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Effect of oral function and postoperative eating patterns on salivary bacterial counts in gastrointestinal tract surgery patients: A preliminary study

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Perioperative oral care

Abstract *Background/purpose:* Perioperative oral care is widely provided to prevent postoperative pneumonia and surgical site infections in patients undergoing surgery under general anesthesia. However, there is a lack of clarity regarding the kind of oral care that should be provided for different patients. The purpose of this study was to clarify the factors that influence the increase in salivary bacterial counts before and after gastrointestinal surgery to identify patients with a particular need for oral care.
Materials and methods: Twenty patients undergoing gastrointestinal surgery were examined before surgery for denture use, number of remaining teeth, regular dental care, Oral Hygiene Index-Simplfied tongue coating, tongue pressure, bite pressure, masticatory efficiency, and dry mouth. Saliva samples were collected before surgery, in the fasting period after surgery, and in the oral feeding period. Total bacterial counts were determined by real-time PCR, and factors associated with bacterial counts were investigated.
Results: Patients with decreased oral functions, such as tongue pressure, bite pressure, and masticatory efficiency, tended to have higher salivary bacterial counts in the preoperative, fasting, and oral feeding periods. Regarding the pre- and postoperative changes, salivary

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bacterial counts increased in the fasting period compared to the pre-operative period and returned to preoperative values in the oral feeding period.
Conclusion: Perioperative oral care is important for patients with reduced oral function because the number of bacteria in saliva tends to be higher in such patients. As the number of bacteria in saliva increases during the fasting period, oral care is important, and oral feeding should be restarted as soon as possible.

Introduction

Perioperative oral care (POC) for cancer, heart and organ transplant surgery, radiation therapy, and chemotherapy patients began to be covered by public health insurance in Japan in 2012. The purpose of POC is to prevent adverse events, such as postoperative pneumonia, surgical site infection, and mucositis due to chemotherapy or radiotherapy, by removing the source of infection in the oral cavity and establishing good oral hygiene. After introducing POC, a reduction in postoperative pneumonia in esophageal and pulmonary surgery,[1–3] surgical site infection in colorectal cancer,[4,5] and the incidence and severity of oral mucositis by molecular-targeted drugs has been reported.[6,7] In addition, big data analysis using receipt data showed that POC reduces postoperative pneumonia in patients with gastrointestinal cancers such as esophageal, stomach, and colon cancer and reduces mortality rate within 30 days.[8] Effectiveness of POC has become widely known, and POC is currently being introduced in many hospitals. POC intervention is often performed just prior to surgery, so procedures that involve bleeding, such as scaling and tooth extraction, are often not possible because of the possibility of blood infection. Also, when the number of surgeries is high, there is not enough manpower to provide care to all patients. Therefore, if patients at high risk for postoperative pneumonia can be screened preoperatively, it will identify patients for whom POC should be a focused intervention. However, the criteria for the type of oral care to be provided to different kinds of patients have not yet been clarified.

Aspiration pneumonia often occurs in elderly individuals requiring nursing care, and the importance of oral care in preventing aspiration pneumonia has been reported.[9] As people age, decline in oral function can progress to a loss of appetite and then to a decline in overall body function, such as sarcopenia and undernutrition, ultimately leading to the need for nursing care. Our research group found that tongue pressure decreases as the number of functional teeth decreases even in healthy elderly people, and that low tongue pressure increases the number of bacteria in saliva.[10,11] Moreover, elderly patients who require nursing care and have decreased tongue pressure are more prone to aspiration pneumonia and have a higher mortality rate due to aspiration pneumonia.[12] Decreased tongue pressure in the elderly is associated with systemic sarcopenia. In addition, tongue pressure reduces the self-cleaning function of the oral cavity, which leads to an increase in oral bacteria, and also to difficulty in forming and feeding food masses smoothly, which can lead to aspiration pneumonia. The same may occur in perioperative patients as well as in the elderly. Our study found that postoperative oral intake was associated with salivary bacterial counts.[13] However, no study has examined the relationship between oral function and salivary bacterial counts in perioperative patients. This study aimed to identify patients who require perioperative oral function management. To this end, a pilot study was conducted in a small number of patients undergoing gastrointestinal surgery to examine the factors that influence salivary bacterial counts before and after surgery, particularly the influence of oral function and postoperative eating patterns.

