial framework has various functional sinuses: the maxilla and mandible are attached with anomalous alveolar teeth, the mouth contains the tongue, the facial nerve innervates the facial muscles of expression, and there are salivary glands and temporomandibular joints. These anatomical peculiarities make the surgery more difficult and risky, increasing the likelihood of postoperative complications (12). Postoperative complications after OSCC repair and reconstruction mainly include pulmonary infection, electrolyte disorders, hypoproteinemia, delirium, deep vein thrombosis of the lower extremities, bleeding in the operating area, infection in the operating area, wound dehiscence, and subcutaneous hematoma. Among these, postoperative infection is a common complication of oral

Highlight box

Key findings

- Preoperative radiotherapy treatment, perioperative blood transfusion, and preoperative WBC and Alb levels are independent risk factors for postoperative complications of infection in patients with OSCC. Greater attention should be paid to these characteristics in clinical work to reduce the occurrence of postoperative infections and improve patient's recurrence and quality of life.

What is known and what is new?

- The occurrence of infection after restorative reconstruction in patients with OSCC is a common clinical complication.
- Infection after restorative reconstruction in patients with OSCC increases the probability of tumour recurrence and significantly reduces patients' postoperative quality of life.

What is the implication, and what should change now?

- There are still many factors that can contribute to the development of post-operative infections during the treatment of OSCC, which can affect the patient's prognosis. Individualized treatment measures should be taken according to the different clinical characteristics of the individual in order to reduce the possibility of postoperative infection so as to enhance patients' quality of life after surgery.

and maxillofacial surgery, and the causes of postoperative infection are quite complex (13). Because of the mixed colonization of aerobic and anaerobic flora in the oral cavity, repair and reconstruction surgery can disrupt the microecological balance in the oral cavity, which is susceptible to the formation of microbiota diversity in multiple wounds. The oral and maxillofacial areas have rich blood and lymphatic circulation and are connected to the cranial brain upward and the neck downward, which are the beginning of the respiratory and digestive tracts. Their moist and warm physiological environments are prone to the growth of bacteria. In addition, the structure of the oral and maxillofacial cavities and sinuses is complex, and it is difficult to sterilize them thoroughly. Therefore, postoperative surgical site infection and pulmonary infection are the most common complications (14,15). According to the literature, the incidence of infection after OSCC repair and reconstruction can range from 15.0% to 26.1% (16-18), and the operation time, preoperative radiotherapy, mandibular resection, and oral-neck communication have been shown to be the risk factors for postoperative infection in oral cancer. It has also been reported that patients with squamous cell carcinoma of the oral cavity who receive radiotherapy for head and neck cancer have poorer survival rates (19), but there are few studies on the prognosis of patients with infection occurring after OSCC. Therefore, based on the preliminary findings of the previous period, we proposed a research hypothesis that patients with diabetes, intraoperative blood transfusion, tumor diameter, and jaw resection may be risk factors affecting postoperative infection, and the occurrence of infection will significantly affect the prognosis of patients, including the overall survival rate of patients. The aim of this study was to analyze the risk factors for the occurrence of infection after repair and reconstruction in patients with OSCC and their impact on patient prognosis. We hope the findings of this study can provide a reference for reducing the occurrence of postoperative complications and improving the quality of life and prognosis of patients with OSCC. We present this article in accordance with the STROBE reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1150/rc).

Methods

Research participants

The study is a retrospective cohort study design. A total of 168 patients with OSCC treated with restorative reconstruction at the Second Affiliated Hospital of Naval Medical University from July 2014 to September 2019 were included in this study.

Inclusion criteria were as follows: (I) patients who underwent repair and reconstruction from whom tissue specimens were obtained by surgery or biopsy that were pathologically confirmed as primary OSCC, (II) patients with complete clinical information, (III) patients who signed an informed consent, and (IV) patients with normal coagulation function.

The exclusion criteria were as follows: (I) patients with secondary oral cancer, metabolic diseases, or systemic nutritional status diseases and those in critical condition or unable to answer questions clearly; (II) patients with combined contraindications to surgery; (III) patients with combined hematologic diseases; and (IV) patients with incomplete clinical information (*Figure 1*).

