



# Risk of Microvascular Anastomosis Performed in Previously Treated Neck

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## 치료력이 있는 경부에서 시행되는 미세문합술의 안정성

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**Background and Objectives** This study aimed to determine if a microvascular anastomosis on the neck, which had previously been treated, increases the risk of early complications, such as flap failure or hemorrhage and venous congestion that necessitates re-exploration.

**Subjects and Method** A retrospective review was conducted on 274 cases of tumor resection with simultaneous free flap reconstruction from 2005 to 2019. Flap failure and re-exploration rate was evaluated according to the clinical variables including treatment history of recipient vessels.

**Results** Twenty-one (7.7%) cases of flap failure were identified and re-exploration was conducted in 51 (18.6%) cases. Although the failure rate appeared to be high when micro-anastomosis was performed in the neck, where neck dissection with radiotherapy was previously performed (22.7%), there was no statistical significance compared with no previous treatment group. Previous neck dissection with irradiation was found to influence re-exploration {odds ratio (OR)=3.674 [95% confidence interval (CI) 1.348–10.014,  $p=0.011$ ] } compared to no treatment. However, previous radiotherapy or surgery only did not show any significant difference compared to the untreated group. Venous congestion was the most common cause of re-exploration (50.1%), followed by hematoma (33.3%), and previous neck dissection with radiotherapy increased the risk of both [OR for venous congestion=3.056 (95% CI 1.009–9.255),  $p=0.048$ , OR for hematoma=6.286 (95% CI 1.679–23.526),  $p=0.006$ ] compared with no previous treatment. Radiotherapy alone did not change the risk of early complication.

**Conclusion** Micro-anastomosis in a previously treated neck is feasible in terms of flap failure. However, micro-anastomosis in a neck, where neck dissection with radiotherapy were performed, may be more likely to cause complications such as venous congestion and hematoma that necessitate re-exploration.

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## Introduction

Concurrent chemoradiation therapy (CCRT) or organ pre-

serving surgery with adjuvant treatment have been frequently used as an initial treatment in head and neck cancer,<sup>1,2)</sup> because of better functional outcome and a lower rate of acute complications than radical surgery.<sup>3)</sup> However, with the increase of CCRT or organ preserving surgery, salvage surgery after failure of initial treatment is increasing and surgery is

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becoming more important for the treatment of recurrent or residual cancer.<sup>4)</sup> Wide excision to achieve clear margins is important not only in primary but also in salvage surgery, and free flap surgery is the gold standard in the reconstruction of large surgical defects. Although the overall success rate of free flaps in the head and neck is known to be high,<sup>5-9)</sup> microvascular anastomosis in a previously treated neck will be technically more difficult to accomplish than normal condition but increasingly required for recurrent or residual cancer. When the flap's survival is uncertain, rapid re-exploration is important. The overall unplanned reoperation rates after free flap surgery are known to range from 18.0% to 20.0%<sup>10-14)</sup> and there are cases where free flaps are rescued through re-exploration, but there are cases where the rescue fails and the flaps are finally lost. The overall unplanned reoperation rates after free flap surgery are known to range from 18.0% to 20.0%,<sup>10-14)</sup> but there is a lack of accurate analysis of the risk of early complications, such as hemorrhage or venous congestion that necessitate immediate re-exploration, when microvascular anastomosis is performed in the neck where previous treatments such as radiation therapy (RT) or surgery have been performed. Given that unplanned reoperation for flap salvage is a burden to patients and surgeons and result in a prolonged hospital stay and increased health care costs, the identification of risk factors of flap failure or re-exploration is important for treatment. Previous studies have shown that reoperation after free flap surgery is associated with comorbidities such as smoking, hypertension, and prolonged operation time.<sup>10-14)</sup> In addition, the direct causes of reoperation and failure of free flaps include thrombosis, and the most important factor in the development of thrombosis is the technical ability of the surgeon.<sup>8,15)</sup> There have been study on the effects of previous treatment on flap outcome through comparison between salvage surgery and primary surgery, there was no statistically significant effect.<sup>16)</sup> But no studies have subdivided the previous treatment, the risk of performing microvascular anastomosis in the context of previous RT or surgery was not analyzed. As such, the aim of this study is to identify the risk factors for early complications, such as flap failure and re-exploration, and causes that required re-exploration after the microvascular anastomosis, especially previous treatments such as neck dissection or RT, using a single surgeon's data.

