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Relationships between stress urinary incontinence and trunk muscle mass or spinal alignment in older women

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Abstract

Objectives: Relationships between stress urinary incontinence (SUI) and physical function and spinal alignment have not been fully elucidated; therefore, we examined these relationships in older women.

Methods: The participants of this cross-sectional study comprised 21 women with SUI (SUI group) and 41 continent women (continent group) aged >65 years who participated in a community-based health-check survey from 2018 to 2019. We examined age, body mass index, number of deliveries, age at first childbirth, and medical histories as participants' characteristics. SUI was evaluated using the International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF). We also assessed spinal alignment and physical activity, grip strength, trunk and lower limb muscle mass, gait speed, and one-leg standing time as measures of participants' physical function.

Results: Body mass index was significantly higher in the SUI group compared with continents ($P = 0.04$), and trunk muscle mass in the SUI group was significantly lower ($P < 0.01$). Additionally, the thoracic kyphosis angle in the SUI group was significantly larger ($P = 0.02$). In the logistic regression analysis, trunk muscle mass (odds ratio = 0.546, $P = 0.03$) and increased thoracic kyphosis angle (odds ratio = 1.066, $P = 0.045$) were independent factors affecting SUI. Furthermore, there was a negative weak correlation between total ICIQ-SF score and trunk muscle mass ($r = -0.36$, $P < 0.01$), and a positive weak correlation between total ICIQ-SF score and thoracic kyphosis angle ($r = 0.27$, $P < 0.05$).

Conclusion: Trunk muscle mass and thoracic kyphosis angle relate to SUI status and severity among Japanese community-dwelling older women.

KEYWORDS
aging, female, posture, torso, urinary incontinence

1 | INTRODUCTION

Stress urinary incontinence (SUI) is defined as involuntary loss of urine with effort or physical exertion, or with sneezing or coughing.[1] Hannestad et al reported that half of the cases of incontinence in community-dwelling women were caused by SUI, with a prevalence of SUI of approximately 30% in women aged ≥65 years.[2] SUI is the most common type of incontinence in women and highly impacts patients' quality of life.[2,3] The International Continence Society (ICS) indicated that treatment for SUI should begin with conservative management,[4] and as the first treatment option, pelvic floor muscle (PFM) training is useful.[5] However, Sherburn et al[6] suggested that more time may be required to increase muscle strength and acquire new skills in an older population. Therefore, the effect of PFM training may depend on age.

Most research to date has focused on PFM function; few studies of SUI have investigated physical function and spinal alignment, which are presumed to affect the PFMs in older women. Regarding physical function, ≥5% decrease in grip strength was associated with new and sustained SUI, in one study.[7] In another study, sagittal thoracic curvature, lumbar curvature, and pelvic tilt were increased in the incontinence group compared with the continent group;[8] however, patients had different types of urinary incontinence, and the target age was wide. Additionally, Meyer et al[9] reported that the thoracic and lumbar spinal curvatures are not associated with the presence of pelvic floor symptoms. Thus, the association between SUI and spinal alignment remains unclear.

The purpose of the present study was to examine physical function and spinal alignment in older women with or without SUI. To our knowledge, our study is the first to investigate the association between SUI and physical function or spinal alignment, in Japan.

2 | METHODS

2.1 | Participants

The sample size was calculated based on a previous cross-sectional study investigating the association between spinal curvature and pelvic organ prolapse.[10] The calculations showed that a sample size of 46 subjects provided a power of 0.8 and a significance level of 0.05 for detecting the difference between groups. The final sample size was set at 60 in consideration of potential participant exclusions and the statistical analysis method. This cross-sectional study was part of the Togo Town study,[11] which was performed in cooperation with Nagoya University (Department of Integrated Health Sciences) and the Togo Town office, and which was a community-based health-check survey performed from July 2018 to August 2019. Individuals were selected for participation from people living in Togo, a town in Aichi. Inclusion criteria required that the participants had lived in Togo Town, participated in the health check-up survey, and were women aged >65 years. The exclusion criteria were: (a) a history of spine, respiratory, psychiatric, neurological, or rheumatic disorders, cancer, hysterectomy, or symptomatic prolapse; (b) receiving treatment for urinary incontinence; and (c) urgency urinary incontinence, mixed urinary incontinence, or other incontinence. Ninety-six women aged >65 years were assessed for eligibility, and 20 women were excluded based on their medical history. Of the 76 remaining women, 41 were continent (continent group) and 35 had urinary incontinence. Of the 35 women with urinary incontinence, those who had only SUI were included in the SUI group. The final study cohort comprised 21 women with SUI (SUI group) and 41 continent women (continent group) aged >65 years (Figure 1).