Material and methods

Participants

The inclusion criteria in the study were patients aged 20 years or more who underwent gastrointestinal surgery under general anesthesia and visited the Department of Dentistry and Oral Surgery at our University between November 1, 2022, and January 31, 2023. They had been fully informed about the study and gave their consent based on their own free will. Patients scheduled for postoperative ventilator management via intubation were excluded from the study.

Factors examined

The following factors were investigated: denture use, number of remaining teeth, regular dental care, Oral Hygiene Index-Simplified (OHI—S),[14] degree of tongue coating Winkel tongue coating index (WTCI),[15] tongue pressure, bite force, masticatory efficiency, and dry mouth. Tongue pressure was measured using a JMS tongue pressure device (JMS Co. Ltd., Hiroshima, Japan), and a value of less than 20 kPa was considered a decrease. Bite force was measured using the Dental Prescale II (GC Co, Ltd., Tokyo, Japan),[16] and a value less than 200 N was considered a decrease. Masticatory efficiency was measured using a glucose-measuring device (GLUCO SENSOR GS-II) (GC Co, Ltd.),[17] and a value below 100 was considered a decrease. Dry mouth was assessed using the Callacombe Scale.[18] Scaling, Professional mechanical tooth cleaning (PMTC), and tongue cleaning were performed by a dental hygienist. Saliva was also collected after surgery in the fasting and oral feeding phases. Saliva was collected from the bottom of the mouth using a filter paper, according to the method described by Funahara.[11] The following variables were also collected from medical records: age, sex, primary disease, body mass index (BMI), serum albumin level, and operation time. Salivary bacterial counts were measured by real-time polymerase chain reaction (PCR; DNA extraction technique, primer, artificial DNA, and reaction conditions used were as previously reported by Tsuda.[19]

Statistical analysis

All statistical analyses were performed using SPSS ver. 26.0 (Japan IBM Co., Ltd., Tokyo, Japan). The relationship between each variable and the number of bacteria in saliva was analyzed. One-way analysis of variance was used to analyze categorical variables and Spearman's rank correlation coefficient was used to analyze continuous variables. Multivariate analysis was performed using multiple regression analysis, including factors found to be significant in the univariate analysis and other factors of interest. Statistical significance was defined as a two-tailed P value < 0.05.

Ethics

This study was conducted in accordance with the Declaration of Helsinki and the Ethical Guidelines for Medical and Biological Research Involving Human Subjects by the Ministry of Health, Labor, and Welfare of Japan. This study was approved by the Institutional Review Board of our university (No.2022050). Written informed consent was obtained from all subjects involved in the study.

Results

Patient characteristics

Of the 20 patients registered, 13 patients were males and 7 were females, with an average age of 72.1 years. The primary diseases were colon disease in 13 patients and stomach disease in 7 patients. The mean number of remaining teeth was 17.1. Although none of the patients had restrictions on daily activities, tongue pressure decreased in 6 patients, bite force decreased in 5 patients, and masticatory efficiency decreased in 5 patients (Table 1).

Factors related to the number of bacteria in saliva before surgery

We examined the factors associated with preoperative salivary bacterial counts and found that patients with low tongue pressure had significantly higher salivary bacterial counts ($P = 0.037$). Other factors such as older age, denture wearing, and lower bite force and masticatory efficiency were associated with higher average salivary bacterial counts, but no statistically significant differences were found owing to the small number of cases (Table 2).

Table 1 Patients characteristics.

Variable		Number of patients/ mean ± standard deviation
Sex	male	13
	female	7
Age		72.10 ± 0.48
Primary disease	colon	13
	stomach	7
Body mass index		23.87 ± 4.34
Regular dental management	(−)	8
	(+)	12
Denture use	(−)	8
	(+)	12
Tongure pressure	≥ 20 kPa	14
	<20 kPa	6
Bite force	≥ 200 N	15
	<200 N	5
Masticatory efficiency	≥ 100	15
	<100	5
Serum albumin		3.98 ± 0.30
OHI−S		1.08 ± 0.95
Tongue coating index		3.15 ± 2.41
Number of teeth		17.05 ± 10.11
Dry mouth (preoperative)		0.1 ± 0.30
Operation time (minutes)		244.85 ± 75.69

AbbreviationsOHI-S: Oral Hygiene Index - Simplex.

