Magnitude of Myocutaneous Flaps and Factors Associated With Loss of Volume in Oral Cancer Reconstructive Surgery

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Purpose: Myocutaneous flaps are often used to repair oral and maxillofacial defects after surgery for oral cancer; however, their volume decreases during the postoperative period. To facilitate treatment planning, the authors measured the extent of such postoperative flap volume loss and identified associated factors in patients who underwent oral reconstruction with myocutaneous flaps.

Materials and Methods: The authors designed and performed a retrospective observational study of patients who underwent reconstructive procedures involving rectus abdominal myocutaneous (RAM) or pectoralis major myocutaneous (PMMC) flaps at Tokai University Hospital, Kobe University Hospital, or Nagasaki University Hospital from April 2009 through March 2013. Flap type and other clinical variables were examined as potential predictors of flap loss. The primary outcome was flap loss at 6 months postoperatively. Correlations between each potential predictor and the primary outcome were examined using multiple regression analysis.

Results: The subjects were 75 patients whose oral defects were reconstructed with RAM flaps (n = 57) or PMMC flaps (n = 18). RAM flaps exhibited a mean volume shrinkage of 22% at 6 months postoperatively, which was less than the 27.5% displayed by the PMMC flaps, but the difference was not important. Renal failure, previous surgery of the oral region, postoperative radiotherapy, and postoperative serum albumin level were found to be meaningful risk factors for postoperative flap volume loss.

Conclusion: The results of this study suggest that larger flaps should be used in patients who possess these risk factors or are scheduled to undergo postoperative radiotherapy. Future studies should examine the utility of postoperative nutritional management for preventing flap volume loss.

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Oral cancer represents approximately 1 to 3% of all human cancers and is the sixth most common cancer around the world.[1,2] National Comprehensive Cancer Network guidelines for oral cancer state that surgery is the standard treatment for resectable oral cancer, and postoperative radiotherapy or concurrent chemoradiotherapy is strongly recommended for patients whose surgical specimens exhibit risk factors, such as a microscopic positive surgical margin or extracapsular invasion of lymph node metastases during histologic examinations.[3] Regarding surgical procedures, simple resection of the tumor is

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used for early-stage cancer, and reconstructive surgery also is performed in advanced stage cases to minimize functional and esthetic problems. A large proportion of tissue defects produced by resection of oral tumors require reconstruction with a myocutaneous flap.

Surgical flaps can be classified as pedicle flaps and free flaps,[4] and pectoralis major myocutaneous (PMMC) flaps (a type of pedicle flap) and rectus abdominal myocutaneous (RAM) flaps (a type of free flap) are frequently used during surgery for head and neck cancer. It is well recognized that transplanted flaps, including pedicle and free flaps, shrink after a relatively short period and thus must be larger than the target defect, although the optimal size is unclear. In a study of RAM flaps, Kiyokawa et al[5] stated that the length and width of the flap should be 20% larger than the defect, whereas Kimata and Sakuraba[6] reported that flaps should be approximately 30% wider than the target defect.

In addition, Joo et al[7] suggested that free radial forearm free flaps should be at least 40% larger than the target defect. Thus, the optimal flap size for treating oral defects remains an important issue in reconstructive surgery. The authors previously reported that RAM flaps decrease in volume by approximately 24% by 12 months postoperatively and that postoperative radiotherapy might affect the degree of postoperative shrinkage in flap volume.[8] However, no other factors related to the postoperative change in flap volume have been identified. The purpose of this study was to clarify postoperative volume changes exhibited by myocutaneous flaps and identify predictors of postoperative shrinkage in flap volume. The authors hypothesized that flap volume loss would be associated with factors related to the peripheral circulation or nutritional status of the recipient site. To the best of the authors' knowledge, no previous studies have examined the postoperative shrinkage in flap volume in a large number of patients who underwent head and neck reconstructive surgery involving myocutaneous flaps. The specific aims of this retrospective study were to compare postoperative volume changes exhibited by pedicle type myocutaneous flaps (PMMC flaps) and free myocutaneous flaps (RAM flaps) and to clarify the factors associated with the degree of postoperative shrinkage in flap volume.

