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Original article

Decline in tongue pressure during perioperative period in cancer patients without oral feeding

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SUMMARY

Background and aims: Systemic muscle wasting during perioperative periods has a major impact on postoperative morbidity. However, data on oropharyngeal muscle weakness after surgery are scarce. We examined whether maximum tongue pressure (MTP) and hand grip strength (HGS) diminished during the perioperative period without and with oral feeding in patients receiving cancer surgery.
Methods: A total of 258 patients undergoing cancer surgery who had visited a hospital dental clinic were prospectively recruited between October 2015 and February 2016. MTP and HGS were measured on the day before and 4 days after surgery. Data on age, sex, tumor location, surgical procedure, and oral feeding status were obtained from patient medical records. We analyzed for differences in the perioperative changes of MTP and HGS according to surgical procedure, oral feeding, and tumor location using ANOVA.
Results: Neither MTP nor HGS differed significantly among tumor locations before surgery. The proportion of patients with an oral diet at 4 days after surgery was 36.7% and 34.5% for upper GI and colorectum groups versus 89.2% and 86.4% for genitourinary and lung groups, respectively. During the perioperative period, MTP decreased more significantly in patients without oral feeding than in those with oral feeding at 4 days after surgery ($P < 0.01$). HGS was not affected by postoperative oral feeding status. Both MTP and HGS decreased more significantly in the upper gastrointestinal group than in the genitourinary and lung groups ($P < 0.05$), except for MTP between upper GI and genitourinary groups ($P = 0.10$).
Conclusions: MTP, but not HGS, diminishes significantly during the perioperative period without oral feeding. As tongue muscle disuse after surgery may adversely impact postoperative oropharyngeal muscle decline, perioperative tongue muscle strengthening exercises may assist in maintaining muscle strength and good oral feeding.

1. Introduction

Muscle weakness in cancer patients during perioperative periods has a major impact on postoperative morbidity [1]. In particular, preoperative sarcopenia has been reported as a strong risk factor for postoperative complications at various cancer locations [2–6]. One cause of muscle weakness and loss of muscle mass is disuse. During the postoperative period, muscle hypercatabolism from surgical invasion can result in postoperative weight and muscle mass decreases.

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Preoperative muscle loss reduces activity patterns [7], such as a delay in leaving the bed and weakened coughing ability , leading to an increased risk of postoperative pneumonia. Proper nutritional management and physical therapy are advised to prevent this [8]. Particularly in digestive cancer, however, reduced oral food intake in addition to surgical invasion are detrimental to body weight and muscle mass [9,10].

The concept of the Enhanced Recovery After Surgery (ERAS) protocol is widely known [11,12]. This multidisciplinary rehabilitation program aims to enhance early recovery, prevent postoperative complications, and reduce surgical invasion and includes such measures as early enteral or oral feeding, early mobilization, and proper pain control [13]. Initially designed for colorectal cancer, ERAS has since been expanded to upper gastrointestinal (GI) surgery [14]. The ERAS protocol decreases the time until flatus, shortens the length of hospital stay, and increases postoperative quality of life [11,12]. ERAS protocol for gastric cancer also markedly suppresses post-surgical body weight loss [15].

Early oral feeding is an important component in the ERAS protocol. However, postoperative wasting influences the entire body, including the trunk, limbs, and muscles related to eating such as the oral and pharyngeal muscles. Prolonged non-oral food intake may induce oropharyngeal muscle disuse, leading to postoperative muscle weakness in those regions; in fact, prolonged endotracheal intubation is a known risk factor of dysphagia after extubation [16] that is considered a result of oropharyngeal muscle disuse during intubation. However, evidence regarding weakness of the oropharyngeal muscles after surgery remains scarce.

The tongue is essential for eating and swallowing, the body of which consisting of internal and external musculature. As reduced tongue strength has been associated with sarcopenia and dysphagia in hospitalized patients [17,18], we hypothesized that muscle strength declined during the postoperative period in cancer patients with no oral feeding. To verify this, we examined the changes in maximum tongue pressure (MTP) and hand grip strength (HGS) during the perioperative period in patients undergoing cancer surgery.

2. Materials and methods

2.1. Participants

In this single-center prospective cohort study, patients who visited our hospital dental clinic before surgery for cancer were prospectively recruited between October 2015 and November 2016. Patients in unstable general condition or admitted to the intensive care unit were excluded. Information on primary illness and comorbidities and their treatments were extracted from patient records. This study's protocol was approved by the Institutional Review Board of Fujita Health University (Approval ID: 14-103). All participants gave informed consent prior to enrollment in this study.

