Association of Self-reported Height Loss and Kyphosis with Loss of Teeth in Japanese Elderly

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Abstract

Study background: Height loss and kyphosis are useful surrogate markers of osteoporotic vertebral fractures in the elderly. Loss of teeth in the elderly also is associated with osteoporosis. These imply the possibility that self-reported these indices may be associated with loss of teeth in the elderly. This study aimed to clarify the associations of self-reported height loss and kyphosis with number of teeth lost in Japanese elderly.

Subjects and Methods: Among patients who visited dispensing pharmacies in Matsumoto, Japan, 307 patients (75 men and 232 women) aged 50–97 years participated in the study. They completed a structured questionnaire including covariates related to loss of teeth. Self-reported height loss and kyphosis were simply defined as three categories: no; mild-to-moderate; severe.

Results: Analyses of covariance adjusted for covariates revealed that there were no significant differences in the numbers of teeth lost in total, or during the past 1 year among the three self-reported height loss categories. Significant differences were observed in the total numbers of teeth lost among the three self-reported kyphosis categories ($p<0.001$). Subjects who were conscious of severe kyphosis had significantly larger number of teeth lost (mean $\pm$ SEM, 16.1 ± 1.8) than those who were conscious of no kyphosis (8.7 ± 0.6, $p<0.001$) and mild-to-moderate kyphosis (8.3 ± 0.7, $p<0.001$). Furthermore, there were significant differences in the number of teeth lost during the past 1 year among the three self-reported kyphosis categories ($p=0.031$). Subjects who were conscious of severe kyphosis had significantly greater number of teeth lost during the past 1 year (0.9 ± 0.2) than those who were conscious of no kyphosis (0.3 ± 0.1, $p=0.03$).

Conclusions: Our results suggest that Japanese elderly with self-reported severe kyphosis may lost more teeth than those without self-reported severe kyphosis.

Key Words: Height loss, Kyphosis, Tooth loss, Osteoporosis, Fracture

Introduction

Loss of teeth may be associated with changes in nutritional intake, progression of cognitive impairment, increased risk of disability, and increased mortality risk in elderly populations [1-4]. Dental caries and periodontal diseases are major causes of tooth loss in these populations. Retention of teeth is very important for maintenance of general health in the elderly. Although it remains unknown whether future tooth loss can be certainly predicted by evaluating dental caries and periodontal disease, smoking is significantly associated with greater progression of periodontal disease, resulting in tooth loss [5,6].

An association between tooth loss and osteoporosis determined by the percent cortical area at the metacarpal midshaft was firstly reported in postmenopausal women aged 60–69 years [7]. He concluded that middle-aged women may be more likely to retain their teeth if they avoid smoking and undertake an effective program to prevent the progression of osteoporosis. Since then, many investigators have demonstrated the association of periodontal disease progression and/or tooth loss with skeletal bone mineral density (BMD) measured by dual X-ray absorptiometry, especially in postmenopausal women [8-15]. Furthermore, a potential association of osteoporotic spine fractures with tooth loss has been reported, although the relationship between periodontitis and spine fractures remains unclear [16,17].

Two-thirds of patients with vertebral fractures have no symptoms like back pain; therefore, vertebral fractures are accurately determined by lateral radiographs. However, if such radiographs are used to evaluate the association between vertebral fractures and tooth loss, the radiation doses during the acquisition of lateral radiographs may be harmful for individuals without these fractures, making radiology hard to justify. Height loss and kyphosis from younger ages are considered to be surrogate markers or screening tools for vertebral fractures in the elderly [18,19]. Conversely, several thresholds for height loss to distinguish individuals with and without vertebral fractures have been suggested. However, it is likely that many elderly people may not accurately remember their heights at younger ages. Patients' estimated current height tended to be incorrect, with a mean difference of −2.5 cm from the current measured height, in a total of 8,610 patients with a mean age of 70.9 years [20]. Regarding kyphosis, after adjustment for age, a 15° increase in kyphosis was associated with the presence of a vertebral fracture (OR, 1.57; 95% CI, 1.46–1.69) [21]. Kyphosis was more strongly related to thoracic fractures than to lumbar fractures, and kyphosis was most prominent in women with multiple thoracic wedge fractures in their study. However, untrained investigators are unlikely to be able to easily measure the degree of kyphosis.