The Research Ethics Committee of Nagoya University School of Medicine approved this study (18-506), and all participants provided written informed consent prior to participation. This study met the guidelines of the Declaration of Helsinki.

2.2 | Outcomes

2.2.1 | SUI

The International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF) was used as a condition-specific questionnaire assessing the subjective symptoms and quality of life of women with urinary incontinence, and its reliability, validity, and responsiveness have been sufficiently verified.[12] The Japanese version of the ICIQ-SF has also been verified for reliability, validity, and responsiveness.[13] The ICIQ-SF is scored according to three items: "frequency of leakage", "amount of leakage", and "interference with everyday life". Additionally, the score consists of one reference item, "When does urine leak?", which is not included in the score. The total score ranges from 0 to 21 points, and higher scores indicate more severe symptoms of urinary incontinence and poorer quality of life. In this study, participants were classified by the presence or absence of approximately

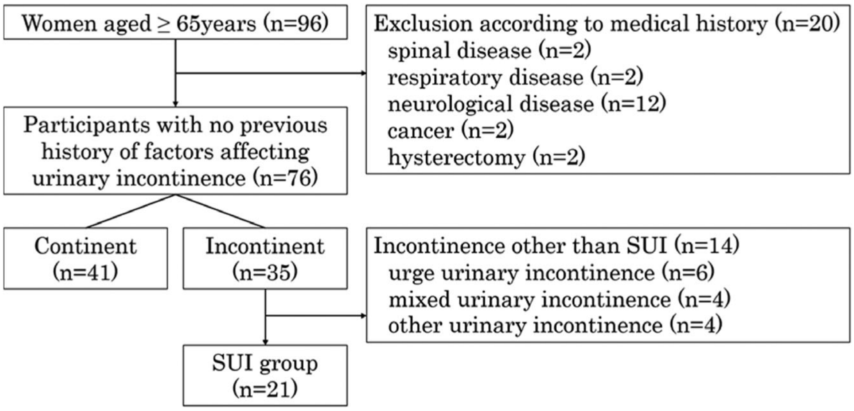

FIGURE 1 Participant flowchart. SUI, stress urinary incontinence

once a week or less often urinary incontinence defined as a rating of ≥1 on the ICIQ-SF. Among the women with urinary incontinence, those who checked "leaks when coughing or sneezing" or "leaks when physically active or exercising" constituted the SUI group.

2.3 | Physical functions

Physical activity was evaluated using the Japanese version of the International Physical Activity Questionnaire-Short Form (IPAQ-SF). The IPAQ-SF consists of four questions: (a) physical activity related to walking; (b) moderate physical activity; (c) vigorous physical activity; and (d) sitting time.

We evaluated grip strength as an index of whole-body muscle strength using a digital grip strength meter (TKK5401 digital dynamometer; Takei Kiki Kogyo Co., Ltd., Niigata, Japan). The measurement was performed twice for each hand. The highest value was recorded for each hand, and the mean of the two hands was calculated.

The muscle mass of each participant's trunk and lower limbs was measured using a body composition analyzer (MC-780A; TANITA, Tokyo, Japan), and the muscle mass of the trunk or lower limbs was divided by the square of the height to standardize.

Participants performed the 10-m walking test twice at a normal speed, and the mean was calculated as the normal walking speed.

With participants standing with both hands on their hips and eyes open, we measured the time during which one leg was raised by approximately 5 cm. The upper limit of the measurement time was 30 seconds. The measurement termination criteria were when the raised leg touched the floor, when the supporting leg moved, when the hand separated from the waist, and when the raised leg touched the opposite side. The measurement was performed once for each side, and the mean of the left and right was calculated.