The objective of this retrospective study was to investigate the relationship between postoperative infection and prognosis in patients with oral squamous cell carcinoma who underwent repair and reconstruction. According to our previous investigations, the prevalence of postoperative infection in patients with oral squamous cell carcinoma treated with prosthesis reconstruction is about 9%. The allowable error is 3%, the confidence is $1-\alpha=0.95$, and the sample size, 145 cases is obtained by using PASS 15 software. Assuming that the non-response rate of the subjects is 10%, the sample size $N=145\div 0.9=161$ cases is required. Therefore, the sample size of the study population planned for this study was 180 cases. There were 12 cases of actual attrition and partial loss of access, with a final count of 168 cases.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics board of Second Affiliated Hospital of Naval Medical University (No. LCKY2014054) and informed consent was taken from all the patients.

Clinical data

The general information questionnaire included demographic data [e.g., age, gender, body mass index (BMI)] and clinical data [American Society of Anesthesiologists (ASA) classification; e.g., diabetes status, hypertension, hyperlipidemia, smoking history, dental status, preoperative radiotherapy, tumor diameter, depth of tumor infiltration, jaw resection status, free-flap type, cervical lymph node dissection, transtracheal resection, perioperative transfusion,

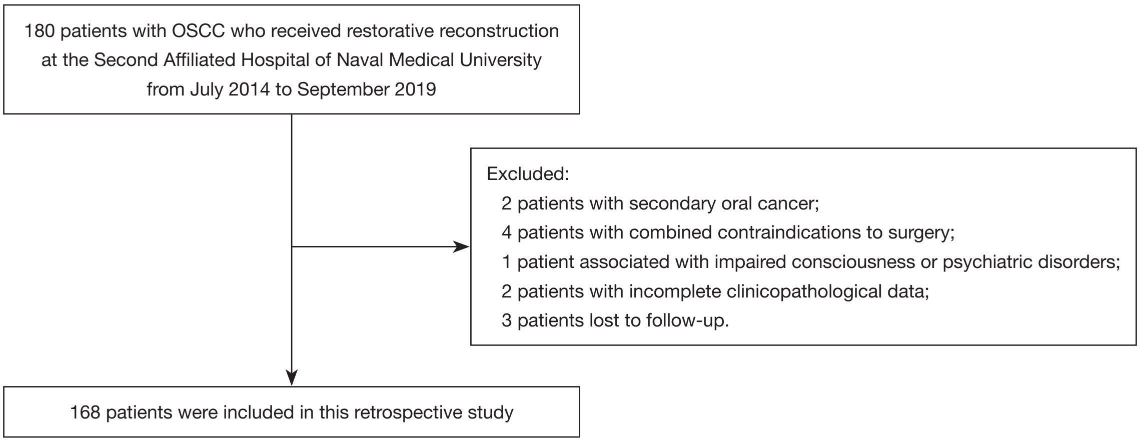

Figure 1 Flowchart of patient selection. OSCC, oral squamous cell carcinoma.

operative time, intraoperative blood loss, hospital days, relevant laboratory indicators, and prognostic indicators].

During hospitalization, members of the research group were responsible for collecting data on infection and disease course changes. After patients were discharged from hospital, a WeChat group would be set up, and patients were told to contact members of the investigation group through WeChat group or telephone if their condition changed.

Postoperative infection

According to the CDC National Nosocomial Infections Surveillance system and Johnson's criteria, Postoperative infection is an infection which is defined as a surgery-related infection that happens to the site of the surgical incision or its immediate vicinity within 30 days of the surgery (20-24). Incisional infections are diagnosed if there is pus oozing from the wound or if the wound is open and the surgeon performs a positive bacterial culture of the wound or drainage fluid due to symptoms of infection (e.g., redness, swelling, fever, or pain in the wound, etc.). An interstitial infection is diagnosed if the drainage tube draws a purulent discharge or an abscess can be palpated, but the wound shows no signs of abnormal discharge.

Postoperative recurrence

Postoperative recurrence of OSCC was defined as that confirmed by histopathology occurring at least 3 months after surgery (25).

