Tongue pressure in patients with tongue cancer resection and reconstruction

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ABSTRACT

Objective: Assessment of tongue function following tongue reconstruction is important to evaluate patient status. To assess tongue function in patients who had undergone tongue reconstruction, the surgical team used a simple, hand-held tongue pressure measurement device to measure tongue power.
Methods: Tongue power of 30 patients (25 males, 5 females; average age: 53.6 ± 15.0 years) was calculated using a hand-held tongue pressure measurement device, six months postoperation. The defects were classified into minimal glossectomy (MG) ($n = 8$), near-half partial glossectomy of the mobile tongue (PG) ($n = 5$), hemi-glossectomy (HG) ($n = 4$), more than half partial glossectomy of the mobile tongue (SG-MT) ($n = 7$), and subtotal glossectomy (SG) ($n = 6$). As seen in other tongue assessments, a simple articulatory test, food evaluation, and speech intelligibility assessment were also performed; resulting correlations were statistically calculated using tongue pressure values.
Results: The tongue pressure values were $94.0 \pm 14.5\%$ in MG, 48.5 ± 13.2^{a} % in PG, 40.4 ± 18.7^{a} % in HG, $19.3 \pm 7.7^{a,b}$ % in SG-MT, and $15.3 \pm 5.6^{a,b}$ % in SG (a: <0.05 vs. MG, b: <0.05 vs. PG). The Pearson r was 0.77, 0.67, and 0.74 when correlated with simple articulatory test, food evaluation, and speech intelligibility assessment, respectively.
Conclusion: Tongue pressure measurement in patients with tongue cancer resection and reconstruction facilitated determination of patients' tongue function status.

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1. Introduction

For patients who have undergone tongue reconstruction, tongue function evaluation is an important factor in assessment of deglutition and articulation ability; however, most tongue function assessments remain subjective and complicated. Tongue pressure measurement has been used to evaluate tongue function, and several methods of evaluating tongue pressure have been reported. Tongue pressure measurement devices that use small pressure sensors, which are placed in replica dentures or palatal appliances, are commonly used in dentistry [1,2]. Nonetheless, such small pressure sensors are expensive and require use of replica dentures or palatal appliances, regardless of functionality. Another separate method of tongue pressure measurement employs balloon-type pressure measurement devices. Robbins et al. developed a method using balloon air pressure to evaluate tongue pressure [3]. This device was further modified by Hayashi et al. to increase its clinical relevance [4]. It is well reported that disease severity and tongue resection type strongly affect postoperative speech and swallowing ability [5,6]. However, there is a paucity of reports regarding the measurement of tongue pressure after tumor resection and reconstruction [7,8]. In the present study, we used a clinically convenient balloon-type tongue measurement device to measure tongue pressure of patients who had undergone tongue tumor resection and reconstructive surgery and to clarify the relationship between tongue pressure and tongue resection type. These measurements were also compared to other tongue function assessments.

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2. Methods

From April 2010 to March 2012, 30 patients (25 males, 5 females; average age: 53.6 ± 15.0 years) in Saitama Cancer Center (Saitama, Japan) had their tongue power measured and were given other function-based evaluations six months post-operation following tongue cancer resection and reconstruction. Patients who had preoperative radiotherapy or chemotherapy and postoperative radiotherapy or chemotherapy before six months post-operation were excluded from the study. Tongue defects were classified as either minimal glossectomy (MG) ($n = 8$), near half of partial glossectomy of the mobile tongue (PG) ($n = 5$), hemi-glossectomy (HG) ($n = 4$), more than half partial glossectomy of the mobile tongue (SG-MT) ($n = 7$), and subtotal glossectomy (SG) ($n = 6$) (Fig. 1). TNM classification was T1N0M0 ($n = 5$) and T2N0M0 ($n = 3$) in MG group, T2N0M0 ($n = 2$), T2N2bM0 ($n = 2$) and T3N1M0 ($n = 1$) in PG group, T2N1M0 ($n = 1$), T3N0M0 ($n = 1$) and T3N1M0 ($n = 2$) in HG group, T2N2bM0 ($n = 1$), T3N0M0 ($n = 2$), T3N1M0 ($n = 2$) and T3N2bM0 ($n = 2$) in SG-MT group, and T3N2bM0 ($n = 3$), T4aN0M0 ($n = 2$) and T4aN1M0 ($n = 1$) in SG group. Tongue pressure was measured using a hand-held tongue pressure measurement device (JMS company, Hiroshima, Japan) (Fig. 2). The tongue probe was inflated with air at an initial pressure of 20 kPa. Patients were placed in a relaxed sitting position and the probe was placed on the center of the tongue. The measurement was performed three times, interspaced with 30 s rest. The maximal voluntary tongue pressure was recorded, and the mean value of the three measurements was defined as tongue pressure. Mean values were divided by the Japanese average values of each age group (41.7 kPa in 20–29 year olds, 41.9 kPa in 30–39 year olds, 40.4 kPa in 40–49 year olds, 40.7 kPa in 50–59 year olds, 37.6 kPa in 60–69 year olds, and 31.9 kPa in 70–79 year olds) and percentages calculated [9].

