noninvasive, no significant difference was discovered. In the present case, the skull was apparently destructed and the dura was visibly thin with multiple defects, while the tumor mass was of rather small size and did not even have direct contact with the bone. Immunohistochemical analysis showed positive MMP-9 expression by some tumor cells, whereas MMP-2 expression was negative. Restricted to a very small tumor volume, the authors could hardly do much more research. However, it is reasonably assumed that the tumor caused destruction during its growing process by secreting certain substances associated with skull and dura mater catabolism, directly or indirectly. Few studies to date have investigated the relationship between meningioma and molecules associated with bone metabolism, and further research is needed in this area.

Osteolytic behavior often strongly infers malignant or atypical types of meningiomas as contended by many authors,[15–17] and in an earlier study the researchers even argued all osteolytic meningiomas had malignant features.[18] But this doctrine has changed as more and more benign meningiomas with osteolytic characteristics have been reported.[11,13,19,20] In this case as well, the tumor turned out to be a World Health Organization (WHO) grade I benign meningioma, although it caused significant bone osteolysis and had no distinct boundary from the brain tissue.

Surgical resection remains the optimum therapy for benign meningiomas. It could be questionable in this case to remove the osteolytic bone, since there appeared to be no direct contact between the tumor and the bone. Ichimura et al[19] reported a meningioma presenting radiologically as an osteolytic lesion in the right parietal bone that exactly resembled the current case. No tumor mass was found in the operation, but histological examination showed cells of microcystic meningioma in the internal part of the defective bone. Therefore, Simpson grade I resection is recommended for osteolytic meaningless if possible, that is macroscopic complete tumor resection with removal of affected dura and bone, which is associated with good recurrence/progression free survival.[21]

CONCLUSIONS

It is very rare that a meningioma situated at the convexity of the brain does not have a dura attachment and causes osteolysis of the skull. Knowledge of this case is crucial for clinicians to be aware of this entity because it can be easily confused with bone tumors. Further research is required to explore the association between meningioma and bone metabolism, to better understand the mechanism of osteolysis.

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OPEN

Examination of Suprahyoid Muscle Resection and Other Factors Affecting Swallowing Function in Patients With Advanced Oral Cancer After Surgical Resection and Reconstruction

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Abstract: Dysphagia is one of the most common adverse effects associated with oral cancer therapy and could greatly impair postoperative quality of life. The objective of this study was to analyze postoperative swallowing outcomes and factors influencing postoperative swallowing function in patients with advanced oral cancer who underwent primary reconstruction after surgical resection to identify patients at risk of experiencing severe dysphagia after immediate reconstruction of surgical defects, and to determine an ideal approach to provide appropriate perioperative interventions. The swallowing status was evaluated at 4 week postoperatively using the Functional Oral Intake Scale. We also analyzed the effects of patient, tumor, surgical, and other factors on postoperative swallowing function. The study included 67 patients. At 4 weeks postoperatively, 11 patients showed reduced swallowing function, whereas 56 patients showed good swallowing function. The number of resected suprahyoid muscles (odds ratio, 1.55; 95% confidence interval, 1.03–2.32; $P=0.035$) was an independent factor influencing postoperative swallowing function. Thus, among patients who underwent radical resection of oral cancer with primary reconstruction, those with extensive resection of the suprahyoid muscles were at higher risk of developing postoperative dysphagia. These findings are expected to facilitate increased vigilance for dysphagia, better counseling, and appropriate rehabilitation interventions.

Key Words: Dysphagia; oral cancer, quality of life;, swallowing

Oral cancer is often diagnosed at an advanced stage (stage 3 or 4),[1] and surgical treatment plays a central role in radical therapy. As control of cervical lymph-node metastasis affects the prognosis of advanced oral cancer, neck dissection is widely performed. Moreover, depending on factors, such as the extent of tumor progression and lymphatic flow, a pull-through operation that removes neck dissection tissue and the primary lesion en bloc may be indicated. Reconstructive surgery is performed after resection in cases with large defects. Advancements in free-flap reconstruction methods have helped improve the survival rates by allowing more extensive resections, whereas reduction of muscle atrophy and fibrosis of the surrounding tissue has helped improve postoperative disability in many cases.[2] In addition, the safety, functionality, and esthetics of pedunculated flaps, such as the temporalis and buccinator muscle flaps, have been confirmed, and it has become possible to select a reconstruction method according to the patient's condition, defect site, and defect area.[3,4] However, dysphagia after surgery for advanced oral cancer is not uncommon, despite the advancements in surgical styles.