The 36-Item Short Form Health Survey (SF-36) score

The SF-36 is a widely used questionnaire for measuring self-perceptions of quality of life in a specific population. It consists of 36 questions on 8 dimensions: physical functioning (10 questions), role-physical (4 questions), bodily pain (3 questions), general health (5 questions), vitality (4 questions), social functioning (2 questions), role-emotional (3 questions), and mental health (5 questions). Besides this, it also consists of two aggregated scores, the Physical Component Summary (PCS) and the Mental Component Summary (MCS), respectively made up of physical or mental components. The scores for each aspect of the scale vary from 0 to 100, while higher scores represent a higher level of quality of life (26).

Kaplan-Meier survival curve

After discharge from the hospital, a 3-year follow-up visit was conducted by telephone, e-mail, and outpatient review. The follow-up included tumor marker testing and routine physical examination. If there was any uncomfort, patients were instructed to consult a doctor timely. The follow-up ended after 3 years or the patient's death, and the follow-up deadline was September 2022.

Statistical analysis

Statistical software SPSS 26 (IBM Corp.) was used to analyze the patient's case data. The measurement data were described by $\bar{x}$±s if they followed normal distribution, and the counting data were described by composition ratio (%). Statistical analysis between groups was performed with the *t*-test and chi-squared test, and factors influencing the occurrence of postoperative infection and prognosis were analyzed by multivariate logistic regression. Survival rates were analyzed by Kaplan-Meier survival curves, and differences between groups were compared using the log-rank method. A two-side P value <0.05 was considered statistically significant.

Results

Baseline data

The baseline data are shown in *Table 1*. A total of 22

Table 1 Baseline data of included patients in the 2 groups

Item	Infection group, n (%)	Non-infection group, n (%)	χ^2	P
Recurrence			11.578	0.001
Yes	9 (40.9)	18 (12.3)		
No	13 (59.1)	128 (87.7)		
Age (years)			6.641	0.010
≥60	14 (63.6)	51 (34.9)		
<60	8 (36.4)	95 (65.1)		
Gender			0.000	0.987
Male	9 (40.9)	86 (58.9)		
Female	13 (59.1)	60 (41.1)		
BMI (kg/m^2)			6.970	0.008
≥24	7 (31.8)	90 (61.6)		
<24	15 (68.2)	56 (38.4)		
ASA classification			4.463	0.035
≥2	14 (63.6)	58 (39.7)		
<2	8 (36.4)	88 (60.3)		
Diabetes			4.441	0.035
Yes	13 (59.1)	52 (35.6)		
No	9 (40.9)	94 (64.4)		
With hypertension or not			0.003	0.955
Yes	8 (36.4)	54 (37.0)		
No	14 (63.6)	92 (63.0)		
With hyperlipidemia or not			1.130	0.288
Yes	6 (27.3)	57 (39.0)		
No	16 (72.7)	89 (61.0)		
Smoking history			1.859	0.173
Yes	10 (45.5)	45 (30.8)		
No	12 (54.5)	101 (69.2)		
Dental status			4.193	0.041
Good	10 (45.5)	99 (67.8)		
Poor	12 (54.5)	47 (32.2)		

Table 1 (*continued*)

Table 1 (*continued*)

Item	Infection group, n (%)	Non-infection group, n (%)	χ^2	P
Received preoperative radiotherapy or not			7.984	0.005
Yes	13 (59.1)	42 (28.8)		
No	9 (40.9)	104 (71.2)		
Tumor diameter			4.298	0.038
≥3 cm	11 (50.0)	41 (28.1)		
<3 cm	11 (50.0)	105 (71.9)		
Depth of tumor infiltration			3.991	0.046
≥5 mm	11 (50.0)	42 (28.8)		
<5 mm	11 (50.0)	104 (71.2)		
Jaw resection status			15.732	0.000
Yes	15 (68.2)	38 (26.0)		
No	7 (31.8)	108 (74.0)		
Free-flap type			3.991	0.046
Bone quality	11 (50.0)	42 (28.8)		
Nonbone quality	11 (50.0)	104 (71.2)		
Cervical lymph node dissection			9.886	0.002
Ipsilateral	9 (40.9)	108 (74.0)		
Bilateral	13 (59.1)	38 (26.0)		
Titanium plate reconstruction			1.674	0.196
Yes	10 (45.5)	46 (31.5)		
No	12 (54.5)	100 (68.5)		
Tracheotomy			6.025	0.014
Yes	13 (59.1)	47 (32.2)		
No	9 (40.9)	99 (67.8)		
Perioperative blood transfusion			7.917	0.005
≥5 mm	11 (50.0)	32 (21.9)		
<5 mm	11 (50.0)	114 (78.1)		
Operative time			13.951	0.000
≥260 min	16 (72.7)	46 (31.5)		
<260 min	6 (27.3)	100 (68.5)		
Intraoperative blood loss			2.575	0.109
≥200 mL	9 (40.9)	36 (24.7)		
<200 mL	13 (59.1)	110 (75.3)		
Hospital days			5.958	0.015
≥13 d	14 (63.6)	53 (36.3)		
<13 d	8 (36.4)	93 (63.7)		