If height loss and kyphosis are associated with prevalent

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vertebral fractures, self-reported these indices may be associated with loss of teeth in the elderly. Therefore, the purpose of this study was to evaluate the associations of self-reported height loss and kyphosis from younger ages with number of teeth lost in Japanese elderly.

Methods

Participants and questionnaire

Among patients who visited five dispensing pharmacies in Matsumoto, Japan between November 2012 and February 2013, 307 patients (75 men and 232 women) aged 50–97 years provided written informed consent to participate in the study. They completed a structured questionnaire including age, body height, body weight, numbers of teeth lost in total and during the past 1 year, current periodontal status, number of visits to dental clinics during the past 1 year, smoking status, height loss, and kyphosis. Self-reported height loss and kyphosis were simply defined as three categories: no; mild-to-moderate; severe. Self-reported periodontal status was defined according to our previous study [22] as follows: healthy gingiva; bleeding during tooth brushing; easily bleeding without tooth brushing; severe bleeding, swelling of gingiva, and tooth mobility. In addition to the questionnaire, the pharmacists in the dispensing pharmacies provided the details of medications for osteoporosis.

Validation of self-reported numbers of teeth lost

To validate the self-reported numbers of teeth lost in our questionnaire, the actual and self-reported numbers of teeth remaining were evaluated in 200 dental patients (56 men and 144 women) aged 50–90 years (mean age: 66.5 years) who visited the dental clinic of one author (YK) in Nagano Prefecture for the treatment of dental diseases. In this preliminary study, we selected the patients who have not visited dentists for several years. In addition, we examined self-reported number of teeth at first visit of these patients.

Informed consent was obtained from patients and that the study was performed in accordance with the Declaration of Helsinki. The ethics committee of Matsumoto Dental University reviewed and approved the study protocol (date of approval: April 1, 2012, approval number: no. 0121).

Data analysis

The data for continuous variables were expressed as means ± standard deviation (SD). The chi-square test or one-way analysis of variance (ANOVA) was used to investigate differences in age, sex (male), body height, body weight, current periodontal status (four categories), number of visits to dental clinics during the past 1 year (0, 1, 2, 3, ≥ 4), smoking history (yes or no), and use of medications for osteoporosis (yes or no) among the three self-reported height loss and kyphosis categories. A Pearson correlation coefficient was calculated between the actual and self-reported numbers of teeth remaining to validate the self-reported numbers of teeth lost in 200 dental patients.

Analysis of covariance (ANCOVA) with the Bonferroni correction, adjusted for age, sex (binary), body height, body weight, current periodontal status (four categories), number of visits to dental clinics during the past 1 year, smoking history (yes or no), and use of medications for osteoporosis (yes or no) was used to calculate the numbers of teeth lost in total and during the 1 year among the three self-reported height

loss and kyphosis categories. The data were analyzed using IBM SPSS Statistics for Windows, Version 19.0 (IBM Corp., Armonk, NY). Values of $p<0.05$ were considered statistically significant.

Results

The characteristics of the 307 study subjects are shown in *Table 1*. The mean age (± SD) of all subjects was 69.4 (± 9.5) years. Overall, 67 subjects were conscious of no height loss, 191 had mild-to-moderate height loss, and 49 had severe height loss. Furthermore, 169 were conscious of no kyphosis, 117 had mild-to-moderate kyphosis, and 21 had severe kyphosis. The mean number of teeth lost in total was 9.1 (± 9.6). During the past 1 year, 73 subjects (23.8%) had lost one or more teeth. In total, 153 subjects (49.8%) had been treated with osteoporosis medications. Of these, 135 subjects had bisphosphonate (BP) therapy. The mean duration of BP use was 29.1 months, although nine subjects with BP therapy did not remember the precise duration.

