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Cost analysis of oral and maxillofacial free flap reconstruction for patients at an institution in China

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Abstract. Free flap transplantation has become a mainstay for the restoration of oral and maxillofacial defects. However, the complexity of the surgical procedure and long hospitalization time result in high hospitalization costs. This study was performed to retrospectively analyse the composition of hospitalization expenses and factors influencing this for 507 patients who underwent oral and maxillofacial free flap transplantation at a representative medical institution in China. The aim was to provide evidence for the reasonable control of expenditure and effective utilization of medical resources, and to gain an indirect reflection of the healthcare model characteristics of public hospitals in China. The average hospitalization cost was found to be US$ 9265 ± 2284. Factors affecting hospitalization expenses were the type of free flap, tracheotomy, postoperative complications, and length of stay. The largest proportion of hospitalization expenses was the cost of materials (44.94%). Although the total hospitalization cost was lower than that in Western countries, the medical burden of patients was higher, and the corresponding medical charges do not fully reflect the value of medical services. We recommend reducing hospitalization expenses and the medical burden by shortening the hospital stay, selecting reasonably priced medical materials, strengthening airway management of patients undergoing tracheotomy, and enhancing the control and treatment of comorbidities in order to reduce the incidence of postoperative complications.

Key words: oral and maxillofacial surgery; free flap reconstruction; hospitalization expenses; medical burden.

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Oral and maxillofacial cancer accounts for over 500,000 cancer diagnoses annually worldwide[1] . In 2015 alone, 48,100 new oral and maxillofacial cancer cases were reported in China[2]. Free flap transplantation has become a mainstay for the restoration of oral and maxillofacial defects in recent years, offering improved vascularity and wound healing, the potential for innervation, tailoring of wound defects, and a wide variety of tissue options[3]. With advancements made and the development of microsurgery

technology and surgical materials, surgical success rates have increased to almost 95–99%[4,5]. Over 600 cases of vascularized free flap transplantation are performed at Peking University School and Hospital of Stomatology each year, with a success rate of 97%[5], making it one of the hospitals with the highest number of cases and the highest success rate in the world.

Healthcare costs in China have increased every year since 2009[6]. Hospitalization expenses related to vascularized free flap transplantation in reconstruction for oral and maxillofacial defects are high owing to the complexity of the surgical procedure and the long hospitalization time. This places an enormous economic burden on the family and society, and this economic burden has an increasing impact on the patient's choice of treatment plan. In this study, a total of 507 surgeries were analyzed retrospectively to study the composition of hospitalization expenses and factors affecting this, with the aim of providing evidence for the reasonable control of expenditure and effective utilization of medical resources for patients, and to gain an indirect reflection of the healthcare model characteristics of public hospitals in China.

Materials and methods

Patients

This retrospective study was approved by the Ethics Committee of Peking University School and Hospital of Stomatology. Adult patients who were hospitalized in the Oral and Maxillofacial Department of Peking University School and Hospital of Stomatology and who received vascularized free flap reconstruction performed by a single surgical team from January 1, 2015, to December 31, 2016, were included in the study. During the study period, this hospital implemented the charge standard released by the government in 1999, and there were no price adjustments. Relevant patient data were collected through a review of their medical records.

Data collection

The demographic characteristics of the patients, including sex and age, were recorded. Comorbidities were diagnosed according to the International Classification of Diseases Tenth Revision (ICD-10). Information related to surgery included the type of free flap, operation time, whether or not blood transfusion was performed, and whether or not a tracheotomy was performed. Free flaps were divided by type into bone tissue flaps and soft tissue flaps: bone tissue flaps included fibula flaps and iliac crest free flaps, whereas soft tissue flaps included anterolateral thigh flaps (ALTFs) and radial forearm free flaps (RFFFs).

Postoperative complications were classified according to the available literature[7,8], including microvascular complications, wound-related complications (e.g., wound infection, haematoma or haemorrhage, seroma, or salivary fistula), respiratory complications (e.g., pulmonary infection or respiratory failure), cardiovascular complications (e.g., heart failure or coronary artery insufficiency), digestive complications (e.g., gastrointestinal bleeding or stress ulcers), and other complications. With regard to the length of stay, the day of admission to the hospital was treated as the first day of hospitalization and the day of discharge was considered as the last day.

Hospitalization expense data were collected. The total cost was divided into surgical and anaesthetic costs, medical material cost (examination, treatment, and surgical materials), nursing cost (nursing treatment cost and electrocardiographic monitoring cost), medicine cost, examination cost (pathology, laboratory tests, radiation, ultrasound, and general examination), and bed cost.