BMI, Body Mass Index; ASA, American Society of Anesthesiologists.

Table 2 Distribution and constituent ratio of the infection sites in patients with OSCC

Infection site	n	Constituent ratio (%)
Surgical wound	10	45.5
Respiratory tract	11	50.0
Skin and soft tissue	1	4.5
Urinary tract	0	0.0
Total	22	100.0

OSCC, oral squamous cell carcinoma.

patients developed postoperative infection, with an infection rate of 13.1%. The *t*-test results showed that recurrence, age, BMI, ASA classification, diabetes status, dental status, preoperative radiotherapy, tumor diameter, depth of tumor infiltration, jaw resection status, type of free flap, cervical lymph node dissection, tracheotomy, availability of perioperative blood transfusion, and operative time were significantly different between the infection and non-infection groups (P<0.05). In the infection group, a total of 9 cases (40.9%) had recurrence after surgery, while 18 (12.3%) cases had recurrence in the non-infection group. In the infection group, a total of 14 (63.6%) patients were aged ≥60 years, 7 (31.8%) patients had a BMI ≥24 kg/m^2, 14 (63.6%) patients had an ASA classification ≥2, 13 (59.1%) patients had accompanying diabetes, 10 (45.5%) patients had good dental condition, and 13 (59.1%) patients received preoperative radiotherapy. Tumor diameter ≥3 cm, tumor infiltration depth ≥5 mm, bone-free flap, and blood transfusion during the perioperative period each occurred in 11 (50.0%) patients. Jaw resection was performed in 15 (68.2%) patients, unilateral cervical lymph node dissection was performed in 9 (40.9%) patients, tracheotomy was performed in 13 (59.1%) patients, 16 (72.7%) patients had an operative time ≥260 min, and 14 (63.6%) patients had a hospital stay length of ≥13 days. In the non-infection group, 51 (34.9%) patients were aged ≥60 years, 90 (61.6%) patients had a BMI ≥24 kg/m^2, 58 (39.7%) patients had an ASA classification ≥2, 52 (35.6%) patients had accompanying diabetes, 99 (67.8%) patients were in good dental condition, 42 (28.8%) patients received preoperative radiotherapy, 41 (28.1%) patients had a tumor diameter ≥3 cm, 42 (28.8%) patients had a tumor infiltration depth ≥5 mm, 42 (28.8%) patients underwent bone free-flap procedure, 38 (26.0%) patients underwent Jaw bone resection, 108 (74.0%) patients underwent unilateral cervical lymph node dissection, 47 (32.2%) patients underwent tracheotomy, 32 (21.9%) patients underwent blood transfusion during the perioperative period, 46 (31.5%) patients had an operative time ≥260 min, and 53 (36.3%) patients had a hospital stay ≥13 days.

Distribution and constituent ratio of the infection sites in patients with OSCC

A total of 22 cases of infection occurred, and in 10 cases (45.5%), the surgical wounds were infected. Respiratory tract infections accounted for 11 cases, representing half of all infections and the largest proportion. There was only 1 case (4.5%) of skin and soft tissue site infection, and cases of urinary tract infection (*Table 2*).

Comparison of laboratory and associated indices of patients in the infection and non-infection groups

In the infection group, the average preoperative white blood cell (WBC) count was (11.70±3.40)×10^9/L, the average preoperative albumin (Alb) was 35.87±8.85 g/L, the average platelet-to-lymphocyte ratio (PLR) was 139.36±20.70, the average neutrophil-to-lymphocyte ratio (NLR) was 3.40±1.89, and the average lymphocyte-to-monocyte ratio (LMR) was 4.75±1.72. In the non-infection group, the average preoperative WBC count was (9.75±2.82)×10^9/L, the average preoperative Alb was 41.70±8.90 g/L, the average PLR was 128.33±16.99, the average NLR was 2.60±1.46, and the average LMR was 5.35±1.92. Analysis by *t*-test showed that preoperative WBC, preoperative Alb, PLR, and NLR between the infection and non-infection groups were significantly different (P<0.05; *Table 3*).

