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Original Article

A retrospective cross-sectional analysis of the association between the number of medications and oral functions in university hospital outpatients

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Abstract

Purpose: The purpose of this study was to analyze the association between the number of medications and oral functions.

Methods: The study participants were selected from individuals who were attending regular follow-up as hospital outpatients. Patient profiles, the number of medications used, and measured values of oral function were extracted. These data were analyzed statistically for sex, age, and grouping according to the number of medications taken (no medication, G1; 1-4 medications, G2; ≥ 5 medications, G3). Conditional logistic regression analysis was performed to evaluate the effects of medications on oral function.

Results: A total of 172 patients (66 males and 106 females) were registered; 50 participants belonged to G1, 68 to G2, and 54 to G3. Significant inter-group differences were identified for tongue-lip motor function (oral diadochokinesis: ODK) and maximum tongue pressure in terms of age, but not in terms of sex. G3 showed significantly lower ODK than G1, and logistic regression analysis revealed that the number of medications was significantly associated with ODK/pa/. Age and MTP also significantly affected ODK/ta/ and /ka/.

Conclusion: Within the limitations of this study, the present findings suggest that the number of medications taken has an impact on tongue-lip motor function.

Keywords: oral function, oral hypofunction, polypharmacy, university hospital outpatients

Introduction

Although average life expectancy has increased globally over the last few decades, the increase of the elderly population generally implies that many individuals now have age-related multimorbidities [1]. Elderly individuals with multimorbidities are commonly prescribed multiple medications and may sometimes suffer adverse effects due to drug interactions or age-related changes in pharmacokinetics [2]. The use of multiple medicines is referred to as polypharmacy, although there have been multiple definitions of this term in previous articles [3-5]. However, the most common definition of polypharmacy has been merely the number of medications taken daily, i.e., five or more [3-5]. Adverse health outcomes such as malnutrition and frailty have been reported as negative consequences of polypharmacy, and therefore practical efforts to provide appropriate prescriptions are needed to reduce these adverse effects [6,7].

It has been reported that multimorbidity and/or polypharmacy can also have negative effects on the oral function of elderly individuals, such as xerostomia and oral mucosal lesions [8-11]. However, oral health is not limited to the oral environment, as oral functions also have an impact

on physical function, nutritional status, and general health [12,13]. The concept of “oral hypofunction” was proposed by The Japanese Society of Gerodontology in 2018 [14], and seven oral functions have been assessed for diagnosis of oral hypofunction [13,14]. For this purpose, a threshold value is assigned to each oral function, and individuals are diagnosed as being hypofunctional when at least three oral functions fall below the threshold values. This concept has encouraged various studies of oral function and contributed to progress in this field. However, the association between polypharmacy and oral function still remains insufficiently explored.

The aim of the present study was to investigate the effects of medication on oral functions that are assessed for diagnosis of oral hypofunction, especially from the viewpoint of the number of medicines being taken by individuals, and to discuss the impact of polypharmacy on oral function. The hypothesis was that polypharmacy would impact some of these oral functions.

Materials and Methods

Study design and ethical approval

The present study was designed as a retrospective observational study performed in accordance with the Declaration of Helsinki and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study protocol was reviewed and approved by the institutional ethical review committee for an observational study (approval number: 23147-00). Written informed consent from the participants was waived in view of the retrospective use of medical records.

Participant inclusion and exclusion criteria

Potential participants were individuals who visited Kyushu University Hospital for regular follow-up as outpatients between April 2020 and May 2023.

The inclusion criteria for patients were as follows: (1) all fully or partially edentulous sites had been restored with fixed or removable prostheses, and absence of any problematic oral conditions including those related to prostheses, (2) absence of any active dental problems at the time of oral function assessment, and (3) verbal confirmation of medication adherence, and proper recording of data for oral function and medication.

The exclusion criteria for patients were as follows: (1) presence of fully or partially edentulous sites that had not been restored with fixed or removable prostheses, (2) necessity of dental treatment for active dental problems at the time of oral function measurement, (3) failure to extract any of the necessary data for oral function and medication, (4) refusal for registration as a participant, and (5) previous oral surgical resection, chemotherapy or radiotherapy for tumors or tumor-like conditions.