This study was designed as a pilot study and it was difficult to obtain significant differences owing to the small sample size. Therefore, we compared the correlation coefficients between each factor and the preoperative salivary bacterial counts. In the preoperative period, the number of bacteria in saliva showed a positive correlation with age and the OHI−S scores, but it exhibited a negative correlation with tongue pressure, bite force, masticatory efficiency, and other factors indicating oral function (Fig. 1).

Factors related to the number of bacteria in saliva after surgery

We examined the factors associated with salivary bacterial counts during the postoperative fasting period. As in the preoperative period, the salivary bacterial counts tended to increase in patients who were older and had lower tongue pressure, bite force, and masticatory efficiency; however, the differences were not statistically significant (Table 3). Regarding the factors related to the number of bacteria in saliva during the oral feeding phase, there was a tendency for the number of bacteria in saliva to increase in patients with lower tongue pressure, bite force, and masticatory efficiency, but the differences were not statistically significant (Table 4). On comparing the correlation coefficients between each factor and postoperative salivary bacterial counts, a negative correlation was found between oral function and salivary bacterial counts in the fasting (Fig. 2) and oral feeding phases (Fig. 3), as in the preoperative phase, although no statistically significant differences were found.

Table 2 Factors related to number of bacteria in saliva before surgery.

Variable		mean ± SD	correlation coefficient	P-value
i) Category data				
Sex	male	4.71 ± 1.96		0.951
	female	4.65 + 1.68		
Regular dental management	(−)	4.48 ± 2.29		0.689
	(+)	4.83 ± 1.53		
Denture use	(−)	4.20 ± 1.41		0.340
	(+)	5.01 ± 2.04		
Tongue pressure	≥ 20	4.14 ± 1.61		0.037
	<20	5.96 ± 1.77		
Bite force	≥ 200	4.40 ± 1.77		0.233
	<200	5.55 ± 1.89		
Masticatory efficiency	≥ 100	3.77 ± 1.66		0.205
	<100	4.99 ± 1.82		
ii) Continuous data				
Age			0.310	0.183
Body mass index			0.067	0.778
Dry mouth (preoperative)			−0.064	0.789
Serum albumin			0.014	0.954
Number of teeth			0.022	0.927
OHI—S			0.147	0.536
Tongue coating			−0.177	0.457

AbbreviationsOHI-S: Oral Hygiene Index - Simplex.

Changes in the number of bacteria in saliva before surgery and in the fasting and oral feeding phases.

We examined the logarithm of the number of bacteria in saliva by setting the preoperative value to 1 and calculating the change in the number of bacteria in saliva in the fasting and oral feeding phases. Bacterial counts increased in the fasting phase and returned to preoperative values in the oral feeding phase, but the number of cases was small and the difference was not statistically significant (Fig. 4).

Discussion

This study showed that salivary bacterial counts were higher in patients with decreased oral function and that bacterial counts increased after surgery when the patients were not eating orally.

The tongue forms, moves, and sends food masses to the pharynx, and a decrease in tongue pressure interferes with the swallowing sequence. A previous study showed that in hospitalized elderly patients requiring long-term care, a decrease in the number of remaining teeth was associated with a decrease in tongue pressure, which was associated with an increase in death from aspiration pneumonia.[12] Tashiro, in a study on elderly people in an isolated island region, found that a decrease in the number of molars involved in occlusion was significantly associated with decreased tongue pressure. Moreover, they reported that fixed dental prostheses, such as bridges, prevent tongue pressure reduction; however, removable prostheses, such as dentures, cannot prevent tongue pressure reduction.[10] A significant association has been reported between decreased tongue pressure and increased salivary bacterial counts in institutionalized elderly patients requiring long-term care.[11] While these studies have indicated an association between poor oral function and increased salivary bacterial counts in the elderly, there have been no similar reports on perioperative patients. Identifying factors associated with increased salivary bacterial counts in perioperative patients would help determine which patients require focused oral care.