Dysphagia is one of the most common adverse effects associated with oral cancer therapy. Normal swallowing involves complex interlocking movements of the oral cavity, pharynx, larynx, and esophagus. Food and liquids must pass through the esophagus without refluxing into the nasopharyngeal cavity or entering the trachea. Oral cancer therapy can temporarily or permanently damage some or many of these functions, resulting in dysphagia, which imposes long-term limitations on oral feeding. Such patients require alternative nutritional pathways, such as a nasogastric tube, gastric fistula, or intravenous hyperalimentation, all of which have a major influence on postoperative quality of life (QOL) and patient return to society. Postoperative swallowing function is considered the most important QOL-related concern for patients with head and neck cancer.[5,6] Factors reported to affect swallowing function after head and neck cancer surgery include the tumor size, tongue resection range, patient's age, reconstruction method, and use of radiation therapy [7–11] (Supplemental Digital Content, Table 1, http://links.lww.com/SCS/E216). However, these results are not specific to oral cancer, and because of the large number of complex processes involved in swallowing, these procedures have not been standardized. Good swallowing function may be achieved with extensive excision of the tongue base; conversely, severely impaired swallowing function may result in cases with a small area of excision. Therefore, we considered the possibility that factors not reported thus far may have an effect. It has long been considered that the movement of the hyolaryngeal complex has an important effect on swallowing function. Surgery for oral cancer often involves excision of the suprahyoid muscles, which control these functions; however, this factor has not been previously considered. Identification of cases prone to experiencing prolonged dysphagia is very important to provide sufficient counseling before surgery and appropriate interventions such as perioperative rehabilitation. To identify patients with oral cancer who will experience severe dysphagia after immediate reconstruction of surgical defects and to determine an ideal approach to provide appropriate perioperative interventions, we assessed the swallowing status at 4 weeks postoperatively and examined the effects of various perioperative factors, including the effect of resection of the suprahyoid muscles.

MATERIALS AND METHODS

Patients

We retrospectively examined patients with oral cancer who underwent primary reconstruction immediately after radical surgery at the Department of Oral and Maxillofacial Surgery of

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Nara Medical University Hospital between June 2016 and April 2020. Only primary cases were included; all other cases were excluded. This study was approved by the Nara Medical University Ethics Committee on September 8, 2020 (approval number 2736).

Treatment for the Patients

During surgical resection of oral cancer, all patients who underwent primary reconstruction also underwent tracheostomy, along with neck dissection, depending on the state of cervical lymph-node metastasis. For the primary lesion, we used a pull-through operation based on the progression range and lymphatic flow, and free-flap reconstruction was used for maxillary, mandibular, and soft-tissue defects. Once the patient showed sufficient recovery of the cough reflex after the operation, the tracheostomy cannula was changed to an uncuffed cannula. At this point, the first swallowing endoscopy was performed to assess whether oral feeding could resume. If oral intake could not be resumed, swallowing rehabilitation was added. Subsequently, swallowing endoscopy or the modified barium swallow study was performed again for evaluation.

Swallowing training was introduced before surgery, and based on the examination findings, various procedures, such as posture, manipulation, change in bolus amount and viscosity, range of motion exercise, and strengthening exercise, were modified.

Swallowing Function Evaluation

In this study, we evaluated the degree of swallowing-function improvement at 4 weeks postoperatively, when postoperative adjuvant therapy was considered. At this point, we also examined the perioperative factors that could affect reduced swallowing function. Regarding swallowing training, we intervened before the operation and continued after the operation according to the examination findings.