## Subjects and Methods

### Patients

This study constituted a retrospective review of consecutive cases where tumor resection and free flaps are performed simultaneously in the head and neck between January 2005 and August 2019. All surgeries were performed by a single surgeon. We excluded patients younger than 18 years and those who underwent tumor resection and free flap reconstruction more than twice. Patient characteristics, perioperative data, and re-exploration data were collected from the medical records. Patient characteristics and perioperative data included patient age, sex, cardiovascular disease, diabetes mellitus, smoking, body mass index (BMI), reconstruction site, donor site, previous irradiation, history of surgery at the anastomosis site, size of the removed mass, operation time, and cause of re-exploration. The Institutional Review Board of Seoul National University approved this retrospective study of medical records (IRB No. H-2002-076-1101).

The patients were grouped according to the previously treated condition of site of recipient vessels used for anastomosis, not by the previously treated condition of the reconstruction site. Even if the free flap was performed in salvage cases, if the microvascular anastomosis is performed in the context of no previous treatment, like contralateral neck or superficial temporal or external carotid which is higher than previous treatment field or internal mammary artery which is lower than treatment field is regarded as surgery in the field of no previous treatment. Patients were categorized into groups based on BMI according to the World Health Organization's definition of overweight and obese ( $>25.0 \text{ kg/m}^2$ ). Primary tumor site was categorized into oral cavity and oropharynx including salivary gland origin cancers (buccal, alveolar ridge, retromolar trigon, floor of mouth, palate, tongue, tonsil, posterior pharyngeal wall, mandible), larynx and hypopharynx and esophagus, maxilla (maxilla, sinus), ear (external auditory canal and auricle). Because it was a retrospective study, we could not get accurate data on free flap size. Instead, the size of the surgical specimen of the primary tumor was used. The duration of operation was categorized as less than either 12 hours or greater than 12 hours.

### Statistical analysis

Univariate analyses were performed using the chi-squared and Fisher's exact tests to correlate outcomes and categorical variables. All free flaps performed in each patient were ana-

alyzed independently. All perioperative variables were analyzed for a correlation with flap failure and re-exploration. Variables with  $p \leq 0.05$  on univariate analyses were included in the multiple logistic regression analysis.  $p$ -values  $< 0.05$  were considered statistically significant. All calculations were performed using SPSS ver. 13.0 (SPSS Inc., Chicago, IL, USA).

## Results

### Outcome of free flap

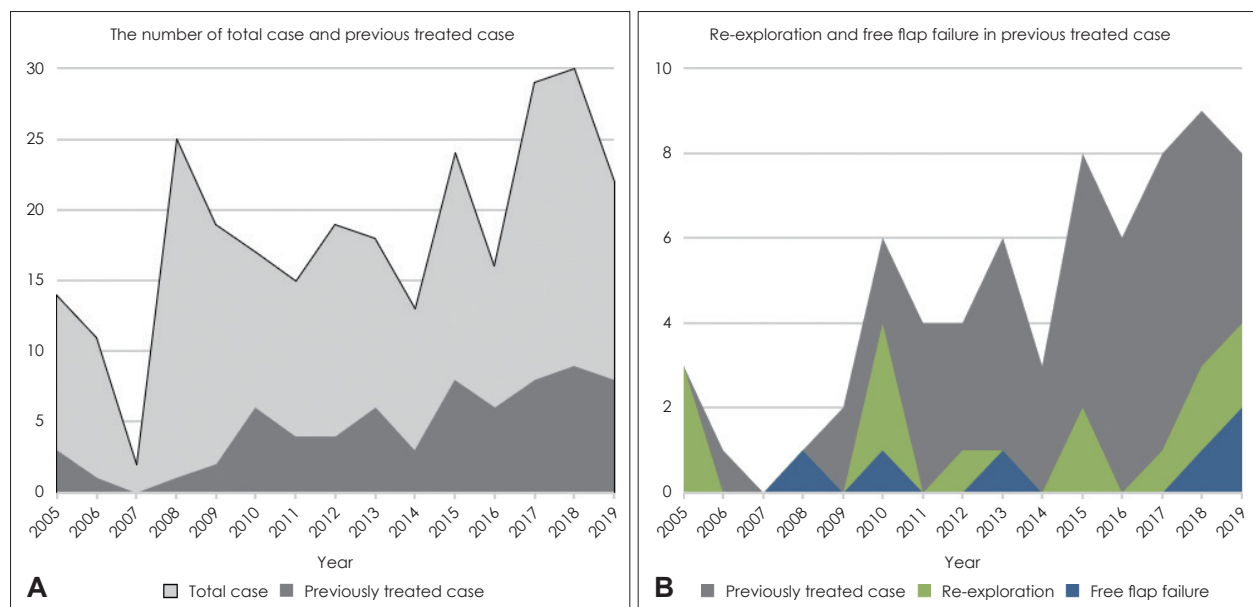
A total of 274 patients who underwent simultaneous tumor resection and free flap reconstruction surgery of the head and neck were included. Fig. 1A shows the number of cases per year and the increasing number and proportion of cases of previous treatment such as neck dissection or RT at the anastomosis site. Free flap failure occurred in 21 cases (7.7%), and in 6 cases (8.7%) of 69 patients who had previously undergone neck dissection or radiotherapy at the anastomosis site, and 15 (7.3%) of 205 patients who had not received previous treatment at the anastomosis site. Re-exploration was performed in 51 cases (18.6%); 20 cases (29.0%) of 69 patients who had previously received neck dissection or RT at the anastomosis site and 31 (15.1%) of 205 patients who had not received previous treatment at the anastomosis site. In the year when there was a lot of microvascular anastomosis in the site where surgery or radiotherapy had previously been performed, there was a tendency that reoperation was performed more