2.2. Data collection

MTP and HGS were evaluated on the day before and 4 days after surgery by an experienced dentist and hygienists in each patient's room.

To measure MTP (kPa), a tongue pressure sensor balloon probe connected to a digital tongue pressure meter (JMS, Hiroshima, Japan) was placed on the dorsal tongue surface. The subject was asked to press the probe against the hard palate at maximum strength using the tongue for 3 s (Fig. 1). After several practice movements, tongue pressure was assessed 3 times and the mean value was calculated. Grip strength (kg) was determined for both hands using a digital hand dynamometer (Grip-D, Takei Instruments, Niigata, Japan). Measurements were carried out in triplicate for each hand, and the mean grip strength of the stronger side was used for analysis.

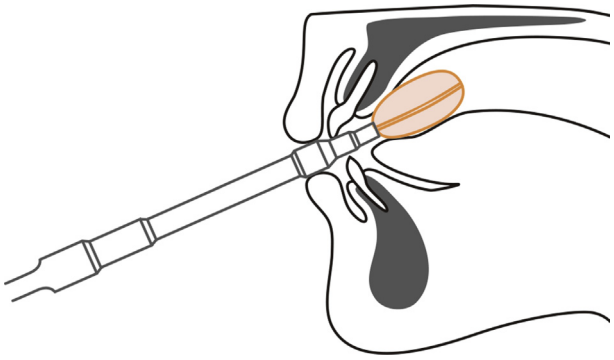

Fig. 1. Schematic of tongue pressure measurement. After a tongue pressure sensor balloon probe connected to a digital tongue pressure meter was placed on the dorsal tongue surface, the subject was asked to press the probe against the hard palate at maximum strength with the tongue for 3 s.

Body mass index (BMI, [kg/m^2]), serum albumin (Alb, [mg/dL]), and other laboratory data were collected from patient medical records at a date close to that of the physical evaluations. Tumor location, surgical procedure, and oral feeding status were also obtained from medical records. Tumor location was classified into 4 regions: the upper GI tract (upper GI), colorectum, genitourinary tract (genitourinary), and lung. Surgical procedure was judged as open or laparoscopic surgery. Oral feeding status at 4 days after surgery was classified as oral feeding or no oral feeding. Subjects were also divided into 3 age categories: the young group (<65 years old: young), young-old group (65–74 years old: y-old), and old-old group (>75 years old: o-old).

2.3. Data analysis

For preoperative values, analysis of variance (ANOVA) was used to test for differences in MTP, HGS, BMI, and Alb by sex, age, and tumor location on the day before surgery. For perioperative changes, the changes in MTP, HGS, BMI, and Alb where calculated as the postoperative value divided by the preoperative value. Differences in the perioperative changes of these parameters based on sex, age, surgical procedure, oral feeding, and tumor location were first evaluated by the Student's *t*-test or one-way ANOVA. After excluding sex and age due to no significant effect on the parameters in univariate analysis, three-way ANOVA was employed to test for differences in perioperative changes according to surgical procedure, oral feeding, and tumor location. Tukey's test was adopted for multiple comparisons.

Statistical analyses were performed using IBM SPSS Statistics 20.0 software (IBM, Armonk, NY, USA). The critical value for rejecting the null hypothesis was $P < 0.05$.

3. Results

3.1. Participant characteristics

A total of 258 patients (mean ± SD age 66.3 ± 11.4 years) were included in the study and summarized in Table 1. There were 85 patients (32.9%) in the young group, 116 patients (45.0%) in the y-old group, and 57 patients (22.1%) in the o-old group. All patients in the upper GI and lung cancer groups underwent laparoscopic surgery, as compared with 46.6% of colorectum cancer patients and

Table 1
Demographic data of participants.

Variable	Group	N (%)
Age group	Young	85 (32.9)
	Y-old	116 (45.0)
	O-old	57 (22.1)
Sex	Male	162 (62.8)
Surgical procedure	Laparoscopy	209 (81.0)
Oral feeding 4 days after surgery		165 (64.0)
Tumor location	Upper GI	60 (23.3)
	Colorectum	58 (22.5)
	Genitourinary	74 (28.7)
	Lung	66 (25.6)

Y-old, young-old; O-old, old-old.