Evaluation of oral function parameters

Six oral functions were evaluated following the diagnosis of oral hypofunction, as follows [13,14].

Oral mucosal wetness (OMW)

Oral mucosal wetness was measured using a specific oral moisture checker (Mucus, Life Co., Saitama, Japan). The tip of this device covered with a small disposal bag was placed on the tongue and the measurement value was displayed. Based on the diagnostic criterion for oral hypofunction, the

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value of 27.0 was defined as the threshold. Patients showing a value lower than 27.0 were diagnosed as having oral dryness [13,14].

Maximum occlusal force (MOF)

MOF was measured using a pressure-sensitive sheet (Dental Prescale II, GC Corp., Tokyo, Japan) and a dedicated software package (Bite Force Analyzer, GC Corp.).

The patient was instructed to bite a sheet placed intercuspally for 3 s and the sheet was then analyzed using the software. The threshold value for this system was 500 N [13].

Tongue-lip motor function (oral diadochokinesis: ODK)

Tongue-lip motor function was evaluated using a specific device (Kenkokun Handy, Takei Scientific Instruments Co., Niigata, Japan). The number of spoken repetitive syllables (/pa/ for lip motor function, /ta/ for anterior tongue motor function, and /ka/ for posterior tongue motor function) within 5 s was counted respectively. The threshold value for each syllable was 6 times per second [13,14].

Maximum tongue pressure (MTP)

MTP was measured using a specific device (TPM-01, JMS Co., Ltd., Hiroshima, Japan) consisting of an inflated balloon attached to a tongue pressure probe. The maximum value of compression caused by tongue elevation against the balloon for seconds was recorded. The threshold value was 30 kPa [13,14].

Masticatory performance (MP)

MP was evaluated as the glucose concentration resulting from crushed gummy jelly particles in 10 mL of water. The patient was instructed to chew a gummy jelly (Glucoram, GC Corp.) voluntarily for 20 s and then rinse out the particles with 10 mL of water. The glucose concentration was measured using a specific device (Glucose Sensor GS-II, GC Corp.), and the threshold value was set at 100 mg/dL [13,14].

Swallowing function (SF)

SF was assessed as the score of a self-administered questionnaire for swallowing screening (the 10-item Eating Assessment Tool: EAT-10). Individuals with a score of 3 or higher were considered to show deterioration of SF [13,14].

Data extraction and statistical analysis

Potential study participants were selected, and their medical records were sourced. These medical records needed to include the patient profiles (age, sex, the number of residual teeth and occlusal supports) and the data related to oral function and medications. Only patients for whom all these data were available were included in the study.

All data were analyzed for normal distribution using the Shapiro-Wilk normality test. First, the participants were divided into 2 groups according to sex and age (<70 years and ≥70 years) and their numerical data (number of residual teeth, occlusal supports and medication, and oral function) were compared statistically (Wilcoxon rank sum test following Shapiro-Wilk normality test). Secondly, the participants were classified into three groups according to the number of medications they were receiving (no medication, G1; 1-4 medications, G2; ≥5 medications, G3). All numerical data were also analyzed statistically (Kruskal-Wallis test and Steel-Dwass test as a *post hoc* test). Finally, significant factors revealed by these comparative analyses among the three groups were further evaluated as categorical objective variables using conditional stepwise logistic regression. All numerical data were categorized according to the threshold values (measured values of oral function) and median values (numbers of residual teeth and occlusal supports). The participants were also categorized according to the number of their medications (threshold: five) based on the definition of polypharmacy [3-5]. In this analysis, odds ratios (ORs), 95% confidence intervals (CIs), local outlier factor (LOF) *P*-value and area under the curve (AUC) were also calculated. All statistical analyses were performed using JMP Pro 17.0.0 (SAS Institute, Cary, NC, USA) and differences at *P* < 0.05 were considered statistically significant.