frequently (Fig 1B). The demographic data of patients in the untreated and previously treated group are shown in Table 1 and the patients in the previously treated group showed a lower rate of overweight or smoking. And more larynx, hypopharynx or esophagus patients were included. A total of 69 patients had previous treatment history at the site of the microvascular anastomosis. Among them, 52.2% received radiotherapy, 15.9% received neck dissection, and 31.9% received both radiotherapy and neck dissection.

### Variables related to free flap failure or re-exploration

Free flap failure occurred in 21 of the 274 cases in total (7.7%). No significant correlation was found between demographics, comorbidities, reconstruction site and flap failure (Table 2). Analysis according to the donor site showed that failure of radial free forearm free flap did not occur at all and the failure rate was higher in the case of reconstruction with a flap that is rarely used like scapular, iliac crest, and rectus abdominis flap. Although the failure rate appeared higher in microvascular anastomosis in patients previously treated both by neck dissection and RT (22.7%) than other groups (0–7.3%), there was no statistically significant difference according to the previous treatment at the anastomosis site ( $p=0.053$ ).

Of the 274 patients, 51 underwent re-exploration after free flap reconstruction because of the risk of flap compromise. The results of the univariate analysis of variables related to



**Fig. 1.** Cases per year. Total number of free flap cases and microvascular anastomosis in previously treated neck (A), Number of microvascular anastomosis in previously treated neck, Re-exploration, and flap failure per year (B).

**Table 1.** Demographic according to the treatment history of neck where micro-anastomosis is performed

Variables	Untreated neck (n=205)	Previously treated neck (n=69)	p-value
Mean age (range)	59 (23–85)	61 (20–75)	0.160
Male:female	146:59	55:14	0.168
BMI > 25	52 (25.4)	9 (13.0)	0.033
Current smoker	35 (17.1)	4 (5.8)	0.020
Systemic disease			
Cardiovascular disease	78 (38.0)	18 (26.1)	0.072
Diabetes	40 (19.2)	11 (16.0)	0.510
Primary lesion			0.026
Oral cavity, salivary gland, oropharynx	160 (78.0)	47 (68.1)	
Larynx, hypopharynx, esophagus	27 (13.2)	19 (27.5)	
Maxilla	12 (5.8)	3 (4.3)	
Ear	6 (2.9)	0 (0.0)	
Pathology			0.676
SCC	172 (83.9)	62 (89.9)	
Salivary origin (MEC, ACC, AdC)	19 (9.2)	3 (4.3)	
Sarcoma	5 (2.4)	1 (1.4)	
Others	9 (4.4)	3 (4.3)	
Tumor classification			0.072
T1 or T2	108 (52.7)	27 (39.1)	
T3 or T4	91 (44.4)	37 (53.6)	
Unspecific	6 (2.9)	5 (7.2)	
Previous treatment			
RT/CCRT		36 (52.2)	
Neck dissection		11 (15.9)	
Neck dissection with RT/CCRT		22 (31.9)	