Like in other tongue function studies, simple articulatory test, food evaluation, and speech intelligibility assessments were also performed in the patient sample. The simple articulatory test was assessed using the Japanese "ta-ti-tu-te-to", "ka-ki-ku-ke-ko", "ra-ri-ru-re-ro" sounds, which are significantly affected by tongue tumor resection, and speech-language-hearing therapists scored the tests (total 0–9; 0–3 in each sound) [10]. Food evaluation was determined by examining patient diet and scored as: (1) normal diet: 5 points; (2) normal diet with some limitation: 4 points; (3) minced diet: 3 points; (4) pureed or liquid diet: 2 points; and (5) feeding tube diet: 1 point. Speech intelligibility assessment was scored according to ability to conduct daily conversations (Table 1). After assessment, correlations were statistically calculated using tongue pressure values.
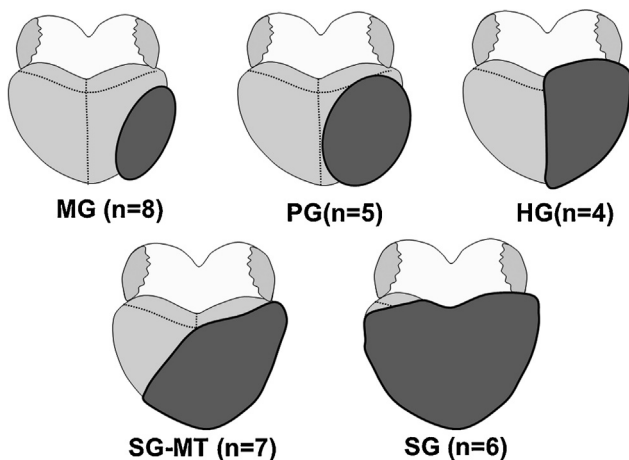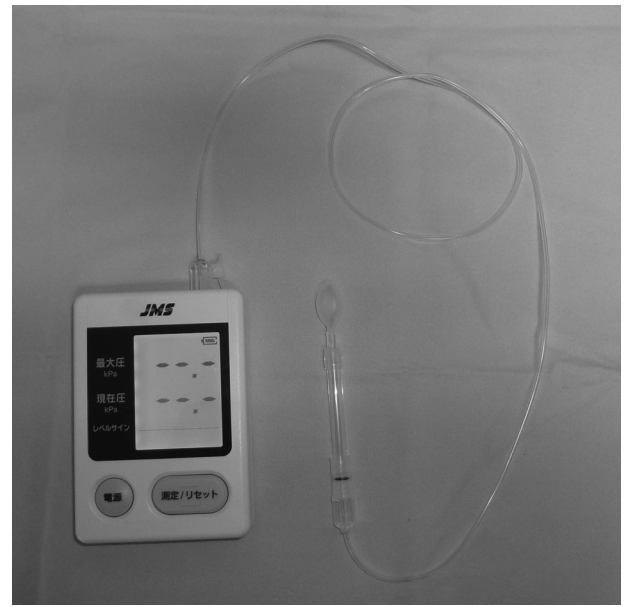
Fig. 2. Hand-held tongue pressure measurement device (JMS company, Hiroshima, Japan).

Summary statistics of data are expressed as means $\pm$ standard deviation. Statistical comparison was performed by ANOVA with post hoc Bonferroni test. Correlations assessed the relationship between numerical variables, and a linear regression model was developed. Variables were assessed for statistical significance using the Pearson correlation, with statistical significance accepted at $p < 0.05$. All statistical calculations were performed using Prism software (GraphPad Software Inc. San Diego, CA).

3. Results

Average group ages were 60.1 ± 16.1 in MG, 52.8 ± 14.6 in PG, 60.3 ± 5.9 in HG, 65.8 ± 8.5 in SG-MT, and 51.0 ± 16.2 in SG. The reconstructive methods used were primary closure (MG = 8), anterolateral thigh flap (PG = 5, HG = 4, SG-MT = 7, SG = 2), and rectus abdominis myocutaneous flap (SG = 4). Tongue pressure values were $94.0 \pm 14.5\%$ in MG, 48.5 ± 13.2^a % in PG, 40.4 ± 18.7^a % in HG, $19.3 \pm 7.7^{a,b}$ % in SG-MT, and $15.3 \pm 5.6^{a,b}$ % in SG (a: <0.05 vs. MG; b: <0.05 vs. PG). One patient in the SG group was unable to measure tongue pressure because the small reconstructed tongue volume did not allow for compression of the tongue measurement probe (Fig. 3). Results of simple articulator test were 8.9 ± 0.4 in MG, 7.3 ± 1.5 in PG, 6.7 ± 0.6^a in HG, $4.2 \pm 1.1^{a,b}$ in SG-MT, and 5.2 ± 0.8^a in SG (a: <0.05 vs. MG; b: <0.05 vs. PG) (Fig. 4). The food evaluation test was 5.0 ± 0.0 in MG, 4.8 ± 0.4 in PG, 4.0 ± 1.4 in HG, $3.4 \pm 0.5^{a,b}$ in SG-MT, and 3.3 ± 0.5^{ab} in SG (a: <0.05 vs. MG; b: <0.05 vs. PG) (Fig. 5). Speech intelligibility assessment was 10.0 ± 0.0 in MG, 9.2 ± 1.3 in PG,

Fig. 1. Classification of tongue tumor resection.

Table 1
Hirose's scoring system for speech ability.

Factor	A: By Family	B: By Others
Clearly understood	5 points	5 points
Occasionally misunderstood	4 points	4 points
Understood only when subject is known	3 points	3 points
Occasionally understood	2 points	2 points
Never understood	1 points	1 points
Scoring for A and B	Intelligibility	
8–10 points	Excellently intelligible speech	
5–7 points	Moderately intelligible speech	
4 points fewer	Poorly intelligible speech	