Materials and Methods

To meet the study aims, the authors designed and performed a retrospective observational study. The study population was composed of all patients who underwent reconstructive surgical procedures involving myocutaneous flaps to repair defects produced during resection of oral tumors at Tokai University Hospital (Kanagawa, Japan), Kobe University Hospital (Kobe, Japan), or Nagasaki University Hospital (Nagasaki, Japan) from April 2009 through March 2013. To be eligible for the study, patients had to undergo flap reconstruction with a PMMC or RAM flap. Patients were excluded if they did not undergo computed tomography (CT) or magnetic resonance imaging (MRI) examination at 1 and 6 months postoperatively. Flap size was measured on CT or MRI scans with a slice interval no larger than 5 mm. In a preliminary study, the authors confirmed there were no differences in flap loss measurements obtained with CT and MRI. During the examinations, the position of the patient's head was fixed so that the Camper plane was perpendicular to the floor. At 1 month postoperatively (baseline), the maximal dimensions of the CT or MRI slice in which the flap area was largest were measured. A region of interest (ROI) that exhibited suitable contrast between the flap and normal structures was chosen by ROI selection software, and then fat and muscle tissue were identified semi-automatically.[8,9] A 2-dimensional measurement method was adopted because measuring the 3-dimensional volume of PMMC flaps was considered inappropriate owing to the difficulty of distinguishing between the pedicle and the skin paddle. A second set of measurements was obtained using the same method and tissue slices at 6 months postoperatively (Fig 1). The mean values recorded by 2 oral and maxillofacial surgeons were used for analysis.

Various clinical factors were examined as possible predictors of postoperative change in flap volume. The primary outcome was the change in flap volume. The candidate predictor variables were *1)* demographic factors (age and gender); *2)* flap types (PMMC and RAM); *3)* factors associated with the patient's general condition (body mass index [BMI], diabetes mellitus [DM], preoperative serum albumin level, serum albumin level at 4 weeks postoperatively, and renal failure); and *4)* treatment factors (primary site, previous surgery of the oral region, history of radiotherapy, surgical site infections [SSIs], marginal flap necrosis, and postoperative radiotherapy). Correlations between each variable and flap loss were analyzed using the Mann-Whitney *U* test, and multivariate analysis was performed using multiple regression analysis. The study was performed according to the Declaration of Helsinki on medical protocols and was approved by each hospital's institutional review board.

Results

Forty-eight patients were male and 27 were female. Patients' ages ranged from 12 to 89 years (mean 68.3 yr). PMMC and RAM flaps were used in 18 and 57 procedures, respectively. By 6 months postoperatively, the flaps had decreased to 76.0% of their