Data are presented as n (%). BMI: body mass index, SCC: squamous cell carcinoma, MEC: mucoepidermoid carcinoma, ACC: adenoid cystic carcinoma, AdC: adenocarcinoma, RT: radiation therapy, CCRT: concurrent chemoradiation therapy

re-exploration are listed in Table 2. The rate of re-exploration was significantly higher in patients in whom microvascular anastomosis was performed in the context of previous treatment ( $p=0.004$ ), size of the resected tumor greater than 10 cm in largest diameter ( $p=0.001$ ) and the operation time exceeded 12 hours ( $p=0.003$ ). Subsequently, the multiple logistic regression analysis showed that more than 12 hours of surgery {odds ratio (OR)=2.648 [95% confidence interval (CI) 1.256–5.737,  $p=0.014$ ]} and neck dissection with RT [OR=3.674 (95% CI 1.348–10.014,  $p=0.011$ )] at the anastomosis site were independent risk factors for re-exploration (Table 3). The risk of re-exploration or flap failure in patients who received only one treatment, either radiotherapy or surgery, showed no difference when compared with no previous treatment group.

### Causes of re-exploration

Venous congestion was the most common cause of re-exploration (26 cases, 50.1%), followed by hematoma (17 cases, 33.3%). Salvage surgery was successful in 53.8% of cases of

venous congestion and 88.2% of cases of hematoma (Table 4). In the univariate analysis for the risk of each complication, venous congestion showed a tendency to occur more frequently in patients whose microvascular anastomoses were performed in previously operated terrain, with or without RT (22.7% in with RT, 18.2% without RT); but showed statistically borderline significance ( $p=0.050$ ). The arterial crisis showed no statistical relationship with any variable and hematoma occurred more frequently in female and in cases where microvascular anastomosis was performed on previously treated terrain and resected mass greater than 10 cm in largest diameter (Table 5). In the logistic regression analysis, previous neck dissection with irradiation at the anastomosis site increased the risk of venous congestion [OR=3.056 (95% CI 1.009–9.255,  $p=0.048$ )] and hematoma [OR=6.286 (95% CI 1.679–23.526,  $p=0.006$ )] compared to no previous treatment. In addition, previous neck dissection only group at the anastomosis site also showed a higher risk of hematoma [OR=6.286 (95% CI 1.140–34.699,  $p=0.035$ )] compared to the no previous treatment group (Table 6).

**Table 2.** Univariate analysis of factors for free flap failure and re-exploration

Variables	Flap failure (n=21)		Re-exploration (n=51)	
	n (%)	p-value	n (%)	p-value
Age		0.765		0.445
≤ 60 (n=126)	9 (7.1)		21 (16.7)	
> 60 (n=148)	12 (8.1)		30 (20.3)	
Sex		0.760		0.121
Male (n=201)	16 (8.0)		33 (16.4)	
Female (n=73)	5 (6.8)		18 (24.7)	
BMI		0.480		0.810
BMI > 25 (n=61)	4 (6.6)		12 (19.7)	
BMI ≤ 25 (n=213)	17 (8.0)		39 (18.3)	
Current smoker (in 28 days)		0.161		0.223
Yes (n=39)	5 (12.8)		10 (34.4)	
No (n=235)	16 (6.8)		41 (17.4)	
Cardiovascular disease		0.154		0.488
Yes (n=96)	10 (10.4)		20 (20.8)	
No (n=178)	11 (6.2)		31 (17.4)	
Diabetes		0.211		0.844
Yes (n=51)	2 (3.9)		9 (17.6)	
No (n=223)	19 (8.5)		42 (18.8)	
Reconstruction site		0.086		0.253
Oral cavity, oropharynx (n=207)	14 (6.8)		40 (19.3)	
Larynx, hypopharynx, esophagus (n=46)	3 (6.5)		6 (13.0)	
Maxilla (n=15)	4 (26.7)		5 (33.3)	
Ear (n=6)	0 (0)		0 (0)	
Donor site		0.069		0.110
ALTf/RFFF (n=191)	10 (5.2)		29 (15.2)	
Fibular/scapular/iliac crest flap (n=62)	8 (12.9)		16 (25.8)	
LD/rectus abdominis flap (n=19)	3 (14.3)		6 (31.6)	
Jejunal flap (n=2)	0 (0)		0 (0)	
Previous treatment at anastomosis site		0.053		0.004
No (n=205)	15 (7.3)		31 (15.1)	
RT/CCRT only (n=35)	1 (2.8)		6 (16.7)	
Neck dissection only (n=11)	0 (0)		4 (36.4)	
Neck dissection with RT/CCRT (n=22)	5 (22.7)		10 (45.5)	
Operation time (hour)		0.090		0.003
> 12 hours (n=43)	6 (14.0)		15 (34.9)	
≤ 12 hours (n=231)	15 (6.5)		36 (15.6)	
Removed mass (large diameter)		0.455		0.001
> 10 cm (n=32)	3 (9.4)		13 (40.6)	
≤ 10 cm (n=242)	18 (7.4)		38 (15.7)	