Swallowing function at 4 weeks postoperatively was assessed using the Functional Oral Intake Scale (FOIS).[12] The FOIS is frequently used to evaluate the swallowing function of patients with head and neck cancer.[13,14] In this scale, levels 1 to 3 correspond to dependence on tube feeding, whereas levels 4 to 7 indicate total oral feeding with no dependence on tube feeding but with different food shapes (Supplemental Digital Content, Table 2, http://links.lww.com/SCS/E216). In the present study, patients with scores of 1 to 3 constituted the group with insufficient recovery of swallowing function, whereas those with scores of 4 to 7 constituted the group with good recovery of swallowing function. We statistically analyzed each factor to determine significant differences between the groups.

The following factors were extracted from medical and surgical records: age, sex, Eastern Cooperative Oncology Group Performance Status (PS) and preoperative physical status as per the American Society of Anesthesiologists (ASA) classification as patient factors; site of primary lesion, TNM classification (Union for International Cancer Control's, 8th edition), and stage as tumor factors; and neck dissection (unilateral or bilateral), number of resected suprahyoid muscles (left–right mylohyoid muscles, digastric muscle anterior and posterior bellies, stylohyoid muscle, and geniohyoid muscle), presence or absence of tongue resection, maxillary and mandibular resection, and the flap used for reconstruction (free anterolateral thigh flap, free forearm flap, free fibular flap, and other flap) as surgical factors.

Statistical Analysis

EZR version 1.37 [15] was used for statistical analysis. Student *t* test, the Mann-Whitney U test, and Fisher exact test were used to compare the factors assessed with the FOIS at 4 weeks postoperatively. Factors that showed statistically significant differences in the univariate analysis were entered as explanatory variables in the logistic regression analysis. $P < 0.05$ was considered to indicate a statistically significant difference.

RESULTS

The study included 70 patients with oral cancer. From these, 3 secondary cases were excluded, leaving 67 patients for analysis. Included were 37 men and 30 women with a mean age of 68.4 years (range, 18–89 y). Forty-seven, 16, and 4 patients exhibited PS (performance status) 0, PS 1, and PS 2, respectively, whereas 6, 58, and 3 patients exhibited ASA 1, ASA 2, and ASA 3, respectively.

The primary tumor site was the tongue in 22 patients, mandible in 24 patients, buccal mucosa in 7 patients, maxillary gingiva in 10 patients, and floor of the mouth in 4 patients. Eleven, 13, 43, 13, 23, 22, 9, 3, 11, and 53 cases showed T2, T3, T4, N0, N1, N2b, N2c, stage 2, stage 3, and stage 4 tumors, respectively (Supplemental Digital Content, Table 3, http://links.lww.com/SCS/E216).

Neck dissection was unilateral in 50 cases and bilateral in 17 cases. The number of suprahyoid muscles resected ranged from 0 to 6, with a mean of 2.13. Tongue resection was performed in 29 cases and not performed in 38 cases. Marginal mandibulectomy was performed in 8 cases, more than segmental mandibulectomy was performed in 23 cases, and not mandibulectomy was performed in 36 cases. Maxillectomy was performed in 10 cases, and no maxillectomy was performed in 57 cases. The flap used for reconstruction was a free anterolateral thigh flap in 31 cases, free fibular flap in 22 cases, free forearm flap in 10 cases, and other flap in 4 cases.

The mean timing of the first postoperative swallowing endoscopy was 12.4 days (range, 6–30 d). The mean time to beginning of oral feeding was 17.6 days (7–61 d), and the mean time to withdrawal of tube feeding was 20.7 days (9–63 d).

At 4 weeks postoperatively, 11 patients had insufficient recovery of swallowing function (FOIS 1–3) and 56 patients had good recovery of swallowing function (FOIS 4–7) (Fig. 1).

Analysis of the factors showed significant differences in preoperative PS ($P < 0.001$) among the patient factors and T classification ($P = 0.039$) among the tumor factors. Among the surgical factors, postoperative swallowing function differed significantly depending on the number of suprahyoid muscle resections ($P = 0.006$). In contrast, no significant differences were observed in unilateral and bilateral neck dissection, presence or absence of tongue resection, maxillary and mandibular resection, or type of flap (Supplemental Digital Content, Table 4, http://links.lww.com/SCS/E216).