Table 1 Characteristics of the 172 study participants (66 males and 106 females), and those categorized by sex

Variable	Total	Sex		<i>P</i> -value†
		male	female	
Age	71.0 (64.3-77.0)	72.0 (63.8-78.0)	71.0 (64.8-77.0)	0.635
Number of medications	3.0 (0-6.0)	3.0 (0-6.0)	2.5 (0-5.3)	0.502
Number of residual teeth	20.0 (13.3-25.0)	20.0 (13.0-24.3)	20.0 (13.8-25.0)	0.748
Number of occlusal supports	8.5 (3.0-12.0)	8.0 (3.0-12.0)	9.0 (3.0-13.0)	0.634

Data are presented as median values and IQRs. †Differences between the groups using Wilcoxon rank sum test for continuous variables

Table 2 Characteristics of the 172 study participants (66 males and 106 females) categorized by age

Variable	Age		<i>P</i> -value†
	<70 years (<i>n</i> = 67)	≥70 years (<i>n</i> = 105)	
Number of medications	5.0 (0-5.0)	3.0 (1.0-6.0)	0.010
Number of residual teeth	23.0 (20.0-26.0)	17.0 (12.0-22.0)	<0.001
Number of occlusal supports	11.0 (7.0-13.0)	6.0 (1.0-12.0)	<0.001

Data are presented as median values and IQRs. †Differences between the groups using Wilcoxon rank sum test for continuous variables

Table 3 Medications received by the participants

Medicines	Number of participants
Antihypertensive drugs	60
Anti-peptic ulcer drugs	51
Stomachic drugs	
Antacid drugs	
Antihyperlipidemic drugs	45
Antidepressant drugs	30
Antidiabetic drugs	29
Bone-targeted drugs	24
Analgesic drugs	23
Anticoagulant drugs	23
Antithrombotic drugs	
Allergy drugs	21
Gout drugs	16
Hormone drugs	13
Antihormone drugs	
Steroid drugs	12
Diuretic drugs	4

Results

A total of 172 patients (66 males and 106 females) were registered as study participants. Their profiles are shown in Table 1. The data are shown as median and interquartile range (IQR) after the Shapiro-Wilk normality test. The table also shows the profiles according to sex. In terms of sex categorization, no significant differences were found among the profiles (Wilcoxon rank sum test). Table 2 shows the profiles in terms of age category (<70 years or ≥70 years); significant differences between the two groups were evident for all profiles (Wilcoxon rank sum test). It was noteworthy that the median number of medications for younger participants (<70 years) was higher than that for older participants (≥70 years).

Analysis of the medical records showed that 50 of the 172 participants were unmedicated (G1), 68 had 1-4 medications (G2), and 54 had ≥5 medications (G3). One male participant (aged 43 years) was taking 30 medications per day. Details of the various medications are shown in Table 3. The most prescribed type of medication was antihypertensive agents (60 participants), followed by anti-peptic ulcer/stomachic/antacid agents (51 participants) and antihyperlipidemic agents (45 participants).

Table 4 shows the results related to oral function in terms of median values and IQRs for the participants overall and according to sex, and the ratio (%) of participants whose oral function parameters fell below the threshold values. Statistical comparisons of oral function revealed no significant differences in terms of sex (Wilcoxon rank sum test). Participants who showed poorer MP and SF were comparatively fewer than those for other oral functions. The results of oral functional assessment according

Table 4 Median values, IQRs and number of participants with poorer oral function among total participants, and categorized by sex