Statistical analysis

Data were inputted into Excel (version 2010; Microsoft Corporation, Redmond, WA, USA) by two operators and analyzed using IBM SPSS Statistics version 19.0 software (IBM Corp., Armonk, NY, USA). In general, continuous variables were described by the mean ± standard deviation, whereas categorical variables were summarized by the number and percentage. Factors impacting hospitalization expenses were analyzed by univariate analysis and multivariate linear regression. Univariate analysis was performed using the independent samples *t*-test, while multivariate linear regression was performed using a stepwise selection procedure to choose the final model. The factors impacting postoperative complications were analyzed using univariate analysis and logistic regression. The univariate analysis was performed using the independent samples *t*-test for continuous variables and the χ^2 test for categorical variables. $P < 0.05$ was considered significant.

Results

Patients

Data collected from 507 patients were used in this study. Among the 507 patients, 369 had malignant tumours (72.8%), 101 had benign tumours (19.9%), 19 required a second repair of a tissue defect (3.7%), and 18 had osteomyelitis (3.6%). According to the type of free flap used, 291 patients were treated with fibula flaps (57.4%), 13 with iliac crest free flaps (2.6%), 122 with ALTFs (24.1%), and 81 with RFFFs (15.9%). All patients stayed in the resuscitation room for the night following the surgery. The average length of stay was 15.65 (±3.85) days, and the average postoperative hospital stay was 9.81 (±2.50) days. Patient characteristics and treatment data are summarized in Table 1.

Postoperative complications

Overall, 90 (17.8%) patients developed postoperative complications (Table 2). Among the patients who suffered microvascular complications, the flap survived in 13 cases, while the flap was lost in 15 cases. Therefore, the incidence of microvascular complications in this study sample was 5.5% (28/507), and the success rate of rescue was 46.4% (13/28). The success rate of free flap transplantation was 97.0% (492/507). Other patients with complications showed improvements after corresponding treatments.

Table 1. Summary of characteristics and treatment data of patients ($N = 507$).

Characteristic	*n* (%), or mean ± SD
Age (years)	49.65 ± 16.48
<45	174 (34.3)
45–64	249 (49.1)
≥65	84 (16.6)
Sex	
Male	310 (61.1)
Female	197 (38.9)
Comorbidity	152 (30.0)
Diabetes	44 (8.7)
Hypertension	112 (22.1)
Heart disease	27 (5.3)
Other	26 (5.1)
Two or more comorbidities	48 (9.5)
Type of free flap	
Soft tissue	203 (40.0)
Bone tissue	304 (60.0)
Tracheotomy	307 (60.6)
Blood transfusion	21 (4.1)
Operation time (min)	378.17 ± 91.81
≤360	242 (47.7)
>360	265 (52.3)
Length of stay (days)	15.65 ± 3.85
≤15	304 (60.0)
>15	203 (40.0)

SD, standard deviation.

Table 2. Summary of postoperative complications ($N = 507$).

Outcome	Number of cases	%
Microvascular complication	28	5.5
Loss of flap	15	3.0
Flap survival	13	2.6
Wound complications	43	8.5
Wound infection	20	3.9
Haematoma/haemorrhage	13	2.6
Seroma	5	1.0
Salivary fistula	5	1.0
Respiratory system	31	6.1
Pulmonary infection	29	5.7
Other	2	0.4
Cardiovascular system	8	1.6
Myocardial infarction	2	0.4
Other	6	1.2
Digestive system	5	1.0
Upper gastrointestinal bleed	3	0.6
Stress ulcer	2	0.4
Other complications	4	0.8
Acute pyelonephritis	1	0.2
Suspected pulmonary embolism	1	0.2
Multiple organ dysfunction	1	0.2
Cerebrospinal fluid leakage	1	0.2
Two or more complications	27	5.3

Hospitalization costs

Table 3 summarizes the total cost of hospitalization and classification costs.

The three major expenses were material cost, surgical and anaesthetic costs, and medicine cost, respectively.

Table 4 presents the results of the univariate analysis of factors that may have affected hospitalization expenses. As observed in Table 4, seven individual factors might have affected the hospitalization cost ($P < 0.05$); these were sex, operation time, type of free flap, whether or not a tracheotomy was performed, the presence of comorbidities, occurrence of postoperative complications, and length of stay.

In the multifactor analysis of hospitalization expenses, the total cost was treated as the dependent variable and the seven aforementioned factors were treated as independent variables. Factors that showed statistical significance in the univariate analysis were further included in a multivariate linear regression analysis. A stepwise selection method was used to screen the primary factors that influenced the total cost. $P < 0.05$ was a selection criterion and $P < 0.10$ was an elimination standard. The variance analysis of this model showed that $F = 49.024$ ($P < 0.001$), indicating that the fitting equation was statistically significant. The determinant coefficient R^2 was 0.407 and the adjusted R^2 value was 0.399, indicating a well-fitting effect (Table 5).

