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Original Research

Analysis of the hyoid motion of tongue cancer patients

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ABSTRACT

Objective: We aimed to analyze movement of the hyoid bone in patients with tongue cancer following radical surgery without pre- or postoperative chemotherapy or radiotherapy.
Methods: Ten patients (five males, five females; average age, 56.9 years) with histologically confirmed tongue squamous cell carcinoma underwent pre- and postoperative videofluoroscopic examination of swallowing and radical surgery at the Department of Oral and Maxillofacial Surgery of Kobe University Hospital, Japan. All patients underwent modified radical neck dissection and hemiglossectomy of the mobile tongue with reconstruction using a free radial forearm flap. Hyoid motion was analyzed using the DIPP-Motion PRO2D cineradiography system. According to previous reports, hyoid motion during swallowing is divided into three elements: rearward and upward, forward and upward, and rearward and downward movements. These movements were compared pre- and postoperatively. The endpoints were movement speed, distance, and time.
Results: Postoperatively, radical surgery resulted in motor impairment of the hyoid, with decreased movement capacity, including decreased movement distance, time required, speed, and range of motion during swallowing.
Conclusions: Hyoid motion analysis could be useful to maintain the quality of life of patients with oral cancer in the future as it could also be used to assess patients after bilateral neck dissection, mandibular resection, and radiotherapy.

1. Introduction

Oral cancer accounts for 1–5% of all malignant tumors. Epidemiologically, tongue cancer accounts for a high proportion of oral cancer cases, similar to gingival cancer. Advanced tongue cancer is likely to metastasize to the cervical lymph nodes, necessitating neck dissection with excision of the primary lesion in several cases that require immediate reconstruction according to the extent of tongue resection. However, when reconstructing the tongue, it is impossible to avoid postoperative impairment of oral functions in the form of mastication, swallowing, and articulation.

Various reports regarding functional evaluation after surgery for oral cancer have focused on dysphagia. There are various methods to evaluate dysphagia, including tongue pressure, swallowing pressure, videofluoroscopic examination of swallowing, and endoscopic evaluation of swallowing. Here we focused on postoperative hyoid motion, which can be evaluated objectively. When swallowing, the hyoid bone exhibits upwards and rearwards motion caused by the movement of the suprahyoid muscles and substantially moves forward. Previous reports have clarified that after a bolus passes through the pharynx, the hyoid bone moves rearwards and returns to its original position. En bloc resection of the primary cervical lesion in advanced tongue cancer requires resection of the suprahyoid muscles. Therefore, we aimed to determine how resection of the suprahyoid muscles on one side disrupts the horizontal balance of the hyoid bone and changes movement speed, range, and distance during swallowing.

2. Material and methods

2.1. Patients

Patient characteristics are presented in Table 1. The study cohort included ten patients with primary tongue cancer who were

☆ Asian AOMS: Asian Association of Oral and Maxillofacial Surgeons; ASOMP: Asian Society of Oral and Maxillofacial Pathology; JSOP: Japanese Society of Oral Pathology; JSOMS: Japanese Society of Oral and Maxillofacial Surgeons; JSOM: Japanese Society of Oral Medicine; JAMI: Japanese Academy of Maxillofacial Implants.

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Table 1
Patient characteristics in the present study.

No.	Age (years)	Sex	TN stage	Timing of videofluoroscopic examination of swallowing		Prognosis
				Preoperative (weeks)	Postoperative (months)	
1	77	M	T2N1	2	3	NED
2	74	M	T2N1	1	3	NED
3	66	M	T2N1	1	3	NED
4	57	M	T2N2b	1	3	NED
5	54	M	T3N1	1	6	NED
6	52	F	T2N1	2	4	NED
7	38	F	T2N1	2	3	NED
8	31	F	T2N1	2	6	NED
9	45	F	T2N1	2	4	NED
10	75	F	T2N1	2	4	NED

Abbreviation: NED, No Evidence of Disease.