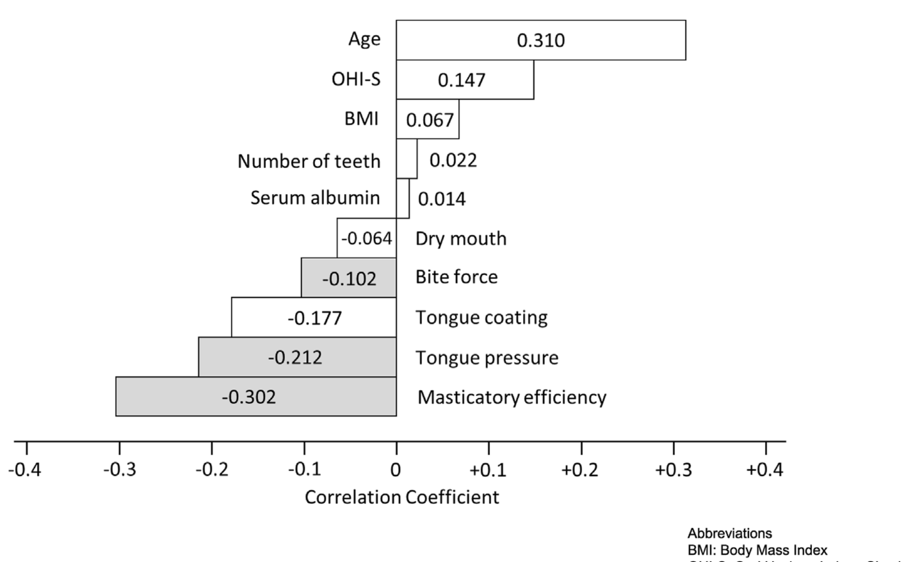

Figure 1 Correlation coefficients between preoperative oral bacterial counts and the variables
Although not significant, preoperative salivary bacterial counts positively correlated with age and the OHI—S scores and negatively correlated with masticatory efficiency, tongue pressure, and bite force.

Table 3 Factors related to number of bacteria in saliva in fasting period.

Variable		mean ± SD	correlation coefficient	P-value
i) Category data				
Sex	male	5.27 ± 2.25		0.704
	female	4.88 ± 2.02		
Regular dental management	(−)	5.62 ± 2.40		0.216
	(+)	4.40 ± 2.06		
Denture use	(−)	5.69 ± 2.40		0.160
	(+)	4.30 ± 1.39		
Tongue pressure	≥ 20	4.69 ± 1.82		0.165
	<20	6.16 ± 2.60		
Bite force	≥ 200	4.88 ± 2.00		0.382
	<200	5.88 ± 2.57		
Masticatory efficiency	≥ 100	3.94 ± 1.22		0.153
	<100	5.53 ± 2.24		
ii) Continuous data				
Age			0.190	0.421
Body mass index			0.189	0.425
Dry mouth			−0.155	0.515
Serum albumin			−0.178	0.453
Number of teeth			−0.188	0.428
Operation time			−0.015	0.949
OHI—S			0.207	0.380
Tongue coating			0.018	0.940

AbbreviationsOHI-S: Oral Hygiene Index - Simplex.

Table 4 Factors related to number of bacteria in saliva after starting oral intake.

Variable		mean ± SD	correlation coefficient	P-value
i) Category data				
Sex	male	4.40 ± 1.81		0.634
	female	4.88 + 2.56		
Regular dental management	(−)	4.00 ± 1.71		0.328
	(+)	4.94 ± 2.23		
Denture use	(−)	3.80 ± 1.33		0.175
	(+)	5.08 ± 2.32		
Tongue pressure	≥ 20	5.68 ± 1.96		0.114
	<20	4.09 ± 1.95		
Bite force	≥ 200	5.51 ± 2.90		0.244
	<200	4.25 ± 1.69		
Masticatory efficiency	≥ 100	4.86 ± 2.12		0.282
	<100	3.96 ± 1.69		
ii) Continuous data				
Age			−0.176	0.457
Body mass index			0.221	0.350
Dry mouth (preoperative)			−0.289	0.515
Serum albumin			0.019	0.453
Number of teeth			−0.046	0.847
Operation time			0.153	0.519
OHI—S			0.249	0.290
Tongue coating			0.066	0.783

AbbreviationsOHI-S: Oral Hygiene Index - Simplex.

The patients in this study were gastrointestinal surgery patients who were fasting on the first postoperative day and required time to start oral intake. The salivary bacterial counts increased during postoperative fasting; however, this may have been due to a decrease in oral self-cleaning when oral intake was absent. Another study also reported that patients who had no oral food intake after surgery had higher oral bacterial counts.[13] Funahara et al. also reported that oral self-cleaning decreased in postoperative patients and the number of bacteria on the tongue coating increased.[20] The Enhanced recovery after surgery guidelines advocate perioperative oral intake as a measure to shorten hospital admissions and reduce complications.[21] In addition to movements in the intestinal tract, oral food intake produces tongue movements, stimulates saliva secretion, and decreases the number of bacteria in saliva when food masses and water pass through the oral cavity; these factors are believed to decrease the risk of aspiration pneumonia.