Risk factors of postoperative infection analyzed by multivariate logistic regression models

Multivariate logistic regression analysis showed that BMI, ASA score, dental status, radiotherapy treatment before surgery, jaw resection status, perioperative blood transfusion, and preoperative WBC and Alb levels were independent influencing factors on whether or not infection occurred after surgery (P<0.05; *Table 4*).

SF-36 score at 3 months after surgery of patients in the 2 groups

At 3 months postoperatively, patients who developed

Table 3 Laboratory and associated indices of patients in both infection and non-infection groups

Item	Infection group (n=22)	Non-infection group (n=146)	*t*	P
Perioperative WBC (×10^9/L)	11.70±3.40	9.75±2.82	–2.943	0.004
Perioperative Alb (g/L)	35.87±8.85	41.70±8.90	2.863	0.005
PLR	139.36±20.70	128.33±16.99	–2.754	0.007
NLR	3.40±1.89	2.60±1.46	–2.313	0.022
LMR	4.75±1.72	5.35±1.92	1.402	0.163

Data are presented as mean ± standard deviation. WBC, white blood cell; Alb, albumin; PLR, platelet lymphocyte rate; NLR, neutrophil-to-lymphocyte ratio; LMR, lymphocyte-to-monocyte ratio.

Table 4 Risk factors of postoperative infection according to multivariate logistic regression analysis

Item	β	SE	Wald	P	Odds ratio (95% CI)
Age	2.821	1.579	3.193	0.074	16.797 (0.761–370.783)
BMI	–3.539	1.717	4.248	0.039	0.029 (0.001–0.841)
ASA classification	3.065	1.504	4.152	0.042	21.443 (1.124–409.095)
Diabetes	0.306	1.109	0.076	0.783	1.357 (0.154–11.930)
Dental status	2.992	1.286	5.415	0.020	19.926 (1.603–247.663)
Received preoperative radiotherapy or not	2.995	1.310	5.232	0.022	19.993 (1.535–260.372)
Tumor diameter ≥3 cm	0.999	1.283	0.607	0.436	2.716 (0.220–33.560)
Jaw resection status	3.390	1.468	5.336	0.021	29.665 (1.671–526.562)
Free-flap type	0.669	1.016	0.434	0.510	1.952 (0.267–14.299)
Cervical lymph node dissection	2.839	1.495	3.607	0.058	17.107 (0.913–320.519)
Transtracheal resection	–1.383	1.264	1.197	0.274	0.251 (0.021–2.987)
Perioperative transfusion	3.372	1.444	5.453	0.020	29.148 (1.719–494.172)
Operative time	2.334	1.367	2.914	0.088	10.320 (0.707–150.546)
Hospital days	0.871	1.112	0.613	0.434	2.389 (0.270–21.146)
Depth of tumor infiltration	2.095	1.423	2.168	0.141	8.126 (0.500–132.158)
Perioperative WBC (×10^9/L)	0.567	0.238	5.660	0.017	1.763 (1.105–2.813)
Perioperative Alb	–0.159	0.075	4.562	0.033	0.853 (0.737–0.987)
PLR	–0.012	0.035	1.281	0.258	1.433 (0.924–1.058)
NLR	0.360	0.318	1.281	0.258	1.433 (0.769–2.673)

BMI, body mass index; ASA, American Society of Anesthesiologists; WBC, white blood cell; Alb, albumin; PLR, platelet lymphocyte rate; NLR, neutrophil-to-lymphocyte ratio.

postoperative infections had a mean SF-36 score of 48.82±2.72 for the vitality dimension, 55.36±4.68 for the social functioning dimension, 48.68±5.42 for the role-emotional dimension, 40.95±4.17 for the mental health dimension; 46.36±9.24 for the physical function dimension, 48.68±11.49 for the role-physical dimension, 51.64±8.26 for the bodily pain dimension, and 49.41±4.04 for the general health dimension. Patients without postoperative infection had a mean score of 51.23±3.99 for the vitality dimension, 56.74±4.30 for the social functioning dimension, 49.40±4.95 for the role-emotional dimension, 43.82±6.20 for the mental health dimension, 50.68±9.34 for the physical function