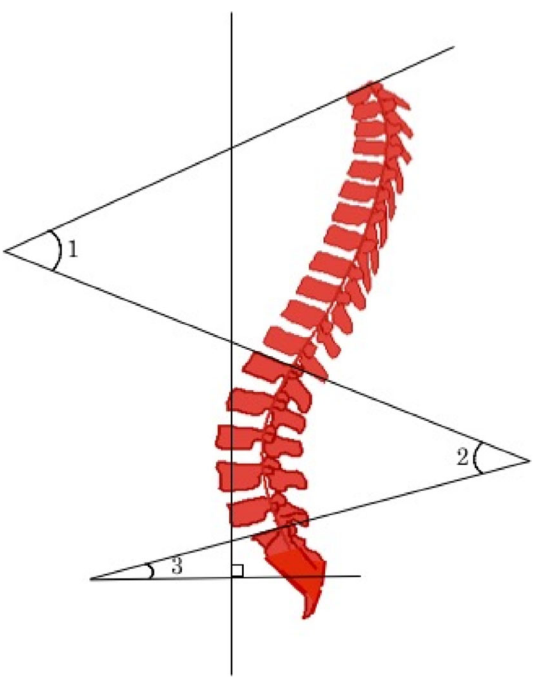

FIGURE 2 Spinal alignments. 1. Thoracic kyphosis angle. 2. Lumbar lordosis angle. 3. Sacral inclination angle

2.4 | Spinal alignment

Spinal curvature was measured using a non-invasive skin surface measurement device (Spinal Mouse; Idiag AG, Fehraltorf, Switzerland), for which the reliability and validity have been sufficiently verified.[14,15] In this study, we confirmed that the assessor had a high intra-rate reliability before taking participants' measurements (unpublished data). During the test, participants spread their bare feet 10 cm apart, adopted a comfortable standing position, looked straight ahead, and the assessor applied the Spinal Mouse to the side of the spinous process from the 7th cervical vertebra to the 3rd sacral vertebra (S3). Thoracic kyphosis, lumbar lordosis, and sacral inclination were then measured. The thoracic kyphosis angle is the curvature of the entire spine from the first thoracic vertebra (Th1) to 12th thoracic vertebra (Th12), and the sum of the 11 angles from Th1/2 to Th11/12. The sum of the six angles from Th12/lumbar 1 to lumbar 5/sacral 1 (S1) in the curvature in the entire lumbar spine from Th12 to S1 is the lumbar lordosis angle (Figure 2). The sacral inclination angle is the angle between the back surface drawn through the sacrum with respect to the vertical line through the spine. The measurements were considered positive values for kyphosis and negative values for lordosis.

2.5 | Statistical analysis

After confirming the normality of the data using the Shapiro–Wilk test, comparisons between groups according to the presence or absence of SUI were performed using an unpaired *t* test for normally distributed data, or the Mann–Whitney *U* test for non-normally distributed data. The working status was compared using the Chi-squared test. To investigate the factors affecting the presence or absence of SUI, we performed logistic regression analysis (forced input method). The dependent variable was the presence or absence of SUI, and the independent variables were items with a significant difference between the SUI group and the continent group. Additionally, we assessed correlations between the severity of SUI and other parameters using Spearman's rank correlation analysis. SPSS version 26.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis, and the significance level was set at $P < 0.05$.