75.7% of genitourinary cancer patients. Before surgery, 220 patients (85.3%) had oral feeding, and 38 patients (14.7%) received parenteral nutrition or enteral nutrition. Of those, 30 patients (13.6%) with oral feeding and 12 patients (31.6%) without oral feeding were undernourished (BMI<18.5 or ALB<3.4). Four days after surgery, 165 patients (64.0%) were receiving oral feeding. Most of them had more than 80% prescribed diet. At 4 days after surgery, 89.2% of patients with genitourinary and 86.4% of lung cancer had begun oral feeding versus only 36.7% of patients with upper GI and 34.5% of colorectum cancer, respectively.

3.2. Preoperative measures

The mean values of MTP, HGS, Alb, and BMI by age and tumor location are shown in Fig. 2. MTP and HGS were significantly lower in women than in men ($P < 0.05$) (Tables 2 and 3) and lower in the o-old group than in the young group ($P < 0.01$). There were no significant differences in these parameters among tumor locations. BMI was lower in women than in men ($P < 0.01$) and Alb was lower in the upper GI group than in the genitourinary group ($P < 0.01$). BMI and Alb did not differ statistically among the age groups.

3.3. Changes in MTP and HGS during the perioperative period

The mean perioperative changes in MTP, HGS, Alb, and BMI according to oral feeding and tumor location are presented in Fig. 3. MTP decreased more significantly in patients without oral feeding than those with oral feeding at 4 days after surgery ($P < 0.01$) (Tables 4 and 5). HGS was not significantly affected by oral feeding status 4 days after surgery ($P = 0.23$), although tumor location had a significant impact on MTP and HGS after surgery (both $P < 0.05$). MTP decreased more significantly in the upper GI and colorectum cancer groups than in the genitourinary and lung cancer groups, except between the upper GI and genitourinary groups ($P = 0.10$). HGS decreased more in upper GI cancer patients than in genitourinary or lung cancer patients.

3.4. Changes in BMI and Alb during the perioperative period

BMI decreased significantly more in the oral feeding group than in the no oral feeding group ($P = 0.03$) (Tables 4 and 5). The perioperative change rate in BMI was significantly different between subjects with colorectum or lung cancer ($P < 0.01$), but not significantly different among others. Alb decreased significantly more in patients with open surgery than in those laparoscopic procedures ($P < 0.01$) and in those without oral feeding than those with oral feeding ($P = 0.03$). The perioperative change rate in Alb was significantly different between patients with upper GI or lung cancer ($P < 0.01$), but not remarkably among others.