BMI: body mass index, ALTf: anterolateral thigh flap, RFFF: radial forearm free flap, LD: latissimus dorsi flap, RT: radiation therapy, CCRT: concurrent chemoradiation therapy

## Discussion

CCRT and organ preserving surgery with adjuvant treatment have been preferred as initial treatment because they outperform radical surgery in functional outcomes and complications.<sup>1-3)</sup> As a result, more cases of salvage surgery are required,

and the number of cases of salvage surgery seems to be also increasing in this study, and microvascular anastomosis at sites which had previously undergone neck dissection and/or RT are likely to lead to early complications and re-exploration. In our study, the overall free flap success rate was 92.3%, which is similar to the previous literature reports, which range from

**Table 3.** Multiple logistic regression analysis of factors for re-exploration

Variable	Adjusted OR	95% CI	Adjusted p-value
Operation time (hour) > 12 hrs	2.648	1.256–5.737	0.014
Removed mass (large diameter) > 10 cm	2.231	0.916–5.438	0.077
Previous treatment at anastomosis site			
No	Reference		
RT/CCRT only	1.093	0.411–2.907	0.858
Neck dissection only	2.116	0.522–8.569	0.294
Neck dissection with RT/CCRT	3.674	1.348–10.014	0.011

RT: radiation therapy, CCRT: concurrent chemoradiation therapy, OR: odds ratio, CI: confidence interval

**Table 4.** Causes of re-exploration

Cause	Number of cases	Salvage (%)	Failure (%)
Venous congestion	26	14 (53.8)	12 (46.2)
Arterial crisis	8	1 (12.5)	7 (87.5)
Hematoma	17	15 (88.2)	2 (11.8)
Total	51	30 (58.8)	21 (41.2)

85% to 98%.<sup>5-9)</sup> Up to 18.6% of patients underwent a re-exploration after free flap reconstruction, which is also similar to reoperation rate in free flap reconstruction surgery of head and neck reported by previous studies.<sup>11,12)</sup> Previous studies have shown that several factors are associated with reoperation and free flap failure, such as previous treatment at the anastomosis site, cardiovascular diseases such as hypertension, angina pectoris, arteriosclerosis, and diabetes.<sup>8,10,13,15)</sup> However, in the head and neck, few authors have confirmed that the previous treatment is a risk factor for re-exploration after free flap reconstruction.<sup>11,14)</sup> The identification of the risk of performing microvascular anastomosis in previously treated neck can help surgeons better consult with patients and make such risks predictable. In the present study we analyzed the free flap reconstruction performed by a single surgeon to reduce the bias due to the differences between surgeons.

Many medical factors, such as comorbidities including cardiovascular disease, diabetes, obesity, and smoking history, may influence re-exploration and flap success.<sup>17,18)</sup> However, in the present study, there was no significant correlation between age, sex, cardiovascular disease, diabetes mellitus, smoking, obesity, and re-exploration and free flap failure.

There have been some papers that compared the success rate of free flaps by donor site. Nakatsuka, et al.<sup>19)</sup> have shown that flap survival rate for radial forearm, rectus abdominis, and jejunum flaps is significantly better than that of other flaps in a series of 2372 head and neck free flap reconstructions. However, Zhou, et al.<sup>20)</sup> have concluded that there is

statistically significant difference between the success rates in fibula flap, anterolateral thigh flap, and radial forearm flap groups. In our series, reconstruction with a flap that is rarely used like scapular, iliac crest and rectus abdominis flaps had higher failure and re-exploration rates and the surgeon's familiarity for the flap may be an important factor influencing flap failure or re-exploration. Also, our analysis showed that surgery duration of more than 12 hours was an independent risk factors for re-exploration [OR=1.253 (95% CI 1.253–6.666,  $p=0.013$ )]. A prolonged anesthesia may set off a longer tissue ischemia, resulting in anoxic injuries.<sup>21)</sup> Prolonged anesthesia also requires more fluid supply during surgery. Large amounts of crystalloid supplies during surgery also are associated with free flap complications.<sup>22)</sup> Wong, et al.<sup>23)</sup> have concluded that operative time is also significantly associated with increased risk for free flap failure in a study including 778 free flap operations. However, the prolonged operation time in this series may mean surgery with larger resection and complex reconstruction as these data are from a single surgeon and the meaning may be that difficult surgeries have a higher risk of re-exploration.