3 | RESULTS

The prevalence of SUI in the 76 community-dwelling older women without a history of urinary incontinence was 28% (n = 21). The

TABLE 1 Participants' characteristics and physical function and spinal alignment with or without SUI

	Older women (n = 62)		
	SUI group (n = 21)	Continent group (n = 41)	*P* value
Age, y[a]	73.7 ± 4.5	72.1 ± 4.8	0.22
BMI, kg/m^{2}[a]	23.3 ± 3.2	21.8 ± 2.9	0.04
Number of births[b,c]	2 (0-3)	2 (1-4)	0.97
Vaginal delivery[b,c]	2 (0-3)	2 (0-4)	0.65
Cesarean[b,c]	0 (0-1)	0 (0-2)	0.73
Instrument deliveries[b,c]	0 (0-0)	0 (0-2)	0.47
Age at first birth, y[a]	26.1 ± 3.7	25.5 ± 2.8	0.54
Total physical activity, METs · min/wk[b]	1239 (60-7518)	1337 (99-8316)	0.68
Vigorous physical activity, METs · min/wk[b]	0 (0-1800)	0 (0-2160)	0.82
Moderate physical activity, METs · min/wk[b]	0 (0-1800)	240 (0-3360)	0.11
Physical activity related to walking, METs · min/wk[b]	677 (0-4158)	677 (0-8316)	0.76
Sitting time, min[b]	330 (60-1080)	240 (60-1020)	0.21
Grip strength, kg[a]	21.8 ± 3.9	22.2 ± 3.4	0.66
Trunk muscle mass, kg/m^{2}[a,d]	8.5 ± 0.7	9.7 ± 1.8	<0.01
Lower limb muscle mass, kg/m^{2}[a,d]	4.9 ± 0.7	4.8 ± 0.6	0.11
Gait speed, m/s[b]	1.4 (0.7-1.6)	1.4 (0.9-1.7)	0.53
One-leg standing time, s[a]	21.0 ± 6.6	19.8 ± 6.8	0.48
Thoracic kyphosis angle, degrees[a]	41.4 ± 11.0	35.0 ± 9.5	0.02
Lumbar lordosis angle, degrees[a]	−19.8 ± 11.0	−20.2 ± 7.9	0.90
Sacral inclination angle, degrees[a]	4.3 ± 9.5	7.6 ± 6.9	0.12

Abbreviations: BMI, body mass index; MET, metabolic equivalent task; SUI, stress urinary incontinence.
[a]Unpaired *t* test, mean ± SD.
[b]Mann–Whitney *U* test, median (range).
[c]n = 53 (SUI group: n = 18; Continent group: n = 35).
[d]n = 60 (SUI group: n = 19; Continent group: n = 41).

TABLE 2 Logistic regression analysis for SUI

	Model 1			Model 2		
	OR	95% CI	*P* value	OR	95% CI	*P* value
BMI, kg/m^2	1.141	0.901-1.444	0.27	1.066	0.801-1.316	0.66
Trunk muscle mass, kg/m^2	0.546	0.316-0.943	0.03	0.485	0.235-0.998	0.04
Thoracic kyphosis angle, degrees	1.066	1.001-1.135	0.045	1.090	1.004-1.183	0.049

Note: Model 1: three variables with a *P* value of <0.05 (ie, BMI, trunk muscle mass, and thoracic kyphosis angle) in the univariate analysis were entered into the logistic regression model (forced input method). Model 2: the logistic regression model was adjusted for age, the number of vaginal deliveries, and the working status without missing value imputation.
Abbreviations: BMI, body mass index; CI, confidence interval; OR odds ratio; SUI, stress urinary incontinence.

frequency of SUI was 71% (n = 15) for "about once a week or less often", 19% (n = 4) for "two to three times a week", and 10% (n = 2) for "about once a day", and the prevalence of SUI leakage volume was 81% (n = 17) for "a small amount", 0 for "a moderate amount", and 5% (n = 1) for "a large amount"; three participants did not answer this question on the form. The median ICIQ-SF total score was 4 (range 1-8).

Comparing the presence or absence of SUI, participants' body mass index (BMI) was significantly higher in the SUI group than in the continent group (23.3 ± 3.2 vs 21.8 ± 2.9, respectively; $P = 0.04$). Additionally, there were no significant differences in age, number of births, and age at first birth (Table 1). Regarding the mode of delivery, vaginal delivery was the major form in both the SUI group and the continent group (86% vs 78%, respectively; $P = 0.65$). There was no significant difference in the working status between the groups ($P = 0.47$).