Variable	Total (<i>n</i> = 172)		Sex				<i>P</i> -value†
			male (<i>n</i> = 66)		female (<i>n</i> = 106)		
	median (IQR)	RPPF (%)‡	median (IQR)	RPPF (%)‡	median (IQR)	RPPF (%)‡	
OMW	27.1 (24.9-28.8)	49.4	27.5 (25.3-29.1)	43.9	26.9 (24.9-28.4)	52.8	0.232
MOF	537.6 (313.7-879.2)	44.8	613.6 (300.0-1043.3)	37.9	511.1 (318.0-825.3)	49.1	0.098
ODK/pa/	6.0 (5.4-6.6)	43.6	6.1 (5.4-6.6)	40.9	6.0 (5.6-6.6)	45.3	0.972
ODK/ta/	5.8 (5.0-6.5)	52.9	5.8 (5.0-6.3)	62.1	6.0 (5.2-6.6)	47.2	0.225
ODK/ka/	5.6 (4.8-6.2)	62.8	5.4 (4.6-6.1)	68.2	5.6 (5.0-6.4)	59.4	0.147
MTP	31.2 (26.6-37.4)	43.0	32.0 (27.1-40.0)	40.9	31.2 (26.6-35.9)	43.3	0.275
MP	135.5 (96.5-178.8)	26.4	144.0 (97.0-187.5)	27.3	133.5 (95.5-176.3)	26.4	0.609
SF	0 (0-2.0)	18.0	0 (0-2.0)	15.2	0 (0-2.0)	19.8	0.897

†Differences between the groups using Wilcoxon rank sum test for continuous variables. ‡Rate of participants with poorer function

Table 5 Median values, IQRs and number of participants with poorer oral functions among total participants and categorized by age

Variable	Age				<i>P</i> -value†
	<70 years (<i>n</i> = 67)		≥70 years (<i>n</i> = 105)		
	median (IQR)	RPPF (%)‡	median (IQR)	RPPF (%)‡	
OMW	26.9 (24.4-28.8)	50.7	27.1 (25.3-28.8)	48.6	0.868
MOF	513.1 (305.7-901.4)	46.3	556.0 (323.0-827.5)	43.8	0.863
ODK/pa/	6.2 (5.8-7.0)	32.8	5.8 (5.2-6.4)	50.5	0.001
ODK/ta/	6.4 (5.6-6.8)	35.8	5.6 (5.0-6.2)	63.8	<0.001
ODK/ka/	6.0 (5.2-6.6)	46.3	5.2 (4.6-6.0)	73.3	<0.001
MTP	33.1 (29.5-39.9)	34.3	31.2 (26.6-37.4)	48.6	0.004
MP	147.0 (106.0-177.0)	22.4	135.5 (96.5-178.8)	29.5	0.336
SF	0 (0-2.0)	14.9	0 (0-2.0)	20.0	0.423

†Differences between the groups using Wilcoxon rank sum test for continuous variables. ‡Rate of participants with poorer function

Table 6 Associations of polypharmacy with oral function parameters

Variable	Total	G1	G2	G3	<i>P</i> -value†
Age	71.0 (64.3-77.0)	65.5 (49.8-72.0)	73.0 (67.3-78.0)	73.0 (66.0-78.0)	<0.001
Number of residual teeth	20.0 (13.3-25.0)	21.5 (17.8-26.0)	20.0 (13.3-25.0)	18.0 (10.0-22.3)	0.017
Number of occlusal supports	8.5 (3.0-12.0)	11.0 (6.0-13.0)	8.5 (3.0-13.0)	7.0 (0-11.0)	0.004
OMW	27.1 (24.9-28.8)	27.5 (24.9-28.8)	26.9 (25.0-28.8)	26.9 (24.2-28.3)	0.585
MOF	537.6 (313.7-879.2)	687.3 (324.4-1033.7)	562.0 (370.1-816.2)	455.0 (252.4-756.4)	0.110
ODK/pa/	6.0 (5.4-6.6)	6.2 (5.6-6.8)	6.2 (5.8-6.6)	5.6 (5.0-6.4)	0.003
ODK/ta/	5.8 (5.0-6.5)	6.2 (5.6-6.6)	5.8 (5.2-6.6)	5.4 (4.6-6.4)	0.008
ODK/ka/	5.6 (4.8-6.2)	5.8 (5.2-6.4)	5.6 (4.8-6.4)	5.1 (4.4-6.0)	0.015
MTP	31.2 (26.6-37.4)	31.7 (27.2-37.0)	30.9 (26.1-37.9)	31.2 (26.7-38.0)	0.852
MP	135.5 (96.5-178.8)	145.0 (115.0-201.8)	131.0 (94.0-171.8)	135.0 (87.8-181.8)	0.173
SF	0 (0-2.0)	0 (0-2.0)	0 (0-2.0)	0 (0-2.0)	0.193

Data are presented as median values and IQRs. †Differences between the groups using Kruskal-Wallis test for continuous variables

to age category are shown in Table 5, and these data were also compared statistically. This revealed significant differences in ODK/pa/, /ta/, /ka/ and MTP according to age category (Wilcoxon rank sum test).