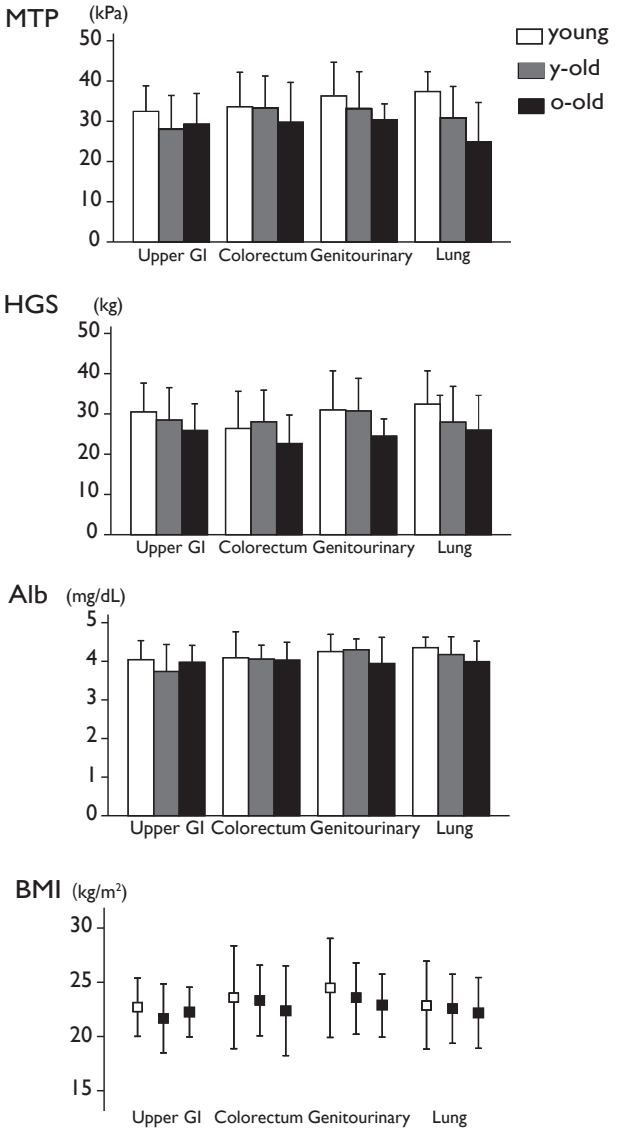

Fig. 2. The mean ± SD of preoperative values of MTP, HGS, Alb, and BMI according to age and tumor location. The error bar represents the mean ± SD. There were no significant differences for these parameters among tumor locations before surgery. MTP and HGS were significantly lower in elderly patients. Alb and BMI were comparable among the age groups. MTP, maximum tongue pressure; HGS, hand grip strength; Alb, albumin; BMI, body mass index.

4. Discussion

The present study sought to clarify whether tongue muscle strength declined during the postoperative period in cancer patients with no oral food intake. Although longer studies are necessary for a more conclusive answer, we can report that tongue pressure declines significantly more during the perioperative period in patients without oral feeding at 4 days after surgery. During the postoperative period, surgical invasion can exacerbate muscle hypercatabolism, where inflammatory cytokines are released, muscles are broken down and amino acid are released, resulting in a loss of muscle mass [9]. For patients without oral feeding after surgery, tongue muscle disuse during bed rest may worsen deterioration of tongue muscle strength. We could not determine the main factor of postoperative MTP decline in this study design, but, probably those factors modulate each factor, leading to exacerbation of MTP decline in upper GI or colorectum

Table 2
The mean ± SD of preoperative values by sex, and tumor location.

	MTP (kPa)		HGS (N)		BMI (kg/m^2)		ALB (mg/dL)	
	Men	Women	Men	Women	Men	Women	Men	Women
Upper GI (N: Men 40, Women 20)	32.1 ± 6.0	26.8 ± 7.5	32.3 ± 5.4	19.6 ± 6.1	22.4 ± 2.9	21.5 ± 3.1	3.9 ± 0.6	4.0 ± 0.5
Colorectum (N: Men 34, Women 24)	32.6 ± 8.4	32.3 ± 9.1	30.4 ± 7.9	20.9 ± 4.3	23.5 ± 3.4	23.0 ± 4.1	4.1 ± 0.4	4.1 ± 0.5
Genitourinary (N: Men 50, Women 24)	35.9 ± 7.8	31.7 ± 9.2	35.0 ± 6.8	21.6 ± 5.1	24.3 ± 3.0	23.5 ± 5.6	4.3 ± 0.4	4.3 ± 0.5
Genitourinary (N: Men 38 Women 28)	32.2 ± 8.0	30.3 ± 9.1	33.5 ± 7.0	20.9 ± 4.2	22.9 ± 2.7	22.3 ± 4.0	4.2 ± 0.4	4.0 ± 0.6

MTP, maximum tongue pressure; HGS, hand grip strength; BMI, body mass index; ALB, serum albmin.

Table 3
Comparison of preoperative values by age, sex, and tumor location.

		MTP	HGS	BMI	ALB
Main effect	Age	<0.01	<0.01	0.17	0.15
	Sex	0.02	<0.01	0.09	0.63
	Tumor location	0.35	0.21	0.53	0.03
Interaction effect	Age * Sex	0.62	0.41	0.31	0.59
	Age * Tumor location	0.18	0.42	0.71	0.19
	Sex * Tumor location	0.06	0.55	0.55	0.31
Post hoc					
Young	vs. Y-old	<0.01	0.04		
	vs. O-old	<0.01	<0.01		
Y-old	vs. O-old	0.04	<0.01		
Upper GI	vs. Colorectum				0.40
	vs. Genitourinary				<0.01
	vs. Lung				0.23
Colorectum	vs. Genitourinary				0.21
	vs. Lung				0.98
Genitourinary	vs. Lung				0.43

Y-old, young-old; O-old, old-old; MTP, maximum tongue pressure; HGS, hand grip strength; BMI, body mass index; ALB, serum albmin.

cancer patients without oral feeding. The tongue has essential roles in mastication and swallowing [19,20], and reduced tongue muscle mass is related to dysphagia [17,21]. Our findings suggest that no postoperative oral diet decreases tongue muscle strength and may impede oral diet resumption if the functional reserve is already declined. Our results also indicate that perioperative tongue muscle strengthening exercises for patients receiving cancer surgery may be useful to maintain tongue muscle strength and adequate oral feeding.