This study was conducted 4 weeks after surgery and did not investigate the effects of postoperative radiation therapy. At that time, there were no cases requiring flap weight loss.

Multivariate analysis revealed that the number of resected suprahyoid muscles was an independent factor associated with poor postoperative swallowing function (Supplemental Digital Content, Table 5, http://links.lww.com/SCS/E216).

DISCUSSION

In this study, we analyzed postoperative swallowing outcomes and factors influencing postoperative swallowing function in patients with advanced oral cancer who underwent primary

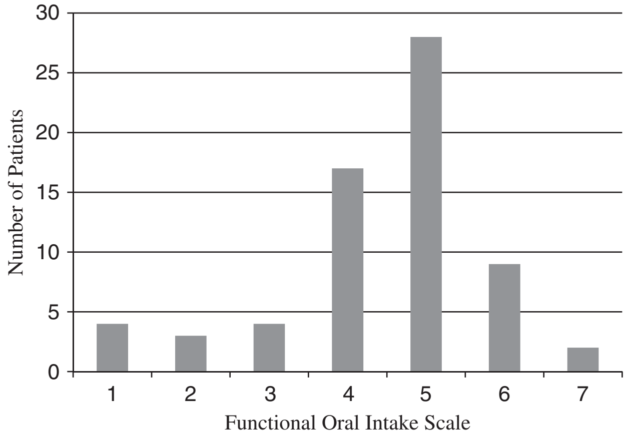

FIGURE 1. Distribution of FOIS scores at 4 weeks postoperatively. FOIS indicates Functional Oral Intake Scale.

reconstruction after surgical resection and found that patients with extensive resection of the suprahyoid muscles were at higher risk of developing postoperative dysphagia.

Assessments of the perceptions of 459 patients with advanced cancer regarding QOL and length of life (LOL) showed that 55% rated QOL and LOL equally, 27% prioritized QOL, and 18% prioritized LOL.[16] Thus, although patients considered cancer control as important, they also emphasized their QOL after treatment.

Although postoperative swallowing function has been found to be the most important QOL concern among patients with oral cancer,[6] a survey of 109 patients with head and neck cancer by Pezdirec et al [17] found that in 40% of the patients, dysphagia interfered with their social life after therapy. Further, of the 45 patients who experienced dysphagia, 80% reported having problems eating in public and 62.2% had problems eating in front of family members, and their QOL was severely damaged by social isolation, the need for tube feeding, and feelings of hopelessness.

In addition, aspiration pneumonia, dehydration, weight loss, poor wound healing, and other issues associated with dysphagia could significantly affect postoperative recovery, delay postoperative treatment, and reduce treatment tolerance. Potential or early postoperative dysphagia has been shown to have a significant impact on overall survival.[10] Therefore, these comorbidities require proper assessment and management and should be prevented whenever possible. It is important to identify risk factors preoperatively, inform patients, and proactively provide interventions such as rehabilitation.

In general, the swallowing process is divided into 3 phases: oral, pharyngeal, and esophageal. The oral phase is completely autonomous and involves putting food in the oral cavity and preparing it for swallowing. Preparing for swallowing involves chewing, mixing with saliva, and forming the food bolus and thus requires coordinated movements of the lips, tongue, teeth, mandible, and soft palate. Next, the tongue propels the bolus backward, and the base of the tongue comes into contact with the posterior wall of the pharynx, which induces the pharyngeal phase, involving a reflex that initiates a complex series of actions. The soft palate elevates to prevent reflux into the nose, and the pharyngeal contractile tissue contracts to push the bolus into the pharynx. The epiglottis inverts to cover the larynx to prevent aspiration. The vocal cords also act to prevent aspiration. The hyolaryngeal complex moves in an anterosuperior direction in conjunction with continuous relaxation and contraction of the cricopharyngeal muscle, which moves the bolus through the esophageal orifice.[18]

After surgery for advanced oral cancer, patients may exhibit dysphagia in the oral phase, specifically with bolus formation and retention and transfer to the posterior pharynx. They may also be unable to sufficiently close the lips, exhibit masticatory dysfunction, have poor bolus control, retain food in the oral cavity, or exhibit premature leakage of food into the pharynx. In the pharyngeal phase, they may exhibit a delayed or absent swallowing response, reduced pharyngeal contractions, reduced inversion of the epiglottis, decreased laryngeal elevation, and reduced coordination.