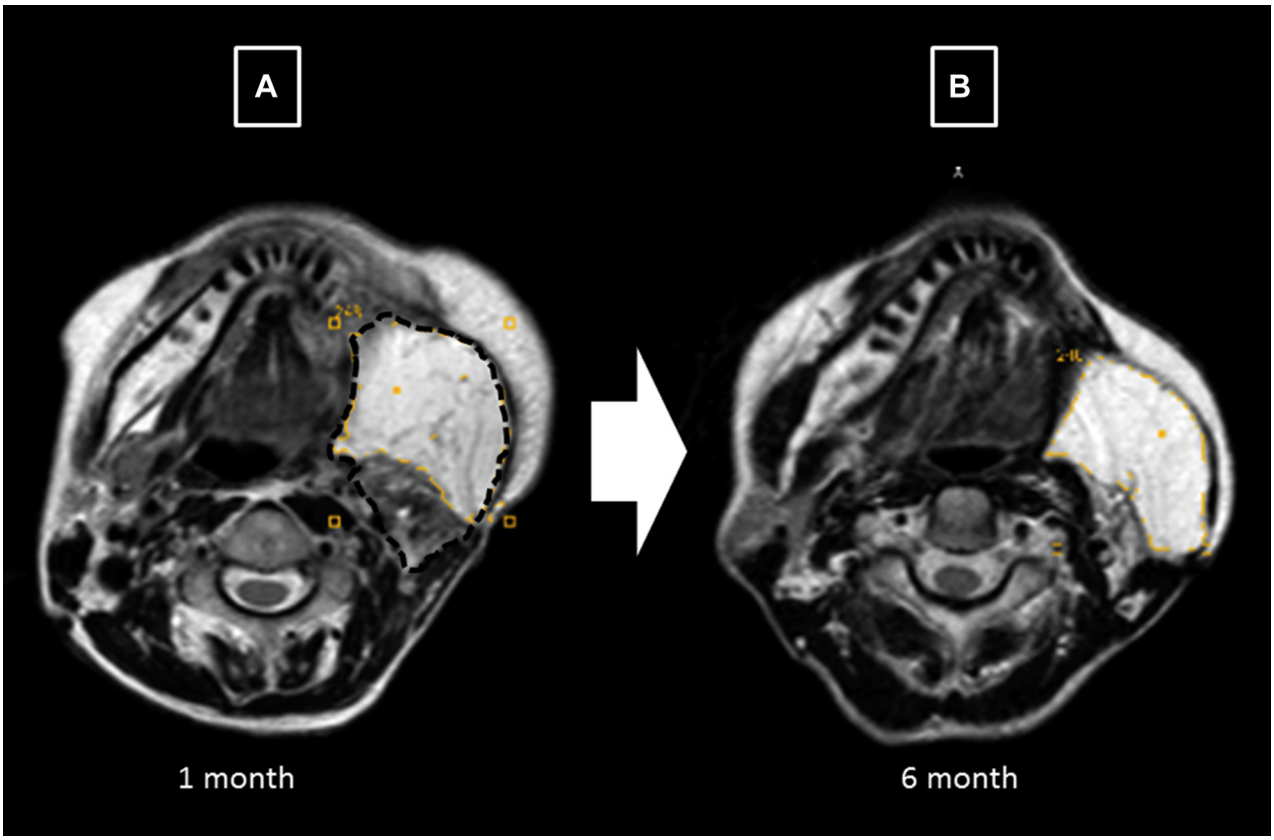

FIGURE 1. Measurement of flap area. The slice in which the area of the flap was largest was chosen. After the region of interest had been selected by the selection software, the dimensions of the flap were calculated. *A*, Image obtained at 1 month postoperatively. *B*, Image acquired at 6 months postoperatively showing shrinkage of the flap.

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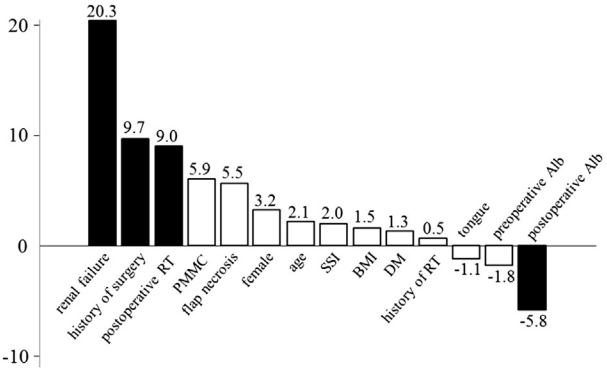

FIGURE 2. Multiple regression coefficients for each risk factor. Four factors (renal failure, previous surgery of the oral region, postoperative radiotherapy, and serum albumin level at 4 weeks postoperatively) were meaningfully associated with the degree of postoperative flap volume loss. Alb, albumin; BMI, body mass index; DM, diabetes mellitus; PMMC, pectoralis major myocutaneous; RAM, rectus abdominal myocutaneous; RT, radiotherapy; SSI, surgical site infection.