4.1. Changes in MTP and HGS during the perioperative period

HGS is often used as a representative indicator of general muscle strength [22], and is reported to have significant correlation with MTP in community and hospitalized individuals [18,23,24]. We observed a similar tendency in preoperative status, in which MTP and HGS had significant associations with age and sex. However, the amount of perioperative change varied: while MTP became significantly decreased after surgery in the no oral feeding group regardless of tumor location (i.e., no interaction between oral feeding and tumor location), HGS displayed no such decline in performance between oral and no oral feeding groups during the perioperative period. Disuse of the mouth likely decreased oral and tongue function during follow-up and caused a postoperative decline in tongue strength. However, patients without oral feeding received sufficient nutrition via naso-gastric tubing or intravenous line during the postoperative period, which may be the reason why HGS was not remarkably affected by post-surgical oral feeding status.

Our findings demonstrated that surgical location had a significant impact on the amount of MTP and HGS decrease. Surgery for GI

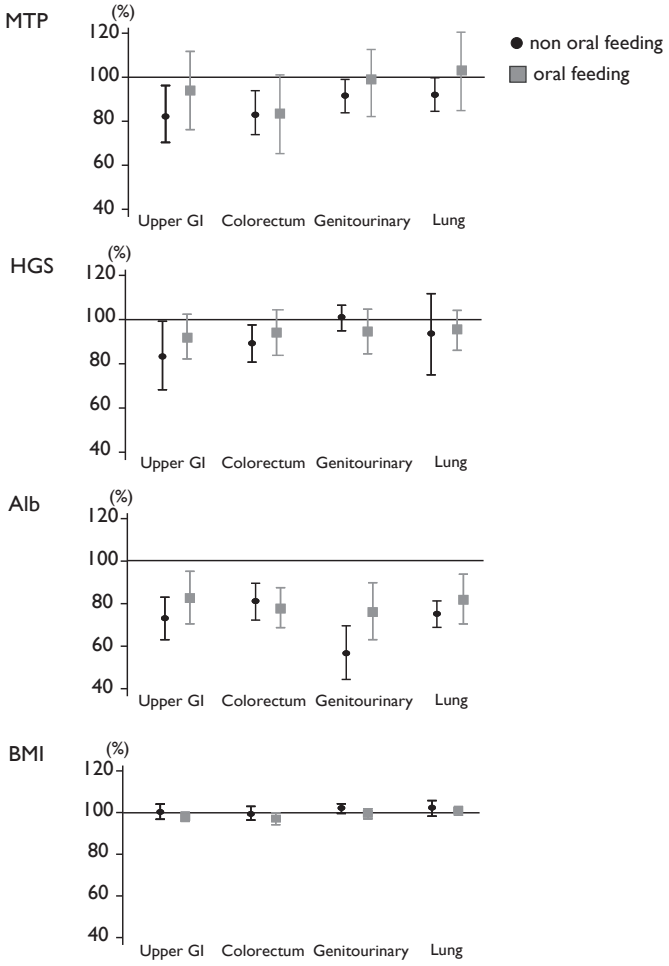

Fig. 3. The mean ± SD of perioperative change values of MTP, HGS, Alb, and BMI by oral feeding and tumor location. The error bar represents the mean ± SD. MTP, but not HGS, decreased significantly in patients with no oral feeding than those with oral feeding at 4 days after surgery. MTP and HGS decreased more significantly in the upper GI group than in the genitourinary or lung group. MTP, maximum tongue pressure; HGS, hand grip strength; Alb, albumin; BMI, body mass index.

cancer is generally more invasive than that for genitourinary or lung cancer. Although we witnessed no statistical significance between laparoscopic and open surgical procedures, postoperative invasion and pain have been described to accelerate muscle hypercatabolism and weaken body functions [1,25,26]. The nil per os period is usually longer in patients with GI than with genitourinary or lung cancer procedures. As early oral feeding is an important component of the ERAS protocol to reduce aspiration pneumonia and other postoperative complications, the observed significant

Table 4
The mean ± SD of value changes during the perioperative period by procedure and oral feeding.

	MTP (kPa)		HGS (N)		BMI (kg/m^2)		ALB (mg/dL)	
	Without	With	Without	With	Without	With	Without	With
Open (N: Without 29, With 20)	87.0 ± 11.6	97.8 ± 27.2	92.6 ± 7.4	95.6 ± 11.7	100.6 ± 3.1	98.5 ± 4.1	67.2 ± 9.0	73.5 ± 10.5
Laparoscopic (N: Without 64, With 145)	87.0 ± 15.3	97.5 ± 18.3	88.3 ± 14.6	95.1 ± 10.4	100.2 ± 3.1	100.0 ± 4.1	75.1 ± 9.2	81.5 ± 11.7

MTP, maximum tongue pressure; HGS, hand grip strength; BMI, body mass index; ALB, serum albmin.