examined at the Department of Oral and Maxillofacial Surgery of Kobe University Hospital, Japan, between April 2012 and December 2014. Patients met the following inclusion criteria: (i) ability to communicate and clear understanding of the treatment regimen, (ii) pre- and postoperative videofluoroscopic examination of swallowing, (iii) hemiglossectomy of the mobile tongue, unilateral neck dissection, and free radial forearm flap reconstruction, (iv) no resection of the lower jawbone during surgery and no postoperative displacement of the occlusion, (v) lip closure possible, (vi) good progress without pre- or postoperative adjuvant chemoradiotherapy, (vii) stable occlusion with natural teeth or dentures, and (viii) no pain during swallowing and stable oral ingestion. All surgeries were performed by the same surgeon. En bloc resection of the primary neck lesion included resection of the suprahyoid (i.e., digastric, geniohyoid, stylohyoid, and mylohyoid) muscles. In our department, patients with advanced oral cancer underwent pre- and postoperative videofluoroscopic examinations of swallowing and endoscopic evaluation of swallowing for postoperative swallowing rehabilitation.

2.2. Analysis method

2.2.1. Timing of videofluoroscopic examination of swallowing

Preoperative testing was conducted approximately 2 weeks before surgery and postoperative testing was conducted within 3–6 months after surgery.

2.2.2. Method of videofluoroscopic examination of swallowing

Videofluoroscopic examination of swallowing was performed at the Department of Otolaryngology-Head and Neck Surgery, Kobe University Hospital, Japan with the subject in the standing position. Using rice gruel containing contrast medium (barium sulfate) as the test food, a metal piece with a diameter of 23.5 mm was affixed to the center of the chin, and X-rays were applied to the cervical region from the left side.

2.2.3. Analysis method and measurement items

Hyoid motion analysis was performed on the footage of the pre- and postoperative videofluoroscopic examination of swallowing using the DIPP-Motion PRO2D cineradiography system (DITECT, Co., Ltd., Tokyo, Japan). When measuring the hyoid position and motion, the uppermost anterior end of the 3rd cervical vertebra was set as point A, the lowest anterior end of the 5th cervical vertebra was set as point B, and the most anterior point of the hyoid bone was set as point C. The line joining points A and B were set as the *Y*-axis, and the line perpendicular to the *Y*-axis that passed through point B was set as the *X*-axis. The following three items were measured: (i) maximum movement distance of point C along the *X*- and *Y*-axes, (ii) area of the figure formed by the trajectory of motion of point C during swallowing, and (iii) rearward and upward movement, forward and upward movement, and movement distance, time, and speed during rearward and downward movement. The Wilcoxon signed-rank test was used to test for significance with the level of significance set at 5%.

3. Results

3.1. Maximum anteroposterior and vertical movement distance of the hyoid bone

The mean movement distance of point C on the *X*-axis, equivalent to the anteroposterior movement of the hyoid bone, was 15.2 mm preoperatively and 9.0 mm postoperatively, reflecting a statistically significant decrease of 41.3%. The mean movement distance of point C on the *Y*-axis, equivalent to the vertical movement of the hyoid bone, was 13.6 mm preoperatively and 8.4 mm postoperatively, reflecting a statistically significant decrease of 35.9% (Table 2).

Table 2
Maximum anteroposterior and vertical movement distance of the hyoid bone.

	Preoperative	Postoperative	p
On the *X*-axis	15.2 mm (7.5–19.4)	9.0 mm (3.5–13.8)	0.012
	Rate of decrease: 41.3%		
On the *Y*-axis	13.6 mm (9.5–19.8)	8.4 mm (2.5–16.3)	0.012
	Rate of decrease: 35.9%		

3.2. Area enclosed by the trajectory of hyoid motion

The figure enclosed by the motion trajectory of point C was equivalent to the range of motion (ROM) of the hyoid bone. Measurement of the area of this figure indicated a significant decrease of 46.5% from 67.1 mm^2 preoperatively to 35.9 mm^2 postoperatively (Table 3).

3.3. Movement distance, time, and speed for each hyoid motion

In agreement with past reports, Fig. 1 shows that the hyoid bone first moved upwards and forwards and then returned to its

Table 3
Area enclosed by the trajectory of hyoid motion.

	Preoperative	Postoperative	p
ROM	67.1 mm^2	35.9 mm^2	0.012
	Rate of decrease: 46.5%		

Abbreviation: ROM, range of motion.