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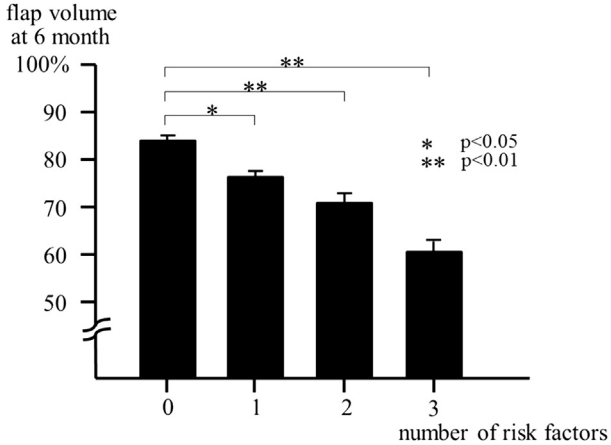

FIGURE 3. Relation between number of risk factors and flap size at 6 months postoperatively. Patients who had at least 1 risk factor for postoperative flap volume loss exhibited substantially larger decreases in flap volume than those who did not display any risk factors.

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baseline size. The RAM flaps exhibited a 22.9% shrinkage, which was less than the 27.5% displayed by the PMMC flaps, but the difference was not important.

Among the factors examined, renal failure, previous surgery of the oral region, postoperative radiotherapy, and serum albumin level at 4 weeks postoperatively were meaningfully correlated with the degree of flap loss (Fig 2). Figure 3 shows the multiple regression coefficients for each factor. Renal failure, previous surgery of the oral region, and postoperative radiotherapy exhibited strong positive correlations with flap shrinkage, whereas serum albumin level at 4 weeks postoperatively displayed a strong negative correlation with flap shrinkage. Other factors, such as flap type, marginal flap necrosis, gender, age, SSI, BMI, DM, history of radiotherapy, the primary site, and preoperative albumin level, exhibited minor correlations with the extent of postoperative flap volume loss (Table 1). Figure 3 shows the relation between the number of risk factors present and flap size at 6 months postoperatively. Flap size decreased as the number of risk factors increased. Meaningful differences in flap size were detected between patients who did not display any risk factors for postoperative flap volume loss and those who had at least 1 risk factor.

Discussion

Surgery is the standard treatment for oral cancer, and patients who are at high risk of recurrence are recommended to undergo postoperative radiotherapy or concurrent chemoradiotherapy.[3] Reconstructive surgery is necessary after the resection of advanced-stage oral cancer to minimize esthetic and functional disorders. Recently, the development of microsurgery has enabled surgeons to choose various types of surgical flaps for repairing defects produced during the resection of oral tumors. Surgical flaps can be divided into pedicle flaps and free flaps.[4] RAM flaps, a type of free myocutaneous flap, are generally selected for reconstructing large soft tissue defects,[10] although PMMC flaps, a type of pedicle myocutaneous flap, are sometimes used for this purpose, especially in patients who have risk factors that are not compatible with the use of free flaps, such as old age, a poor performance status, or complications. The purpose of this study was to measure postoperative volume changes exhibited by myocutaneous flaps and identify factors that influence the postoperative shrinkage in flap volume. As a result, different variables were found to influence the degree of postoperative flap loss.

After surgery, myocutaneous flaps, including free and pedicle flaps, usually shrink over several months, and this can result in esthetic or functional disorders, although the mechanisms responsible for such