Table 5
Comparison of value changes during the perioperative period by procedure, oral feeding, and tumor location by three-way ANOVA.

		MTP	HGS	BMI	ALB
Main effect					
Surgical procedure		0.66	0.83	0.40	<0.01
Oral feeding		<0.01	0.23	0.03	0.03
Tumor location		0.02	0.03	<0.01	<0.01
Interaction effect					
Procedure * Oral feeding		0.20	0.07	0.26	0.37
Procedure * Tumor location		0.02	0.29	0.34	0.11
Oral feeding * Tumor location		0.70	0.44	0.10	0.69
Post hoc (tumor location)					
Upper GI vs.	Colorectum	0.98	0.86	0.35	0.25
	Genitourinary	0.10	0.04	0.91	0.99
	Lung	0.02	0.02	0.39	<0.01
Colorectum vs.	Genitourinary	0.04	0.29	0.67	0.61
	Lung	<0.01	0.20	<0.01	0.33
Genitourinary vs.	Lung	0.86	0.99	0.09	0.06

MTP, maximum tongue pressure; HGS, hand grip strength; BMI, body mass index; ALB, serum albmin.

MTP and HGS decreases by GI surgery support the ERAS indication of maintaining oral function by prompt oral feeding. Further studies are warranted to determine the merits of tongue muscle exercises for this purpose.

There were no significant influences for age or sex on perioperative changes in MTP and HGS, indicating that tongue pressure decreased after surgery regardless of age or sex and was more strongly associated with oral feeding status after surgery and surgical location. This has important clinical implications since preoperative sarcopenia is a strong risk factor for postoperative cancer surgery complications. Diminished tongue pressure is associated with dysphagia [17,27], and more importantly, leads to aspiration pneumonia [28].

4.2. Preoperative values of MTP and HGS

Our results showed that in the preoperative stage, MTP and HGS were significantly lower in the most elderly group, with BMI showing a similar tendency. Many studies have reported that MTP is significantly influenced by age in hospitalized or community-dwelling individuals [29–32]. We could confirm that tongue pressure was diminished regardless of tumor location in our hospitalized cohort undergoing cancer surgery. Recent evidence has suggested a decline in tongue muscle strength to be associated with sarcopenia in elderly people [17,18,32–34]. Hence, diminished tongue pressure associated with sarcopenia in elderly individuals may be an indirect risk factor for dysphagia and postoperative complications in hospitalized cancer patients [2–6].

4.3. Limitations

This study had several limitations. First, it demonstrated the short-term changes in MTP and HGS over a relatively short perioperative period [15,35]. Our patients were usually discharged in a week if they were without complications and had good nutrition, especially those with non-GI surgeries. Since follow-up measurements after discharge were difficult across the various cancer populations, the study period was accordingly short. Further studies with longer observation periods are needed to clarify any postoperative recovery of MTP or HGS along with improvement of oral feeding, the amount of oral feeding and diet texture demanding more mastication and oral performance. Second, this study did not investigate for relationships between a perioperative decline in muscle strength and postoperative complications. Several reports have implicated sarcopenia as a risk factor for adverse post-surgical events and as being related to dysphagia ([36,37]). Future trials with specific surgical organs are required to identify associations among preoperative nutritional status and physical condition, perioperative oral muscle decline, postoperative oral feeding recovery, and complications.

Finally, we did not investigate what sort of enteral feeding (e.g. difference in energy and type of protein) patients received. Recent report suggests that inadequate caloric and protein intake can attribute complications and diet suspensions [38]. It have to be verified whether muscle strength and physical status are influenced by postoperative enteral feeding conditions. Again, further studies with longer observation periods are needed to clarify this issue as well.

5. Conclusion

MTP and HGS were decreased in elderly patients before cancer surgery, as reported previously. MTP, but not HGS, declined significantly during the perioperative period in patients without oral feeding. Our findings suggest that tongue muscle disuse by non-oral feeding after surgery may impact postoperative tongue muscle decline in upper GI or colorectum cancer patients, indicating a potential benefit of perioperative tongue muscle strengthening exercises to maintain tongue muscle integrity and good oral feeding.

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