Table 5 SF-36 score at 3 months after surgery in patients in the 2 groups

Variables	Infection group	Non-infection group	*t*	P
Vitality	48.82±2.72	51.23±3.99	2.730	0.007
Social functioning	55.36±4.68	56.74±4.30	1.382	0.169
Role-emotional	48.68±5.42	49.40±4.95	0.630	0.530
Mental health	40.95±4.17	43.82±6.20	2.090	0.038
Physical functioning	46.36±9.24	50.68±9.34	2.024	0.045
Role-physical	48.68±11.49	53.47±9.23	2.192	0.030
Bodily pain	51.64±8.26	54.76±6.37	2.058	0.041
General health	49.41±4.04	53.82±4.86	4.048	0.000

Data are presented as mean ± standard deviation. SF-36, Medical Outcomes Study 36-Item Short Form Health Survey.

dimension, 53.47±9.23 for the role-physical dimension, 54.76±6.37 for the bodily pain dimension, and 53.82±4.86 for the general health dimension. Among these, there were significant differences in the scores of all dimensions except the social functioning dimension and the emotional functioning dimension in the occurrence of postoperative infection ($P<0.05$; *Table 5*).

Risk factors for recurrence analyzed by logistic regression models

Multivariate logistic regression analysis showed that occurrence of postoperative infection, preoperative radiotherapy treatment, tumor diameter, and depth of tumor infiltration were independent influencing factors of tumor recurrence ($P<0.05$; *Table 6*).

Kaplan-Meier survival curve comparison between 2 groups

This follow-up lasted for 3 years, and a total of 104 participants survived in both groups, representing an overall survival rate of 61.9%. The number of survivors in the infection group at 3 years was 10, representing a survival rate of 45.5%; the number of survivors in the non-infection group at 3 years was 94, representing a survival rate of 64.4%. The difference between the cumulative survival functions of patients in the 2 groups was statistically significant ($P<0.05$; *Figure 2*).

Discussion

OSCC is the most common tumor of the head and neck (27), accounting for about 90% of oral malignancies (28) and ranking sixth among the most common cancers worldwide (29). Therefore, it is particularly important to recognize the risk factors affecting postoperative infection and to intervene early to improve the quality of life of patients after surgery. Based on this, this study analyzed the risk factors of postoperative infection in patients with OSCC after restorative reconstruction.

The results indicated a total of 10 cases (45.5%) of infection at the surgical wound and 11 cases (50.0%) of infection in the respiratory tract, which is consistent with the findings reported in a study by Manchon *et al.* (30), who concluded that the most vulnerable site for infection after oral and maxillofacial surgery is the respiratory tract, followed by the surgical incision. Most patients who undergo oral and maxillofacial surgery need to be operated on under general anesthesia tracheal intubation, with the intubation location being in the patient's oral or nasal cavity. The repair and reconstruction surgery can disrupt the microecological balance in the oral cavity. Moreover, the oral cavity is connected to the oropharynx and respiratory tract, and the moist and warm physiological environment of the oral and nasal cavities is amenable to the harboring of bacteria; this, coupled with the increase of postoperative respiratory secretions and secretions flowing downward, can lead to the occurrence of pulmonary infection.

In addition, the results of this study showed that BMI, ASA score, dental status, preoperative radiotherapy treatment, jaw resection status, perioperative blood transfusion, preoperative WBC, and preoperative serum Alb levels were independent influencing factors for whether postoperative infection occurred. BMI is an important measure of human obesity, an indicator of nutritional status, and a risk factor for metabolic and endocrine

Table 6 Risk factors of recurrence analyzed according to multivariate logistic regression model