The participants were classified into three groups according to the number of medications they were receiving, and the median values and IQRs for these groups are presented in Table 6. All oral functions were analyzed statistically among the three groups. Kruskal-Wallis test indicated significant differences in ODK values. The results of the Steel-Dwass *post hoc* test are shown in Table 7. Significant differences between G1 and G3, and between G2 and G3, were evident for ODK/pa/, and between G1 and G3 for ODK/ta/ and ODK/ka/. However, no significant inter-group differences were found for other oral functions (Table 6).

Statistical comparisons among G1, G2, and G3 revealed significant differences in all ODK values, and therefore ODK value was analyzed as a categorical objective variable using conditional stepwise logistic regression. Sex, age, the number of residual teeth and occlusal supports, the number of medications, and other oral functions were used as categorical explanatory variables. The selected categorical explanatory variables for each ODK are shown in Table 8. Among these categorical explanatory variables, the number of medications (OR: 4.55, 95%CI: 2.12-9.73), the number of residual teeth (OR: 2.76, 95%CI: 1.35-5.62), MOF (OR: 2.83, 95%CI: 1.34-5.98) and MTP (OR: 2.21, 95%CI: 1.11-4.38) were found to be significant predictive variables for ODK/pa/. For ODK/ta/ and /ka/, although the number of medications was selected as one of the explanatory variables, it was not a significant predictive variable; however, age and MTP were significant predictive variables for both functions.

Table 7 Associations of polypharmacy with oral function parameters

Variable	<i>P</i> -value†		
	G1 vs G2	G2 vs G3	G1 vs G3
Age	<0.001	0.100	<0.001
Number of residual teeth	0.362	0.227	0.012
Number of occlusal supports	0.046	0.060	0.003
ODK/pa/	0.705	0.012	0.006
ODK/ta/	0.423	0.071	0.010
ODK/ka/	0.557	0.085	0.018

†Differences between the groups using Steel-Dwass test as a *post-hoc* test**Table 8** Adjusted odds ratios and 95% confidence intervals, *P*-value, LOF *P*-value and AUC of ODK (/pa/, /ta/, and /ka/) assessed using conditional stepwise logistic regression

Objective variable	Explanatory variable	Adjusted ORs (95%CI)†	<i>P</i> -value	LOF <i>P</i> -value	AUC
ODK/pa/	number of medications	4.55 [2.21-9.73]	<0.001	0.084	0.732
	number of residual teeth	2.76 [1.35-5.62]	0.005		
	MOF	2.83 [1.34-5.98]	0.006		
	MTP	2.21 [1.11-4.38]	0.024		
	sex	1.58 [0.79-3.18]	0.198		
ODK/ta/	age	2.23 [1.12-4.43]	0.033	0.504	0.727
	MTP	2.04 [1.04-4.01]	0.038		
	number of medications	2.03 [0.99-4.18]	0.055		
	number of residual teeth	1.91 [0.96-3.81]	0.065		
	sex	1.85 [0.94-3.64]	0.075		
ODK/ka/	MTP	2.33 [1.16-4.68]	0.019	0.113	0.709
	age	2.26 [1.11-4.59]	0.024		
	number of medications	1.94 [0.91-4.12]	0.085		
	number of residual teeth	1.64 [0.80-3.34]	0.176		

†Adjusted ORs, 95% CIs, and *P*-values were calculated using conditional logistic stepwise regression.