The Pearson correlation coefficient between actual number of teeth remaining (mean ± SD, 20.9 ± 5.9) and self-reported number of teeth remaining (18.1 ± 7.1) was 0.82 ($p<0.001$) in 200 dental patients.

One-way ANOVA revealed that subjects with self-reported severe height loss had significantly greater mean age and smaller mean height than those with mild-to-moderate height loss ($p<0.001$) and no height loss ($p<0.001$) *(Table 2)*. Furthermore, they had significantly lower mean weight than those with mild-to-moderate height loss ($p<0.01$) and no height loss ($p<0.001$). They also had significantly greater number of teeth lost in total than those with mild-to-moderate height loss ($p<0.01$) and no height loss ($p<0.001$). In addition, progression of height loss was significantly associated with sex (male) ($p=0.006$), use of medications for osteoporosis (yes) ($p<0.001$), and smoking (yes) ($p=0.011$). No significant differences were observed for current periodontal status, number of teeth lost during the past 1 year, or number of visits to dental clinics during the past 1 year among the three height loss categories.

One-way ANOVA revealed that subjects with self-reported severe kyphosis had significantly greater mean

***Table 1.** Characteristics of 307 study subjects.*

		Mean ± SD or No. of subjects (% subjects)
Age (years)		69.4±9.5
Gender (men)		75 (24.4%)
Body height (cm)		155.3±8.6
Body weight (kg)		54.0±10.0
No. of teeth lost during past their life		9.1±9.6
Osteoporosis medication (yes)		153 (49.8%)
Smoking history (yes)		29 (9.4%)
Current periodontal status	A	203
	B	93
	C	8
	D	3
No. of teeth lost last 1 year		0.4±0.9
No. of visit to dental clinic last 1 year	0	120
	1	46
	2	25
	3	30
	>= 4	86

A: healthy gingival, B: bleeding during tooth brushing, C: easily bleeding, D: severe bleeding, swelling of gingival and tooth mobility

age than those with no height loss ($p<0.001$) and mild-to-moderate height loss ($p<0.05$) *(Table 3)*. They also had significantly smaller mean height than those with mild-to-moderate kyphosis ($p<0.001$) and no kyphosis ($p<0.001$). Subjects with no kyphosis had significantly higher weight than those with mild-to-moderate kyphosis ($p<0.05$) and severe kyphosis ($p<0.001$). Subjects with severe kyphosis had significantly greater number of teeth lost in total than those with mild-to-moderate kyphosis ($p<0.001$) and no kyphosis ($p<0.001$). In addition, progression of kyphosis was significantly associated with sex (male) ($p=0.006$) and use of medications for osteoporosis (yes) ($p<0.001$). No significant differences were observed for smoking, current periodontal status, number of teeth lost during the past 1 year, or number of visits to dental clinics during the past 1 year among the three kyphosis categories.

ANCOVA adjusted for covariates revealed no significant difference in numbers of teeth lost in total among the three self-reported height loss categories ($p=0.56$) *(Figure 1)*. Furthermore, there was no significant difference in numbers of teeth lost during the past 1 year among the three self-reported height loss categories ($p=0.70$). In contrast, a significant difference was observed in total numbers of teeth lost among the three self-reported kyphosis categories ($p<0.001$). Subjects who were conscious of severe kyphosis had significantly larger number of teeth lost (mean ± SEM, 16.1 ± 1.8) than those who were conscious of no kyphosis (8.7 ± 0.6, $p<0.001$) and mild-to-moderate kyphosis (8.3 ± 0.7, $p<0.001$), although there was no significant difference between subjects who were conscious of no and mild-to-moderate kyphosis *(Figure 2)*. Furthermore, there was a significant difference in numbers of teeth lost during the past 1 year among the three self-reported