In the preoperative, fasting, and oral feeding phases, there was a positive correlation between the OHI—S scores and the number of bacteria in saliva, and a negative correlation between oral functions such as tongue pressure, bite pressure, and masticatory efficiency and the number of bacteria in saliva. Low tongue pressure impairs the formation and feeding of food masses, and together with a decrease in the number of teeth, low tongue pressure is associated with decreased masticatory efficiency.[22] Furthermore, decreased masticatory efficiency and oral function have been associated with systemic sarcopenia.[23] It is thought that not only does low tongue pressure have such systemic effects, but it also decreases the self-cleaning function of the oral cavity, leading to an increase in oral bacteria. Low tongue pressure impairs the formation and feeding of food masses, and together with a decrease in the number of teeth, low tongue pressure is associated with decreased masticatory efficiency.[22] Furthermore, decreased masticatory efficiency and oral function have been associated with systemic sarcopenia.[23] Thus, tongue pressure reduction not only has systemic effects, but also decreases the self-cleaning function of the oral cavity, which may lead to an increase in oral bacteria. Oral function is a complex combination of tongue movements and healthy mastication that leads to healthy swallowing; therefore, we believe that swallowing and oral function are related to the number of bacteria in saliva. Tongue pressure, masticatory efficiency, and bite pressure can be easily screened in an outpatient setting; thus, it would be beneficial to test patients suspected of having flails to assess the risk of postoperative aspiration pneumonia. These observations suggest that frequent mouthwashing with povidone-iodine during the perioperative period is important[24] not only for patients scheduled for surgery where postoperative fasting is planned but also for patients suspected of having poor oral function, considering the high number of bacteria in saliva, and that careful oral care is necessary for patients who are unable to gargle.

This study has some limitations. This was a pilot study with a small number of cases, and appropriate statistical studies, such as multivariate analysis, could not be performed. Therefore, we were not able to obtain a clear

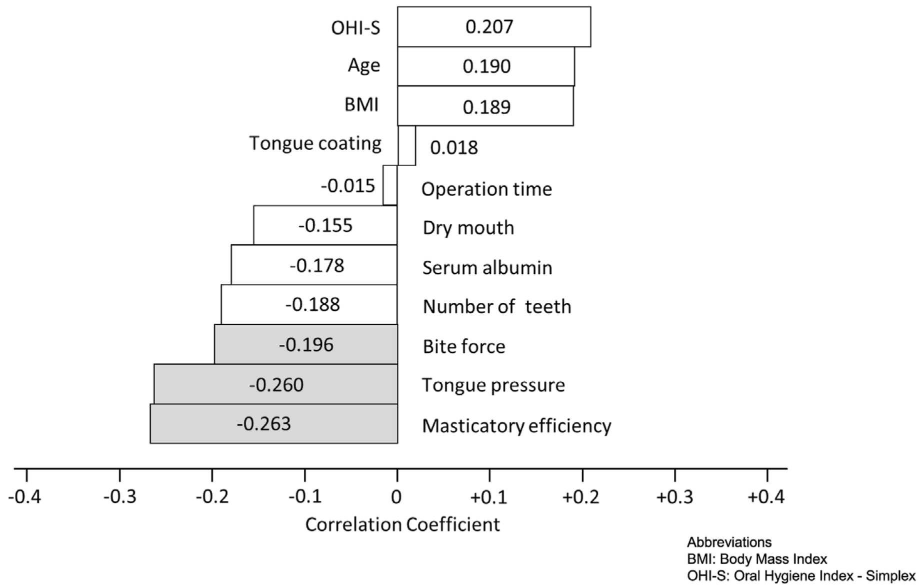

Figure 2 Correlation coefficients between the number of oral bacteria in the fasting phase and the variables
Although not significant, the number of bacteria in saliva in the fasting phase showed a positive correlation with age and the OHI—S scores and a negative correlation with masticatory efficiency, tongue pressure, and bite force, as in the preoperative phase.