Discussion

It has been reported that polypharmacy has multiple adverse consequences systemically [6,7]. Although the impacts of polypharmacy on oral conditions have also been reported, detailed analyses of oral functions in this context have been limited so far. The present study was designed to investigate the effects of polypharmacy on six oral functions that are used for diagnosis of oral hypofunction. These six oral functions are routinely evaluated after prosthetic treatment and at the time of regular follow-up. Oral hygiene has often been evaluated in terms of plaque control, and sometimes the tongue coating index has also been included for diagnosis of oral hypofunction [13,14]. Accordingly, diagnosis of oral hypofunction was not possible for all of the present study cohort. However, as these six oral functions are very important, it was considered meaningful to assess their association with the number of medications received.

The present study clearly demonstrated significant differences among the participants in terms of the number of medications, residual teeth, and occlusal supports when classified according to age, but not according to sex. It was suggested that younger participants had better oral conditions than older participants, but no differences were found between males and females. In this study, the number of medications (≥ 5) was adopted to define participants as receiving polypharmacy, as has been commonly done previously [3-5]. Previous studies reported that it was difficult to define the prevalence of polypharmacy in view of the variety of definitions [3-5]; some previous studies have reported that the prevalence of polypharmacy ranged from 4% to 96.5% [4], or was 37% [5]. The present study participants were limited to dental outpatients who were visiting a university hospital for regular follow-up, meaning that all were comparatively healthy, and most were independent in terms of activities of daily living (ADL). The prevalence of participants receiving polypharmacy (≥ 5 medications) was 31.4%, which is roughly in accord with previous reports [4,5]. Among the various medications, antihypertensive drugs were those prescribed most often, followed by anti-peptic ulcer/ stomachic/antacid and antihyperlipidemic drugs. Previous reports have indicated that hypertension and hypercholesterolemia were frequently diagnosed [15,16], and one previous report stated that anti-peptic ulcer/stomachic/antacid drugs were most frequently prescribed [17].

The median values for oral function parameters in the present participants were comparatively well based on the threshold values, but ODK/ta/ and /ka/ were lower than the threshold values. Significant differences were found for all ODK values and MTP between younger and older participants, although no significant differences were identified in terms of sex. The differences in oral function between males and females might have been related to the characteristics or profiles of the individual participants. Previous studies have reported that males showed significantly higher values than females for some oral functions among younger individuals with the Eichner A dental arch [18], and that this was also partly the case for elderly individuals [19-22]. However, previous studies have not produced consistent findings in terms of differences in oral function between elderly males and females, being possibly dependent on the populations examined and their characteristics, including oral conditions and ADL. At least among the present study participants, no significant differences were observed between males and females, indicating that the participants had similar oral conditions regardless of sex. Regarding the significant differences in ODK values and MTP between younger and older participants, these functions are closely associated with perioral muscles [23,24]. Age-related decline of these functions has been reported [25], and therefore it would be expected that younger and older participants would show significant differences in these functions.

The present participants were classified into three groups according to the number of medications they were receiving, and their oral functions were compared statistically. Interestingly, Kruskal-Wallis test showed significant differences in ODK values among these groups in addition to age, the number of residual teeth and occlusal supports, and ODK values declined in participants who were receiving more than five medications. ODK has been widely recognized as a method for evaluation of tongue-lip motor function or oral motor function [13,14,25-28]. As described above, it has been reported that tongue-lip motor function declines with ageing [25]. The present study showed that there were significant differences in age among the three medication groups, and conditional logistic regression