The main focus of this research was the effect of previous treatment in the field of microvascular anastomosis. As the RT is used frequently as primary treatment in many head and neck cancers, the influence of RT on the microvascular anastomosis became an issue in salvage surgeries. Radiotherapy is known to causes damage to blood vessels, which can cause blood flow reduction and thrombus formation and affect the outcome of the flap.<sup>24)</sup> However the effect of previous irradiation at the anastomosis site on free flap failure remains controversial. Significant correlations between flap failures and previous RT in excess of total 60 Gy have been reported,<sup>25-27)</sup> but a study by Zhao, et al.<sup>14)</sup> did not confirm the statistical relationship between radiotherapy within 30 days prior to surgery and reoperation. Further, in a study by Bengtson, et al.,<sup>28)</sup> there was no significant difference in the incidence of total



**Table 5.** Univariate analysis of factors for cause of re-exploration

Variable	Venous congestion (n=26)		Arterial crisis (n=8)		Hematoma (n=17)	
	n (%)	p-value	n (%)	p-value	n (%)	p-value
Age		0.221		1.000		0.927
≤ 60 (n=126)	9 (7.1)		4 (3.2)		8 (6.3)	
> 60 (n=148)	17 (11.5)		4 (2.7)		9 (6.1)	
Sex		0.369		0.443		0.004
Male (n=201)	21 (10.4)		5 (2.5)		7 (3.5)	
Female (n=73)	5 (6.8)		3 (4.1)		10 (13.7)	
BMI		0.916		0.382		0.771
BMI > 25 (n=61)	6 (9.8)		5 (2.3)		3 (4.9)	
BMI ≤ 25 (n=213)	20 (9.4)		3 (4.9)		14 (6.6)	
Current smoker (in 28 days)		0.232		1.000		0.718
Yes (n=39)	6 (15.4)		1 (2.6)		3 (7.7)	
No (n=235)	20 (8.5)		7 (3.0)		14 (6.0)	
Cardiovascular disease		0.212		1.000		0.616
Yes (n=96)	12 (12.5)		3 (3.1)		5 (5.2)	
No (n=178)	14 (7.9)		5 (2.8)		12 (6.7)	
Diabetes		0.433		0.645		0.531
Yes (n=51)	3 (5.9)		2 (3.9)		4 (7.8)	
No (n=223)	23 (10.3)		6 (2.7)		13 (5.8)	
Reconstruction site		0.454		0.101		0.750
Oral cavity, oropharynx (n=207)	22 (10.6)		6 (2.9)		12 (5.8)	
Larynx, hypopharynx, esophagus (n=46)	2 (4.3)		0 (0)		4 (8.7)	
Maxilla (n=15)	2 (13.3)		2 (13.3)		1 (6.7)	
Ear (n=6)	0 (0)		0 (0)		0 (0)	
Donor site		0.379		0.379		0.459
ALTf/RFFF (n=191)	15 (7.9)		4 (2.1)		10 (5.2)	
Fibular/scapular/iliac crest flap (n=62)	8 (12.9)		3 (4.8)		5 (8.1)	
LD/rectus abdominis flap (n=19)	3 (15.8)		1 (5.3)		2 (10.5)	
Jejunal flap (n=2)	0 (0)		0 (0)		0 (0)	
Previous treatment at anastomosis site		0.050		0.862		0.004
No (n=205)	18 (8.8)		6 (2.9)		7 (3.4)	
RT/CCRT only (n=35)	1 (2.8)		1 (2.8)		4 (11.1)	
Neck dissection only (n=11)	2 (18.2)		0 (0)		2 (18.2)	
Neck dissection with RT/CCRT (n=22)	5 (22.7)		1 (4.5)		4 (18.2)	
Operation time (hour)		0.150		0.114		0.158
> 12 hours (n=43)	7 (16.3)		3 (7.0)		5 (11.6)	
≤ 12 hours (n=231)	19 (8.2)		5 (2.2)		12 (5.2)	
Removed mass (large diameter)		0.204		0.237		0.008
> 10 cm (n=32)	5 (15.6)		2 (6.3)		6 (18.8)	
≤ 10 cm (n=242)	21 (8.7)		6 (2.5)		11 (4.5)	