Table 1. FACTORS RELATED TO FLAP SHRINKAGE

Factors	Patients, n	Flap Shrinkage at 6 mo After Surgery, %	*P* Value
Flap type			.069
RAM	57	22.9	
PMMC	18	27.5	
Age (yr)			.391
≥70	34	24.9	
<70	41	23	
Gender			.247
Male	48	23.8	
Female	27	24.4	
Primary site			.665
Tongue or floor of mouth	30	23.8	
Others	45	24.2	
BMI (kg/m^2)			.540
≥22	42	26.7	
<22	33	21.9	
Albumin preoperatively			.612
≥35 mg/dL	11	23.2	
<3.5 mg/dL	64	25.8	
Albumin 4 wk after surgery			.029
≥3.0 mg/dL	26	22.4	
<3.0 mg/dL	49	27.1	
Diabetes			.750
Absent	65	23.2	
Present	10	29.7	
Renal failure			.001
Absent	71	23.2	
Present	4	38.2	
Previous surgery of oral region			.013
Absent	64	23.2	
Present	11	28.7	
History of radiotherapy			.407
Absent	46	22.4	
Present	29	26.7	
Surgical site infection			.407
Absent	46	22.4	
Present	29	26.7	
Marginal necrosis of flap			.141
Absent	63	22.5	
Present	12	31.8	
Postoperative radiotherapy			.0005
Absent	35	20.6	
Present	40	27	

Abbreviations: BMI, body mass index; PMMC, pectoralis major myocutaneous; RAM, rectus abdominal myocutaneous.

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changes are poorly understood, and no standard prophylaxis against flap loss has been developed. The blood flow of RAM flaps exhibits an axial pattern. In contrast, the blood flow of PMMC flaps displays axial and random patterns, and PMMC flaps tend to exhibit poor blood circulation at their margins, which can result in partial necrosis. In the present study, postoperative shrinkages of RAM and PMMC flaps were investigated. RAM flaps and PMMC flaps had shrunk by 22.9 and 27.5%, respectively, by 6 months postoperatively, although the difference in extent of volume shrinkage between the 2 flap types was not important.

Then, factors that might be associated with postoperative flap shrinkage were investigated. The authors previously reported that postoperative radiotherapy affected the degree of the postoperative shrinkage in flap volume.[8] However, no other factors have been associated with the postoperative change in flap volume. Among the factors examined in the present study, renal failure, previous surgery of the oral region, serum albumin level at 4 weeks postoperatively, and postoperative radiotherapy were shown to be risk factors for a decrease in myocutaneous flap (RAM or PMMC) volume. In addition, the present analysis showed that the decreases in flap volume seen in patients who had at least 1 risk factor were substantially greater than those observed in patients who did not exhibit any of these risk factors. These risk factors seem to be related to the peripheral circulation or nutritional status of the recipient site. Thus, such issues might induce hypoxic conditions, resulting in microcirculatory dysfunction and flap shrinkage. Other factors that were considered related to the microcirculation, such as partial flap necrosis, SSI, DM, and a history of radiotherapy, showed tendencies toward associations with postoperative flap volume loss. The weakness of the associations exhibited by these factors might have been due to the small numbers of patients who displayed these factors.

Cho et al[11] reported that at 24 months postoperatively free anterolateral thigh (ALT) flaps and PMMC flaps exhibited mean volume decreases of 24.8 and 10.8%, respectively. Similarly, Yamaguchi et al[12] found that RAM and ALT flaps displayed a mean final total volume of 82.2%. In contrast, Peleg et al[13] found that PMMC flaps had shrunk by 37% at 6 months postoperatively, and Fujioka et al[14] detected a mean total volume loss of 19.9% among RAM, ALT, and free forearm flaps. Using MRI, the authors previously investigated the cases of 21 patients who underwent oral cancer surgery combined with reconstruction involving a RAM flap and found that the mean decrease in flap volume at 12 months postoperatively was 24%.[8] The variation in the degree of flap volume loss reported in these studies seemed to be due to differences in the patients' background data. The factors associated with flap volume loss are disputed. Joo et al[7] detected a positive correlation between postoperative radiotherapy and postoperative change in flap volume. In contrast, Cho et al[11] and Chatterjee et al[15] reported that postoperative radiotherapy was not associated with the postoperative decrease in flap volume. Joo et al[7] examined various factors, such as age, gender, smoking, alcohol consumption, DM, the primary site, flap shape, and flap size, but did not detect any relations between these parameters and postoperative flap volume loss. However, their study was based on a retrospective analysis of 18 patients who underwent reconstructive surgery using free forearm flaps.