Factors that affected hospitalization expenses of patients were placed in descending order of their contribution, as shown in Table 5: type of free flap, whether or not a tracheotomy was performed, occurrence of postoperative complications, and length of stay.

Logistic regression analysis of postoperative complications

The occurrence of postoperative complications was an independent factor that affected the increase in hospitalization expenses (Table 5). The eight individual factors in Table 4, excepting postoperative complications, were selected for the univariate analysis. Only six factors showed statistical significance in the univariate analysis and these were further included in a logistic regression analysis: age, length of stay, tracheotomy, comorbidity, blood transfusion, and type of free flap. The statistical analysis of factors that may affect postoperative complications showed three high-risk factors for the occurrence of complications: blood transfusion, tracheotomy, and comorbidity (Table 6).

Table 3. Total cost of hospitalization and classification costs.

Variable	Mean (US$)	SD	Median (US$)	Percentage (%)
Material cost	4154	1908	4102	44.94
Surgical and anaesthetic costs	2702	536	2615	29.16
Medicine cost	1126	304	1076	12.15
Examination cost	602	250	564	6.50
Nursing cost	488	231	402	5.26
Bed cost	185	420	76	1.99
Total cost	9265	2284	9106	100.00

Note: The exchange rate of RMB against the US dollar used was the annual average exchange rate in 2016 (6.64:1).

Discussion

Microvascular free flap reconstruction has led to a new era in the treatment of oral and maxillofacial cancer and is now well established as the standard of care in the restoration of oral and maxillofacial defects in several patients. The resource-intensive nature of the surgical procedure itself, along with an often complicated and prolonged inpatient recovery, contributes to high hospital costs[9]. Surgical treatment of oral and maxillofacial cancer is a significant economic burden on the healthcare system as well as on the patients' families. In an era of increasing awareness regarding healthcare costs and efforts to limit healthcare expenditure, efficient use of healthcare budgets has become paramount.

The proportion of individual personal medical expenses in per capita disposable income is an important index to evaluate the medical burden of local residents[10]. Studies have reported a proportion of personal health expenditure for residents in per capita disposable income of >40%, which would lead to catastrophic health expenditure[11]. In the present study, the average hospitalization cost for patients who received free flap transplantation was US$ 9265 ± 2284, representing 2.6 times the Chinese per capita disposable income (US$ 3587.50) in 2016[12]. Previous studies revealed that in Western countries, the average cost for patients with oral and maxillofacial malignancies receiving free flap transplantation ranged from US$ 10,292 to US$ 56,294[7,13,14], which accounts for 24–187% of the disposable income of local residents. The results indicate that in comparison with similar surgeries in Western countries, although the overall cost of such cases was lower than that in Western countries, the medical burden of patients was higher.

The government can reimburse a certain proportion of the cost. In China, medical insurance provided by the government has various forms, e.g., socialized medicine,

Table 4. Univariate analysis of hospitalization expenses.

Variable		Total cost and mean (US$)	*t*/*F*	*P*-value
Age (years)	<45	8980		
	45–64	9273		
	≥65	8828	1.687	0.186[a]
Sex	Male	9346		
	Female	8662	3.377	0.001
Comorbidity	No	8932		
	Yes	9427	−2.084	0.038
The type of free flap	Soft tissue	7790		
	Bone tissue	9942	−11.976	<0.001
Tracheotomy	No	8541		
	Yes	9336	−5.434	<0.001
Blood transfusion	No	8933		
	Yes	9069	−1.124	0.274
Length of operation (min)	≤360	8633		
	>360	9489	−4.116	<0.001
Postoperative complications	No	8867		
	Yes	10,072	−3.819	<0.001
Length of stay (days)	≤15	8756		
	>15	9567	−3.081	0.002

[a] Univariate analysis of variance.

Table 5. Multiple linear regression analysis of factors affecting hospitalization expenses.

Variable	β	SE	Standardized coefficient	*t*	*P*-value
(Constant)	1958.8	788.1			
Type of free flap (bone tissue relative to soft tissue)	2337.0	162.2	0.511	14.411	<0.001
Tracheotomy	891.0	168.6	0.194	5.285	<0.001
Postoperative complications	1028.4	213.5	0.175	4.817	<0.001
Length of stay (days)	99.1	20.8	0.170	4.756	<0.001

SE, standard error.