Table 2. *Differences in characteristics of study subjects among self-reported height loss categories.*

		Mean ± SD or No. of subjects (% subjects)			*P*-value
Self-reported height loss categories		No	Mild to moderate	Severe	
Number of subjects		67	191	49	
Age (years)		62.9 ± 8.8[a]	69.7 ± 8.2[a]	77.2 ± 8.8[a]	<0.001
Gender (men)		25 (37.3%)	44 (23.0%)	6 (12.2%)	0.006
Body height (cm)		160.2 ± 8.0[a]	155.3 ± 7.9[a]	148.6 ± 7.6[a]	<0.001
Body weight (kg)		56.5 ± 11.6[a]	54.4 ± 9.5[b]	49.3 ± 7.5[a,b]	<0.001
No. of teeth lost during past their life		5.0 ± 6.4[a,b]	9.1 ± 9.5[b,c]	14.5 ± 10.8[a,c]	<0.001
Osteoporosis medication (yes)		17 (25.4%)	100 (52.4%)	36 (73.5%)	<0.001
Smoking history (yes)		12 (17.9%)	16 (8.4%)	1 (2.0%)	0.011
Current periodontal status	A	41	122	40	0.344
	B	23	62	8	
	C	2	5	1	
	D	1	2	0	
No. of teeth lost last1 year		0.3 ± 0.7	0.5 ± 1.0	0.5 ± 1.0	0.392
No. of visit to dental clinic last 1 year	0	34	64	22	0.233
	1	8	32	6	
	2	7	15	3	
	3	7	19	4	
	> = 4	11	61	14	

A: healthy gingival, B: bleeding during tooth brushing, C: easily bleeding, D: severe bleeding, swelling of gingival and tooth mobility; a: $P<0.001$, b: $P<0.01$, c: $P<0.05$.

Table 3. *Differences in characteristics of study subjects among self-reported kyphosis categories.*

		Mean±SD or No. of subjects (% subjects)			*P*-value
Self-reported kyphosis categories		No	Mild to moderate	Severe	
Number of subjects		169	117	21	
Age (years)		66.8 ± 8.3[a]	71.8 ± 0.9[a,b]	77.0 ± 7.9[a,b]	<0.001
Gender (men)		52 (30.8%)	22 (18.8%)	1 (4.8%)	0.006
Body height (cm)		156.9 ± 8.5[a]	154.5 ± 8.2[a]	146.7 ± 5.7[a]	<0.001
Body weight (kg)		55.8 ± 10.1[b,c]	52.6 ± 9.3[c]	47.4 ± 9.2[b]	<0.001
No. of teeth lost during past their life		7.3 ± 8.5[a1]	9.5 ± 9.7[a2]	20.8 ± 9.2[a1,a2]	<0.001
Osteoporosis medication (yes)		70 (41.4%)	65 (55.6%)	18 (85.7%)	<0.001
Smoking history (yes)		19 (11.1%)	10 (8.5%)	1 (4.8%)	0.563
Current periodontal status	A	115	71	17	0.485
	B	49	41	3	
	C	3	4	1	
	D	2	1	0	
No. of teeth lost last1 year		0.4 ± 0.8	0.5 ± 1.0	0.8 ± 1.3	0.098
No. of visit to dental clinic last 1 year	0	65	43	12	0.468
	1	29	15	2	
	2	16	9	0	
	3	14	13	3	
	> = 4	45	37	4	

A: healthy gingival, B: bleeding during tooth brushing, C: easily bleeding, D: severe bleeding, swelling of gingival and tooth mobility; a (1,2): $P<0.001$, b: $P<0.01$, c: $P<0.05$.

kyphosis categories (p=0.001). Subjects who were conscious of severe kyphosis had significantly greater number of teeth lost during the past 1 year (0.9 ± 0.2) than those who were conscious of no kyphosis (0.3 ± 0.1, p=0.03) *(Figure 3)*.