analysis was conducted to further examine the effect of all variables on each ODK parameter. As a result, the number of medications was selected as one of the explanatory variables for stepwise regression, and ODK/pa/ identified the number of medications as a significant predictive variable in addition to the number of residual teeth, MOF and MTP. Additionally, MTP and age, and not the number of medications, were identified as significant predictive variables for ODK/ta/ and /ka/. Tongue-lip motor function is regulated by oral motor neuromuscular units, and decline of this function might be related to sensory impairment [25-28]. In addition, it seems reasonable that muscle strength including MOF and MTP would be correlated. A previous study indicated that oral motor function including ODK might be compromised by mild cognitive impairment [29]. Furthermore, multiple studies have suggested that polypharmacy has a negative impact on cognitive ability or dementia [30-33]. Unfortunately, the present study protocol did not include any assessment of cognitive function. However, these previous studies and the present one suggest clinical correlations of polypharmacy with oral motor function or ODK. Tongue motor function evaluated using ODK/ta/ and /pa/ was significantly influenced by MTP and age, but not the number of medications. MTP was directly assessed by the strength of the tongue muscle, and a previous study also demonstrated a correlation between age and reduced tongue motor function. These results seem valid from an anatomical and physiological viewpoint.

Among the adverse effects of medication on oral status, xerostomia or oral dryness have been commonly recognized [11,34-37]. However, xerostomia is generally identified as subjective oral dryness, and is not always associated with salivary flow rate. The present study defined oral dryness as oral mucosal wetness on the tongue assessed using a specific device, and no differences were identified among the three groups categorized according to the number of medications. Although this method is simple and easy to perform, it cannot measure the actual salivary flow rate. Further study would help to evaluate the effects of medication on oral dryness or actual salivary flow rate, as well as subjective and objective evaluation of oral dryness.

The limitations of the present study warrant some comment. As described above, the study participants were limited to outpatients who were visiting a university hospital for maintenance after prosthodontic treatment. This implied that most of them were healthy and had reasonable ADL. Therefore, similar might not be observed for subjects with other statuses, including community-dwelling elderly, inpatients, or elderly individuals requiring nursing care. Although the methods used for assessment of oral function might not be applicable to such elderly patients, a further study of participants with various statuses would be valuable. However, this limitation might have allowed assessment of the effects of polypharmacy on oral functions due to the limited number of confounding factors including systemic diseases and oral status in comparatively healthy participants. To validate the effect of confounding factors on such analyses, further research on various factors such as the characteristics of study participants, the duration of medication, the types of medication, and a wider age range would be warranted. An additional study limitation was the number of participants, in view of its retrospective design. Therefore, a future prospective study using more participants would be desirable. Furthermore, due to the lack of oral hygiene data, the association between the number of prescribed medications and oral hypofunction was assessed using only seven factors. Oral hypofunction would be a major issue in geriatric dentistry [13,14], and a well-designed protocol would be useful for analyzing this issue.

In conclusion, this study has been able to clarify some of the effects of polypharmacy on various oral functions. Tongue-lip motor function evaluated by ODK was shown to be poorer in participants who were receiving more than five medications, and a significant association between polypharmacy (≥ 5 medications) and lip motor function was identified. Although there were some limitations to this study, tongue-lip motor function, which is easy to assess during interview or conversation, may be useful for revealing any adverse effects of medication. Further studies will be required to evaluate the adverse effects of medications on oral function using other parameters, including salivary flow rate, and to clarify the causes of decline in ODKs caused by medications.

Abbreviations

ADL: activities of daily living; AUC: area under the curve; CI: confidence

interval; EAT-10: the 10-item Eating Assessment Tool; IQR: interquartile range; LOF: local outlier factor; MP: masticatory performance; MOF: maximum occlusal force; MTP: maximum tongue pressure; ODK: oral diadochokinesis; OMW: oral mucosal wetness; OR: odds ratio; RPPF: rate of participants with poorer function; SF: swallowing function; STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

Ethical Statements

This retrospective chart review study involving human participants was conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This observational study was approved by the Kyushu University Hospital ethical review committee (approval number: 23147-00).

Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose except for the funding described below. The details were provided using the ICMJE DISCLOSURE FORM.

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Author Contributions

KN: conceptualization, investigation, data curation, formal analysis, writing - original draft, YO: conceptualization, methodology, investigation, formal analysis, funding acquisition, writing - original draft, writing - review and editing, YA: writing - review and editing curation. All authors read and approved the final version of the manuscript.

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Data Availability Statements

The datasets analyzed for the present study are not publicly available due to ethical restriction, but are available from the corresponding author on reasonable request.

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