The results of the comparison of physical function and spinal alignment in the SUI and continent groups are shown in Table 1. There were no differences between the SUI group and continent group for physical

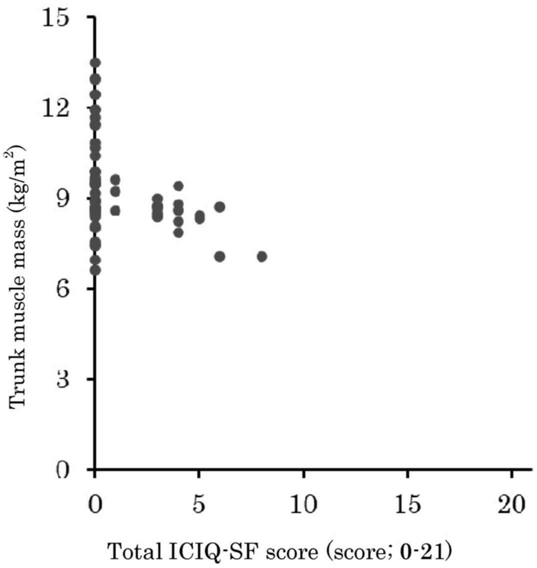

FIGURE 3 Correlation between trunk muscle mass and total ICIQ-SF score. ICIQ-SF, International Constitution on Incontinence Questionnaire-Short Form. The total ICIQ-SF score is negatively correlated with the trunk muscle mass ($r = -0.36$, $P < 0.01$)

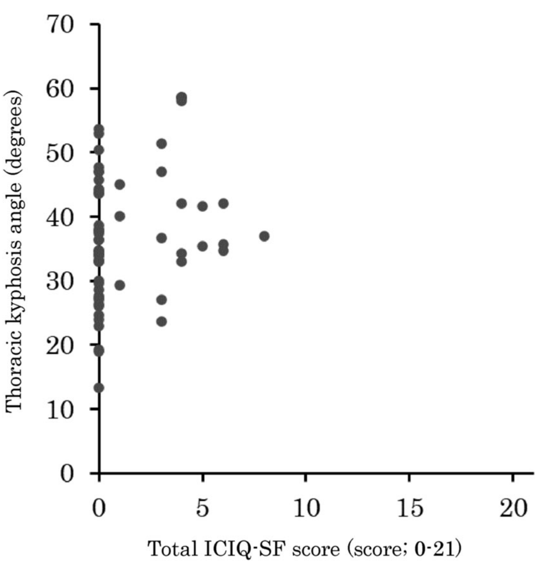

FIGURE 4 Correlation between thoracic kyphosis angle and total ICIQ-SF score. ICIQ-SF, International Constitution on Incontinence Questionnaire-Short Form. The total ICIQ-SF score is positively correlated with the thoracic kyphosis angle ($r = 0.27$, $P = 0.04$)

activity, grip strength, lower limb muscle mass, gait speed, and one-leg standing time. Conversely, trunk muscle mass was significantly lower in the SUI group than in the continent group (8.5 ± 0.7 vs 9.7 ± 1.8, respectively; $P < 0.01$). The thoracic kyphosis angle was significantly larger in the SUI group than in the continent group (41.4 ± 11 vs 35.0 ± 9.5, respectively; $P = 0.02$), while the lumbar lordosis angle and sacral inclination angle did not differ significantly between the groups.

The results of the logistic regression analysis are shown in Table 2. In model 1, the dependent variables were the presence or absence of SUI, and the independent variables were BMI, trunk muscle mass, and thoracic kyphosis, which differed significantly between the SUI group and continent group ($P < 0.05$). Trunk muscle mass (odds ratio = 0.546; 95% confidence interval: 0.316-0.943, $P = 0.03$) and thoracic kyphosis angle (odds ratio = 1.066; 95% confidence interval: 1.001-1.135, $P = 0.045$) were factors affecting the presence or absence of SUI. The logistic regression model (model 2) was adjusted for age, the number of vaginal deliveries, and the working status. Similarly, the trunk muscle mass (odds ratio = 0.485; 95% confidence interval: 0.235-0.998, $P = 0.04$) and the thoracic kyphosis angle (odds ratio = 1.090; 95% confidence interval: 1.004-1.183, $P = 0.049$) were independent factors.