BMI: body mass index, ALTf: anterolateral thigh flap, RFFF: radial forearm free flap, LD: latissimus dorsi flap, RT: radiation therapy, CCRT: concurrent chemoradiation therapy

free flap loss patients that received preoperative radiotherapy (5.3%) and those who did not (5.0%). In our analysis, microvascular anastomosis in terrains, where only RT had been performed, did not significantly increase the risk of flap failure or re-exploration. Although the risk of hematoma requiring re-exploration showed tendency to be higher than that of un-

treated necks [OR=3.536 (95% CI 0.979–12.767,  $p=0.053$ )], the risk of venous congestion was not affected by RT.

In contrast, the risk of re-exploration was significantly higher in patients earlier treated with both neck dissection and RT in whom microvascular anastomosis is performed. However, in case of previous neck dissection and RT, although the

**Table 6.** Logistic regression analysis of previous treatment for cause of re-exploration

	Venous congestion			Hematoma requiring re-exploration		
	Crude OR	95% CI	p-value	Crude OR	95% CI	p-value
No	Reference			Reference		
RT/CCRT only	0.297	0.038–2.296	0.245	3.536	0.979–12.767	0.054
Neck dissection only	2.309	0.463–11.512	0.307	6.286	1.140–34.699	0.035
Neck dissection with RT/CCRT	3.056	1.009–9.255	0.048	6.286	1.679–23.526	0.006

RT: radiation therapy, CCRT: concurrent chemoradiation therapy, OR: odds ratio, CI: confidence interval

rate of flap failure was higher than in other groups, did not show any statistically significant difference in the risk of flap failure. In patients with a history of previous neck surgery, the formation of scar tissue and the vascular condition can affect the outcome of free flaps. In a study by Zhou, et al.,<sup>20)</sup> patients who had previous neck surgery (21.4%) had significantly higher failure rates than those who did not (2.7%) ( $p=0.007$ ). In our study, the most common cause of re-exploration was venous congestion, and more venous congestion occurred in patients who received both neck dissection and radiotherapy before reconstruction surgery. Furthermore, hematoma was the second most common cause (33.3%) of re-exploration, and previous neck dissection with or without RT influenced the development of hematoma requiring re-exploration. Previous neck dissection significantly increased the incidence of hematoma, which may be due to the restriction of drain position due to the pedicle and vascular condition affected by the previous surgery, or the scar tissue and the vascular condition may have been more affected by the postoperative enoxaparine.

As in any retrospective review, this study had some limitations. the database does not contain detailed information on the previous treatment, pedicle status, so we were unable to study these items together as variables.

In conclusion, the flap failure rate did not increase significantly with microvascular anastomosis in previously treated patients, but re-exploration was frequently performed in patients who previously received both neck dissection and RT. In particular, venous congestion and hematoma, the most common causes of re-exploration, were more common in patients who previously underwent both neck dissection and RT. Microvascular anastomosis in the context of previous RT did not increase the risk of flap failure or re-exploration and seemed to be performed safely. Therefore, microvascular anastomosis in previously treated necks, especially those previously treated with RT only, looks feasible without increasing the risk of flap failure. However, the surgeon should check the previous treatment history of the patient and be aware that microvas-

cular anastomosis in the neck where both neck dissection and radiotherapy were performed earlier may be more likely to cause venous congestion or hematoma. In the case of patients with history neck dissection and radiotherapy, careful intraoperative hemostasis and technique are required, and postoperative management should also be taken care of with the higher possibility of re-exploration.

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### Author Contribution

Conceptualization: Soon-Hyun Ahn. Data curation: Se Jin Hyun. Formal analysis: all authors. Funding acquisition: Soon-Hyun Ahn. Methodology: Se Jin Hyun. Project administration: Se Jin Hyun. Resources: Soon-Hyun Ahn. Supervision: Soon-Hyun Ahn. Validation: Soon-Hyun Ahn. Visualization: Se Jin Hyun. Writing—original draft: Se Jin Hyun. Writing—review & editing: all authors.

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