Using the modified barium swallow study, Smith et al[8] assessed swallowing within 90 days of surgery in 100 patients who underwent resection of the oropharynx and immediate reconstruction with a free skin flap. They reported that patients in whom more than half of the root of the tongue was resected and those with history of radiation therapy were at higher risk of early postoperative aspiration. Worley et al[9] used the FOIS to evaluate postoperative swallowing function in 66 patients aged older than or equal to 70 years who underwent surgical resection and reconstruction for head and neck cancer (67% oral cancer). They reported that patients with pT4 and tongue resection were at higher risk of reduced swallowing function. Chang et al[19] conducted videofluoroscopic swallowing studies on 268 patients who underwent free skin flap reconstruction after tongue resection. They reported that old age, history of radiation therapy, and extensive resection were significantly associated with reduced swallowing function. In contrast, tumor size and tongue resection were not associated with dysphagia in the present study. Favoring the opinion of de Vicente et al,[11] we speculate that reconstruction with free flaps could provide good results in cases of advanced cancer; therefore, tumor size and tongue resection are irrelevant factors.

Despite these varying reports, in the present study, the number of resected suprahyoid muscles was a significant factor associated with the postoperative swallowing status. In cases of advanced oral cancer, the pull-through operation is the basis for en bloc resection, which does not damage the lymphatic pathways from the primary oral lesion to the neck. In such cases, multiple suprahyoid muscles are included in the resection, and this impairs hyoid motion. Previous studies have also reported decrease in hyoid bone movement after head and neck cancer surgery.[20] Reduced vertical movement of the hyolaryngeal complex is considered to increase the risk of aspiration due to laryngeal invasion from incomplete airway closure, and reduced anterior hyoid movement is thought to reduce the opening of the upper esophageal sphincter and leave residues in the piriform sinus.[21] In the present study, resection of multiple suprahyoid muscles was also significantly associated with postoperative dysphagia, showing that reduced anterosuperior movement of the hyolaryngeal complex affects postoperative swallowing function.

In general, patients who undergo tongue and oral floor resection often experience problems in the oral phase.[22] In oral cancer, when extensive resection procedures such as suprahyoid muscle resection are required, considering the possibility of pharyngeal phase problems, sufficient assessments need to be performed along with appropriate rehabilitation interventions. The Mendelsohn maneuver and the Shaker exercise have been reported to be effective training methods for addressing dysphagia originating in the hyolaryngeal complex.[21] In our department, as many patients experience difficulty in moving the head voluntarily after neck dissection, we often provide training with a modified Shaker exercise to apply passive manual resistance. The addition of this training seems to be effective because it helps improve swallowing function and transitions patients to oral feeding.

Patients who did not eat orally for more than 2 weeks were reported to have worse swallowing outcomes due to dysphagia, pharyngeal muscle atrophy, and fibrosis.[23] This indicates that it is best to resume oral feeding as soon as possible. In oral cancer, postoperative adjuvant therapy is often started within 4 to 6 weeks; therefore, it may be difficult to perform sufficient swallowing training afterward or to actively resume oral intake. Therefore, it is important to be able to resume oral intake by the time radiation therapy begins.

In this study, we examined the effects on early swallowing function at 4 weeks postoperatively.

One limitation of this study was that baseline dysphagia was not evaluated. Moreover, dysphagia was not examined in patients who received radiation therapy. In future studies, we aim to make comparisons with the baseline swallowing function and evaluate the long-term swallowing status, including that of patients who received postoperative radiation therapy.

CONCLUSION

This study showed that among patients who underwent radical resection of oral cancer with primary reconstruction, those with extensive resection of the suprahyoid muscles were at higher risk of postoperative dysphagia. We believe that consideration of this factor along with other risk factors such as the tongue resection range, which has been reported in many previous studies, can contribute to establishing appropriate interventions for dysphagia in this patient population.

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Edentulous Space Closure Using a Clear Aligner System After Alveolar Ridge Split Augmentation