Item	β	SE	Wald	P	OR (95% CI)
Infection	2.742	0.986	7.732	0.005	15.519 (2.246–107.209)
Age	–0.026	0.525	0.003	0.960	0.974 (0.348–2.723)
Gender	0.362	0.538	0.453	0.501	1.437 (0.500–4.126)
BMI	–0.276	0.558	0.246	0.620	0.759 (0.162–1.424)
ASA classification	–0.733	0.555	1.750	0.186	0.480 (0.278–2.287)
Diabetes	–0.227	0.538	0.178	0.673	0.797 (0.394–3.477)
Hypertension	0.157	0.556	0.080	0.777	1.170 (0.311–2.517)
Hyperlipidemia	–0.122	0.533	0.052	0.819	0.885 (0.275–2.952)
Smoking history	–0.105	0.606	0.030	0.862	0.900 (0.294–3.088)
Dental status	–0.048	0.600	0.006	0.936	0.953 (0.065–0.988)
Preoperative radiotherapy	–1.376	0.696	3.910	0.048	0.253 (1.116–9.274)
Tumor diameter ≥3 cm	1.168	0.540	4.679	0.031	3.217 (1.033–8.507)
Depth of tumor infiltration ≥5 mm	1.087	0.538	4.079	0.043	2.964 (0.399–3.707)
Jaw resection status	0.196	0.569	0.118	0.731	1.216 (0.171–1.701)
Free-flap type	–0.618	0.586	1.112	0.292	0.539 (0.198–2.397)
Cervical lymph node dissection	–0.373	0.637	0.344	0.558	0.688 (0.227–2.575)
Titanium plate reconstruction	–0.268	0.619	0.187	0.666	0.765 (0.232–2.213)
Transtracheal resection	–0.332	0.575	0.334	0.563	0.717 (0.285–3.242)
Perioperative transfusion	–0.040	0.620	0.004	0.949	0.961 (0.500–4.126)
Operative time	–0.491	0.604	0.660	0.417	0.612 (0.187–2.000)
Intraoperative blood loss	0.010	0.617	0.000	0.987	1.010 (0.302–3.383)
Hospital days	–0.565	0.557	1.029	0.310	0.568 (0.191–1.693)

ASA, American Society of Anesthesiologists; OR, odds ratio.

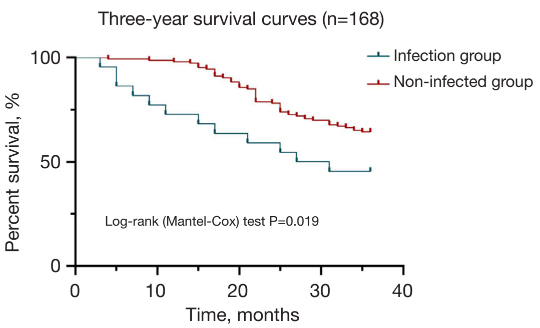

Figure 2 Kaplan-Meier survival curve between the infection group and non-infection group.