Table 6. Logistic regression analysis of factors affecting postoperative complications. .

Variable	β	SE	OR	*P*-value
(Constant)	−2.295	0.302		
Blood transfusion	1.900	0.481	6.686	<0.001
Tracheotomy	1.035	0.293	2.815	<0.001
	0.662	0.250	1.939	0.008

SE, standard error; OR, odds ratio.

urban resident basic medical insurance, and a new rural co-operative medical system. Owing to regional economic imbalances and differences between urban and rural areas, the conditions of medical insurance reimbursement differ in different regions. The actual coverage of medical insurance ranges from 57.74% to 63.86%[15,16]. However, the proportion of actual reimbursement for the medical insurance population ranges from 42% to 67%[17,18]. In 2015, the Chinese National Health and Family Planning Commission put forward and established a unified medical insurance system for urban and rural residents, further enlarging medical insurance coverage and increasing the proportion of reimbursement[19].

In this study, material cost occupied a major proportion of expenses (44.94%) among the hospitalization expenses. Intraoperative internal fixation devices including vascular staplers, titanium plates, and titanium nails were expensive. These three parts alone accounted for 74.6% of the total material cost. Possible reasons for the high proportion of material cost could be as follows.

First, the cost of the material itself is high. When selecting materials for medical use, patients are more willing to choose imported materials for their advantages in terms of performance and quality. However, imported materials are more expensive owing to factors such as tariffs, research and development costs, intellectual property rights, and circulation links[20]. The price of any material is decided based on strict rules and procedures. Although it is impossible to change the prices of materials, patients and operators could choose more cost-effective medical materials through comprehensive evaluation and screening in order to reduce the total cost.

The second possible reason is charging standards. To elaborate, it is commonly believed internationally that surgical and anaesthetic costs and nursing costs are the items that can best reflect the value of medical services provided by medical personnel. Therefore, these two items cost the most in the patients' hospitalization expenses. Considering patients who undergo oral and maxillofacial cancer surgery as an example, the nursing cost in the USA constitutes 36.4%, surgical and anaesthetic costs constitute 27.3%, and the material cost constitutes 15.4%, whereas the surgical and anaesthetic costs, nursing cost, and material cost of such surgeries performed in India were 56.56%, 19.98%, and 9.95%, respectively[21,22]. These findings indicate that surgical and anaesthetic costs as well as the nursing cost constitute the two major components of the total hospitalization cost. However, in the present study, surgical and anaesthetic costs (29.16%) as well as the nursing cost (5.26%) were relatively low, the total of these accounting for a lower proportion of expenses than the medical material cost. These findings are consistent with reports of the proportions of hospitalization expenses for other diseases in China[12]. This reflects the overall low cost of medical services in China, which is an important problem under the current system of Chinese public hospitals[15]. Therefore, the medical reform released by the Chinese National Health and Family Planning Commission in 2016 has proposed reducing the proportions of medicine cost and material cost and to further improve the standards for surgery and nursing costs so that the value of medical services provided is better reflected[23].

Factors that affected the hospitalization expenses of patients included the type of free flap, whether or not a tracheotomy was performed, the occurrence of postoperative complications, and the length of stay (Table 5). An analysis of how these four related factors affected hospitalization expenses is outlined below.

Type of free flap

Costs were significantly higher for patients who received repairs with bone tissue flaps than for those who received soft tissue flaps . This is primarily associated with the additional surgical procedures, including osteotomy and shaping, required for bone tissue flaps, as well as the increased operation time, which further increases surgical and anaesthetic costs. In addition, materials used in bone tissue flaps such as titanium plates, titanium nails, and other internal fixation devices accounted for 51.7% of the total cost, far higher than the 34.3% material cost for soft tissue flaps; this was the primary factor that caused changes in cost.

Whether or not a tracheotomy was performed

A preventive tracheotomy was performed in oral and maxillofacial surgery patients to prevent postoperative tissue swelling and organ shifts that cause upper respiratory obstruction[24]. Incision of the trachea results in a direct connection between the airway and the external environment, making it susceptible to bacterial intrusion. In addition, patients undergoing such a procedure are required to stay in bed for several days (because of special posture requirements) and cannot produce sputum in a timely and effective manner, which can increase the occurrence of postoperative complications such as pulmonary infection, bleeding, and cervical subcutaneous emphysema[25]. In the present study, the incidence of pulmonary infections in patients undergoing tracheotomy was high, accounting for 89.7% of postoperative pulmonary infections. Taken together, the surgical cost, related nursing cost, cost of antibacterial medications, and the additional cost of treating postoperative complications increases patient hospitalization expenses[25]. Therefore, more effective airway management should be implemented in patients undergoing tracheotomy in order to reduce the occurrence of postoperative complications and further decrease hospitalization expenses.