Discussion

Height loss and kyphosis are considered to be surrogate markers of vertebral fractures [18,19]. Our hypothesis was that these self-reported markers may be associated with number of teeth lost, because several investigators have reported associations between tooth loss and osteoporosis [8-17]. In fact, we found that self-reported kyphosis was significantly associated with number of teeth lost in our study, while self-reported height loss was not. It was reported that patients' estimated current height tended to be incorrect [20]. In addition, height loss can

Figure 1. *Total numbers of teeth lost among the three self-reported height loss categories. Data are shown as means ± SEM.*

Figure 2. *Total numbers of teeth lost among the three self-reported kyphosis categories. Data are shown as means ± SEM.*

Figure 3. *Numbers of teeth lost during the past 1 year among the three self-reported kyphosis categories. Data are shown as means ± SEM.*

be caused not only by vertebral fractures, but also to certain extents by intervertebral disk degeneration that decreases disk height, osteoarthritic conditions of the spine, hip, or knee, various inflammatory and structural/congenital spinal deformities, and weakness of the back muscles. No significant relationship was noted between vertebral fractures and height loss in 400 Japanese men and women [23]. Measurement of kyphosis may be similar to that of height loss. However, 10% of women with the most severe kyphosis had 7–17% lower BMD compared with the rest of their cohort [24]. Although we found no difference in numbers of teeth lost between subjects with self-reported no kyphosis and mild-to-moderate kyphosis, individuals with self-reported severe kyphosis may have lost more teeth in total than those with self-reported no or mild-to-moderate kyphosis.

Subjects who were conscious of severe kyphosis had significantly greater number of teeth lost (both total numbers of teeth lost and number of teeth lost during the past 1 year) than those who were conscious of no kyphosis. This implies the possibility that individuals who are conscious of severe kyphosis may lose a greater number of teeth than those without self-reported kyphosis in the future. Women who lost teeth during a 7-year follow-up period experienced less favorable changes in BMD at all sites compared with 144 women who lost no teeth among 189 healthy, white, dentate, postmenopausal women [25]. A significant relationship also was found between changes in skeletal BMD and number of teeth lost during a 5-year study period in Japanese postmenopausal women [15].

The numbers of teeth lost in total and during the past 1 year were self-reported by the participants in this study. It is likely that self-reported numbers of teeth lost may be inaccurate measures; however, many investigators have used self-reported tooth counts in large epidemiological studies to assess the associations between tooth loss and general diseases like arterial diseases and cancer [26-28]. Self-reported numbers of remaining teeth, fillings, root canal therapies, and prostheses were strongly correlated with clinical records (r=0.74–1.0) [29]. In the present study, the correlation coefficient between the actual and self-reported numbers of remaining teeth was 0.82.

This questionnaire-based survey had some limitations. First, all study subjects were patients who visited dispensing pharmacies in Matsumoto, rather than healthy subjects. In addition, some orthopedic clinics were near the dispensing pharmacies in this study, resulting in including many subjects (49.8%) who had been treated with osteoporosis medications. Therefore, our subjects are not representative of normal Japanese elderly. Our sample size of subjects also was relatively small. Further investigations including large numbers of community-dwelling individuals or those who attend medical check-ups will be necessary to clarify our findings.