The present study indicates that in patients who possess risk factors for postoperative flap shrinkage or are scheduled to undergo postoperative radiotherapy, larger flaps should be used, and strict nutritional management is important during the perioperative period because it helps to avoid decreases in flap volume. However, this is a retrospective, nonrandomized study with a small sample, and the modalities used to measure flap size varied among the institutions involved. Furthermore, some factors that influence the peripheral circulation, such as smoking, alcohol abuse, and certain pre-existing systemic disorders, were not examined in the present study. A larger prospective clinical trial is necessary to clarify the effects of these factors on postoperative flap volume loss.

The results of this study suggest that larger flaps should be used in patients who exhibit peripheral circulation-related risk factors for postoperative flap volume loss, such as renal failure or previous surgery of the oral region, and in patients who are scheduled to undergo postoperative radiotherapy. In addition, postoperative nutritional management is important for preventing postoperative flap volume loss.

References

1. Jemal A, Bray F, Center MM, et al: Global cancer statistics 2011. CA Cancer J Clin 61:69, 2011
2. Warnakulasuriya S: Global epidemiology of oral and oropharyngeal cancer. Oral Oncol 45:309, 2009
3. NCCN guidelines version 2. Head and neck cancer 2013. Available at: http://www.nccn.org/professionals/physician_gls/f_guidelines.asp#site. Accessed November 26, 2015.
4. Wong CH, Wei FC: Microsurgical free flap in head and neck reconstruction. Head Neck 32:1236, 2010
5. Kiyokawa K, Tai Y, Inoue Y: Functional reconstruction of swallowing and articulation after total glossectomy without laryngectomy: Money pouch-like reconstruction method using rectus abdominis myocutaneous flap. Plast Reconstr Surg 104:2015, 1999
6. Kimata Y, Sakuraba M: Analysis of the relations between the shape of the reconstructed tongue and postoperative functions after subtotal or total glossectomy. Laryngoscope 113:905, 2003
7. Joo YH, Hwang SH, Sun DI, et al: Assessment of volume changes of radical forearm free flap in head and neck cancer: Long-term results. Oral Oncol 47:72, 2011
8. Sakamoto Y, Takahara T, Ota Y, et al: MRI analysis of chronological changes in free-flap volume in head and neck reconstruction by volumetry. Tokai J Exp Clin Med 39:44, 2014

9. Chityala R, Hoffmann KR, Bednarek DR, et al: Region of interest computed tomography. Proc Soc Photo Opt Instrum Eng 5368: 534, 2011
10. Yokoo S, Komori T, Furudoi S, et al: Indications for vascularized free rectus abdominis musculocutaneous flap in oromandibular region in terms of efficiency of anterior rectus sheath. Microsurgery 23:96, 2003
11. Cho KJ, Joo YH, Sun DI, et al: Perioperative clinical factors affecting volume changes of reconstructed flaps in head and neck cancer patients: Free versus regional flaps. Eur Arch Otorhinolaryngol 268:1061, 2011
12. Yamaguchi K, Kimata Y, Onoda S, et al: Quantitative analysis of free flap volume changes in head and neck reconstruction. Head Neck 34:1403, 2012
13. Peleg M, Sawatari Y, Lopez EA: Assessment of the functionality of the pectoralis major myocutaneous flap skin paddle. Craniofac Surg 22:365, 2011
14. Fujioka M, Masuda K, Imamura Y: Fatty tissue atrophy of free flap used for head and neck reconstruction. Microsurgery 31:32, 2011
15. Chatterjee JS, Lee A, Anderson W, et al: Effect of postoperative radiotherapy on autologous deep inferior epigastric perforator flap volume after immediate breast reconstruction. Br J Surg 96:1135, 2009