Occurrence of postoperative complications

Based on the available literature, the incidence of postoperative complications in patients receiving oral and maxillofacial free flap transplantation ranges from 34.1% to 74%[8,21,26]. Among these, microvascular complications and pulmonary infection are important factors in increasing the length of hospital stay, as well as the total hospitalization cost[7,27]. In the present study, the incidence of postoperative complications was 17.8%, and three high-risk factors were identified for the occurrence of complications: blood transfusion, tracheotomy, and comorbidity (Table 6).

On further analysis of two of these factors that affect postoperative complications, besides tracheotomy, the following was found. First, with regard to blood transfusion, a total of 21 patients (4.1%) underwent blood transfusions, and blood transfusion was an independent factor influencing postoperative complications, consistent with previous reports[8]. Patients who received a blood transfusion were more prone to postoperative complications often because of excessive surgery, massive blood loss during surgery, and an increased operation time. Moreover, blood transfusion in itself could increase the incidence of postoperative complications. Studies have demonstrated that blood transfusion stimulates neutrophil degranulation in patients with an excessive and intense cytokine response, resulting in tissue damage in recipients and reduced levels of immune response[28], along with an increased risk of infections and postoperative complications[29].

Second, with regard to comorbidity, previous studies have shown that the incidence of comorbidities in patients who have undergone similar surgeries ranges from 36.4% to 88.9%[26,30–32]. In the present study, the rate of comorbidity was 30.0%, which is relatively lower than rates reported in the available literature. This could be explained by the fact that the average age of the patients in this study was 49.65 ± 16.48 years, and only 16.6% were aged >65 years; thus, most patients were young and middle-aged, and young and middle-aged patients are associated with a low comorbidity rate compared with the more aged. Although comorbidity was not an independent factor for hospitalization expenses in this study, it was an independent factor for increased postoperative complications, consistent with a previous report[8]. Therefore, preoperative management should be focused on the control and treatment of previous comorbidities.

Length of stay

A previous study revealed that length of stay is the primary factor for and has a positive correlation with hospitalization expenses[33], which implies that effective control of the hospital stay could reduce hospitalization expenses[9]. Studies have reported that the average length of stay of patients who receive oral and maxillofacial free flap transplantation ranges from 15.4 to 22.9 days[9,13]. In the present study, this average was closer to the lower limit of the range (15.65 days); in particular, the postoperative hospital stay was only 9.81 days, but the preoperative length of stay was 6.75 days, which is higher than that of similar patients globally.

There are two possible reasons for this phenomenon: (1) for patients who are admitted under governmental medical insurance, expenses during hospitalization are paid by Medicare proportion[34], i.e., these patients enjoy medical insurance payments only if they complete surgery-related diagnosis and treatment during hospitalization (e.g., pathological diagnosis, preoperative examination, surgical follow-up treatment, and sutures). This is significantly different from the standards followed in Western countries[35]. Moreover, the domestic literature shows that the mean length of stay of patients who use governmental medical insurance is longer than that of patients staying at their own expense[36]. (2) At present, despite the three-grade medical system in China, there is a lack of community health care institutions and related extension services. A majority of patients in this study were non-local, and some patients were discharged only after postoperative suture removal and disease recovery owing to safety concerns, which prolonged their length of stay. Thus, hospitalization procedures could be improved and the preoperative hospital stay shortened, perioperative enhanced recovery after surgery (ERAS) could be developed[37], and effective referrals could be implemented to further reduce the hospital stay[38].

This study was subject to certain limitations . It was a retrospective and single-centre study. Patients undergoing free flap transplantation may continue paying after discharge due to the occurrence of complications and subsequent treatments[14,39]. However, this study aimed to analyze the expenses during hospitalization, which cannot fully reflect the medical burden of such patients.

Based on the findings of this study, patients undergoing oral and maxillofacial free flap transplantation bear a heavy medical burden, and the corresponding medical charges do not fully reflect the value of

the medical services. We recommend reducing hospitalization expenses and the medical burden by further shortening the hospital stay, particularly the preoperative hospital stay, selecting reasonably priced medical materials, strengthening airway management of patients undergoing tracheotomy, and enhancing the control and treatment of previous comorbidities in order to reduce the incidence of postoperative complications.

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Competing interests

There is no conflict of interest.

Ethical approval

Ethical approval obtained from Peking University School and Hospital of Stomatology Biomedical Institutional Review Board (PKUSSIRB-201733015).

Patient consent

Not required.

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