Second, the self-reported periodontal status in this study was only at the time of visit to the dispensing pharmacy. The validity of a simple question asking whether subjects have periodontal symptoms is expected to be relatively good according to our previous study [22]; however, it is unknown whether self-reported periodontal status at the time of visit to a dispensing pharmacy is representative of previous or future
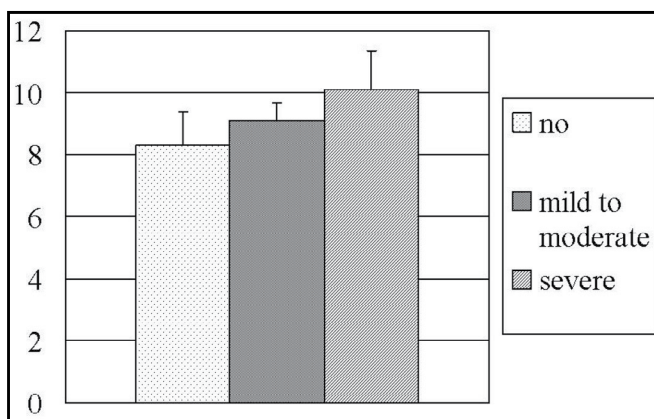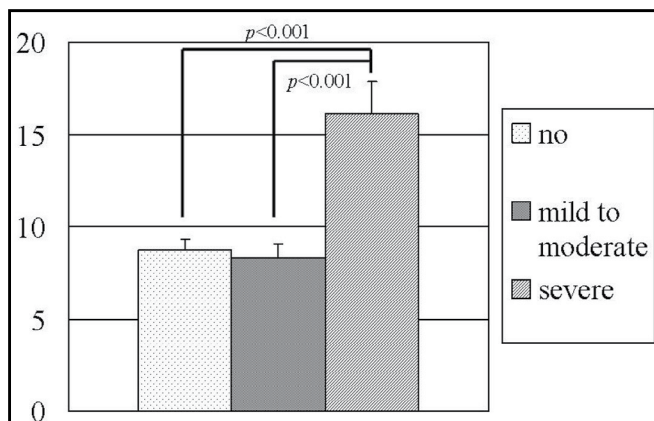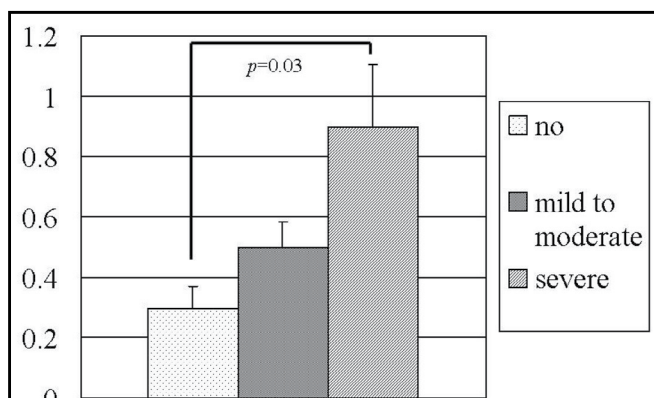
self-reported periodontal status. Clarification of the meaning of the self-reported periodontal status at the time of visit to a dispensing pharmacy would help us to apply our findings.

Third, our study was cross-sectional, but not longitudinal. Therefore, it remains unknown whether tooth loss contributed to an increase in kyphosis or osteoporosis led to both tooth loss and kyphosis in our study. Because loss of teeth is associated with impaired body balance [30], it is possible that tooth loss partly leads to an increase in kyphosis. A longitudinal study is also necessary to assess the detailed mechanism between severe kyphosis and loss of teeth in elderly populations.

Fourth, there was no previous study confirming the association between the self-reported kyphosis and presence of vertebral fractures. However, we recently found significant association between them in 460 Japanese elderly who underwent lateral spine radiographs (unpublished data). Fifth, although we did not examine the internal consistency of the questionnaire regarding self-reported kyphosis and height, this may influence the results.

Conclusions

In this study, there were no significant differences in the numbers of teeth lost, both in total and during the past 1 year, among three self-reported height loss categories. However, subjects with self-reported severe kyphosis had a significantly greater total number of teeth lost than those with self-reported no kyphosis and those with mild-to-moderate kyphosis. In addition, they had a significantly greater number of teeth lost during the past 1 year than those with self-reported no kyphosis. Our results suggest that Japanese elderly with self-reported severe kyphosis may lost more teeth than those without self-reported severe kyphosis.

Acknowledgments

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