disorders (31). Chang *et al.* (32) showed that patients who are obese are more prone to incisional liquefaction and infection than are patients with normal weight. Therefore, after surgery, patients with higher BMI should be closely monitored for changes in infection indicators and other signs of postoperative infection. ASA score is a classification based on the patient's physical condition and surgical risk before anesthesia, with a higher score indicating a worse physical condition and a higher surgical risk of the patient. A previous study has shown that ASA grading is closely related to the incidence of postoperative infection (33). It remains debatable if preoperative radiotherapy can independently influence postoperative infections; Girod *et al.* (34) and Penel *et al.* (35) concluded that there is no relationship between preoperative radiotherapy and postoperative infection in patients regardless of whether they receive radiotherapy, while studies by Ogihara *et al.* (36) and Gan *et al.* (37) suggest that preoperative radiotherapy increases the risk of postoperative infection in patients. Current research suggests that preoperative radiotherapy induces DNA mutations, microvascular damage and soft tissue fibrosis, which slows wound healing and leads to an increased chance of postoperative wound infection (16). To ensure a 5-mm tumor-free margin during surgery, mandibular marginal or segmental resection may be required, relates to the size and location of the tumour (38). When the tumour invasion does not involve the mandibular bone marrow, marginal resection of the mandible is feasible; whereas when the tumour invades into the mandibular bone marrow, segmental resection of the mandible is required (39). Jaw resection can lead to an increased probability of infection likely because jaw resection leads to the formation of oronasal fistulae, which, together with the exposure of the trauma due to surgical treatment, exacerbates bacterial colonization in the oral cavity making it highly susceptible to inflammation. In addition, perioperative blood transfusion suppresses the immunity of the body. Allogeneic blood transfusion results in the release of large amounts of cytokines and inflammatory transmitters from the recipient's neutrophil degranulation, excessive elevation of serum cytokines such as soluble interleukin (IL)-2 receptors and soluble IL-6 receptors, and decreased activity of natural killer/cells and macrophages inhibiting the chemotactic and phagocytic functions of macrophages, all of which can lead to a decrease in the patient's immunity. It has been reported in the literature that perioperative blood transfusion leads to a significant increase in postoperative infectious complications in patients undergoing oncologic and trauma surgery, which is positively correlated with postoperative infection (40). Therefore, clinicians should pay attention to careful hemostasis during surgery, attempt "bloodless operation", and establish correct and reasonable blood transfusion. Mahmood *et al.* (41) reported an elevated preoperative leukocyte count to be an independent risk factor for postoperative infection. An elevated leukocyte count indicates that the body is in a stressful state, which can be aggravated by intense surgical trauma and an extended anesthesia time, thus increasing the risk of postoperative infection. Another study showed that hypoalbuminemia is associated with the occurrence and severity of viral, bacterial, and fungal infections (42), and hypoalbuminemia may be predictive of infection complications and prognosis (43). Alb reflects the nutritional status of the organism, and a decrease in Alb suggests malnutrition, reduced immunity, and decreased ability to defend against pathogenic bacteria. The oxidation and catabolism of albumin play an important role in antimicrobial defense and repair processes, and both innate and adaptive immune responses are dependent on Alb. The systemic inflammatory response in severe infections can alter the function and metabolic kinetics of Alb, thereby increasing the risk of postoperative infection (44). This suggests that physicians should pay close attention to the basic status of patients and changes in the internal environment before surgery and may appropriately delay surgery in patients with excessive preoperative leukocytes and low Alb to avoid postoperative infections.

OSCC is extremely destructive, and harmful habits such as smoking and alcohol abuse can increase the risk of developing the disease, which has a tendency to recurrence and can seriously threaten patients' lives after onset. Even after radical surgery and appropriate adjuvant therapy, the recurrence rate of OSCC after surgery is still as high as 47% (45). The results of this study also found that postoperative infection, preoperative radiotherapy treatment, tumor diameter, and depth of tumor infiltration were independent influencing factors on whether tumor recurrence occurred. What this result indicates is that the occurrence of postoperative infection significantly increases the rate of tumor recurrence. This may be related to the weakened resistance of the body after surgery, on the basis of which the infection further affects the immune system and eventually causes the growth of some of the remaining tumor cells in the body. The size of the primary tumor directly affects the resection rate, and a clean resection of the tumor is directly related to reduced recurrence. There is a strong correlation between increasing depth of tumor infiltration and T classification, positive pathological lymph nodes, extra-lymph node extension, positive margins, and perineural invasion (46). The deeper the tumor infiltration into the surrounding tissues, the higher the risk destruction and distant metastasis, and the lower the likelihood that kill tumor cells completely killed during clinical treatment, resulting in a high risk of recurrent tumors. In conclusion, there are many risk factors affecting postoperative infection after OSCC reconstruction and repair; consequently, medical staff should perform timely preoperative examinations and clinical data analyses in their clinical work in order to gain a full understanding of the tumor size, infiltration depth, preoperative WBC, Alb level, and other indices, while patients with high risk factors should be given increased attention to reduce the occurrence of postoperative infection, in order to improve the quality of treatment and enhance patient prognosis.

This study has some limitations. This was a retrospective study, and although all the data came from the same hospital and were collected by the same group of staff, due to the large time period over which they were collected, the influence of different laboratory testing methods and and drug batches at different time periods on the data cannot be ruled out.

Conclusions

The incidence of postoperative infection after restorative and reconstructive surgery for OSCC deserves the attention of clinicians. For high-risk infected persons, relevant anti-infection measures should be taken early against the infectious source, and the possibility of nosocomial infection should be attached great importance in clinical work. After discharge, patients should also actively do follow-up, education and other related work to reduce the incidence of postoperative infection.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1150/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-1150/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics board of Second Affiliated Hospital of Naval Medical University (No. LCKY2014054) and informed consent was taken from all the patients.

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