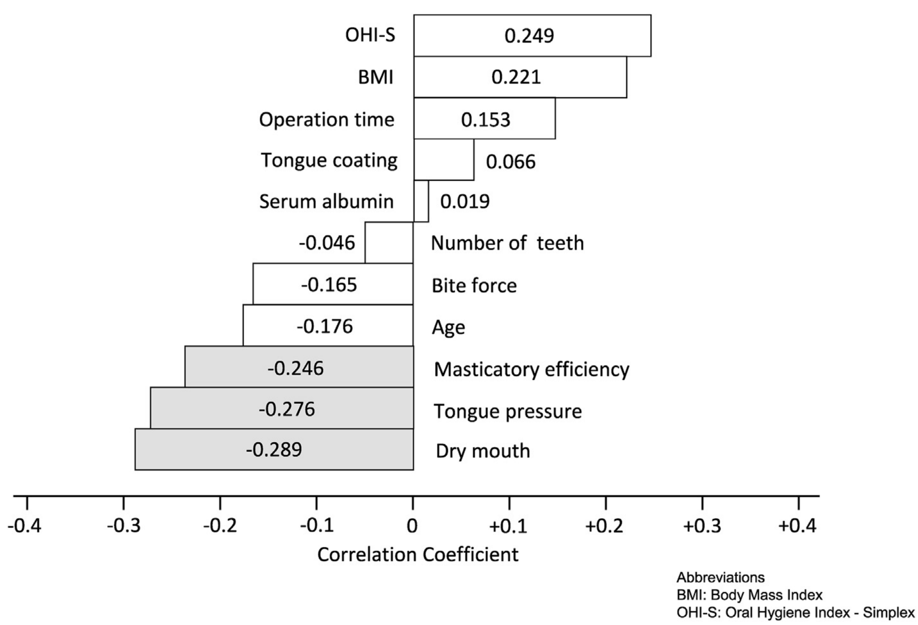

Figure 3 Correlation coefficients between the number of bacteria in saliva during the oral feeding phase and the variables
Although not significant, the number of bacteria in saliva during the oral feeding phase showed a positive correlation with the OHI—S scores, BMI, and operation time and a negative correlation with masticatory efficiency, tongue pressure, and bite force, as in the preoperative and fasting phases.

conclusion. However, few studies have examined the factors that affect the number of bacteria in saliva during the perioperative period. It was found that the number of bacteria in saliva was higher in patients with decreased oral functions, such as tongue pressure, bite pressure, and masticatory efficiency, and that the number of bacteria increased during the fasting period. This is an important finding for the systematization of POC methods.

In the future, we would like to conduct more detailed research on the relationship between oral function and salivary bacterial counts by conducting studies based on a large number of cases, clarifying the relationship between oral function and salivary bacterial counts after adjusting for confounding factors, and comparing the same patients before and after oral function training to see if it can reduce salivary bacterial counts.

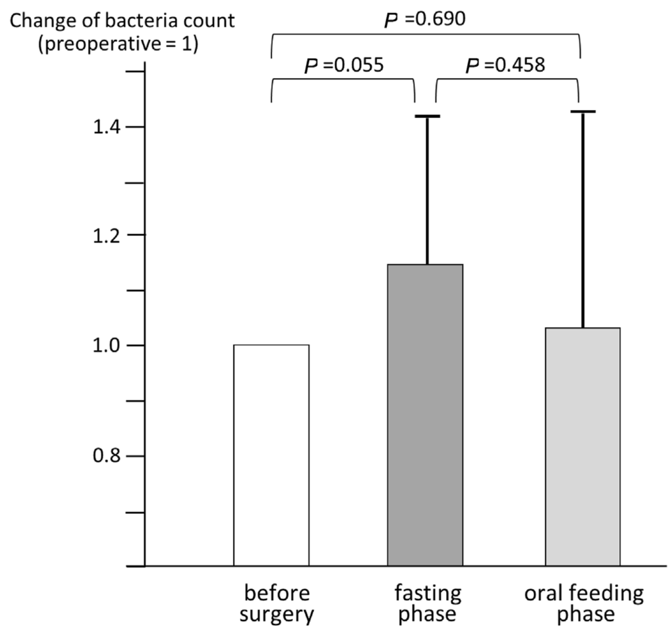

Figure 4 The number of bacteria in saliva during the perioperative period
Although no significant differences were observed, there was an increase in bacterial counts during the fasting period, but bacterial counts decreased after oral intake was started.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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