We found a negative weak correlation between total ICIQ-SF score and trunk muscle mass ($r = -0.36$, $P < 0.01$) and a positive weak correlation between total ICIQ-SF score and thoracic kyphosis angle ($r = 0.27$, $P = 0.04$) (Figures 3 and 4).

4 | DISCUSSION

Our results showed that trunk muscle mass and thoracic kyphosis angle related to SUI among Japanese community-dwelling older women. Few previous reports have investigated the physical functions affecting SUI in older women, and to our knowledge, this study is the first to investigate the association between SUI and spinal alignment in Japan.

In a large-scale epidemiological study of community-dwelling women, the prevalence of SUI was approximately 30% in older women aged ≥65 years.[2] The prevalence of SUI in our study was similar, at 32%, in older women of the same age as in the previous study. Klovning et al[16] classified the total ICIQ-SF score as 1 to 5 (mild), 6 to 12 (moderate), 13 to 18 (severe), and 19 to 21 (most severe). In our study, the average total ICIQ-SF score was 3.9 ± 1.8 points, and mild symptoms occurred in 17 participants (81%).

In this study, when comparing the characteristics of participants with and without SUI, those with SUI had significantly higher BMI compared with those without (continent group). Obesity increases abdominal pressure, chronically loads the pudendal nerves and PFMs,[17] and weakens the PFMs.[18] Additionally, abdominal pressure during physical activity may increase secondary to excessive weight,[17] which causes an increase in intravesical pressure and may lead to SUI. However, our study included few elderly women who were obese with a BMI of ≥25 kg/m^2; thus, the BMI was not an independent factor related to SUI.

Trunk muscle mass was significantly lower in the SUI group than in the continent group, and trunk muscle mass related to a factor affecting the presence or absence of SUI. Furthermore, higher subjective SUI severity was associated with lower trunk muscle mass. Sapsford suggested co-ordination between the PFMs and abdominal muscles, and PFMs are activated by contraction of abdominal muscles.[19,20] Low trunk muscle mass may affect PFM activity, therefore it may have been related to trunk muscles and SUI in our study.

The thoracic kyphosis angle was significantly larger in the SUI group than in the continent group, and this angle related to a factor affecting the presence or absence of SUI. Additionally, higher subjective SUI severity was associated with higher thoracic kyphosis angle. Previous studies reported a relationship between the severity of pelvic organ prolapse and thoracic kyphosis,[10] therefore the results of our study were similar to those of the study of pelvic organ prolapse. Regarding relationship between thoracic kyphosis and PFM, there has been a which study reported that PFM activity at rest is lower in a slumped sitting position, with increased thoracic kyphosis and reduced lumbar lordosis than in an upright sitting position.[21] In addition, in patients with respiratory disease, those with excessive thoracic kyphosis are reported to have high abdominal pressure.[22] Although increased PFM activity is required to maintain continence with increasing abdominal pressure, women with SUI have significantly lower PFM strength vs continent women.[23] Furthermore, PFM weakness has been reported with aging.[24] Older women with SUI may not be able to increase PFM activity against increased abdominal pressure with increased thoracic kyphosis. In a previous study, thoracic kyphosis increased with age;[25] however, we found no significant correlation between age and thoracic kyphosis for all of our participants. The results of this study suggest that thoracic kyphosis may affect SUI.

In the present study, we found no significant difference in the amount of physical activity, grip strength, lower limb muscle mass, normal walking speed, and one-leg standing time when comparing the presence or absence of SUI. Previous studies reported a significant association between one-leg standing time, walking speed, and urgency urinary incontinence.[26] Patients with urgency urinary incontinence remain close to a bathroom and tend to limit physical activity.[27] Conversely, in SUI occurring when abdominal pressure increases, the influence of movement and balance ability was considered small in the present study.

The limitations of this study are that its cross-sectional study means there was potential for reverse causality. Additionally, we did not evaluate PFM strength and the status of constipation, which are presumed to have a significant effect on SUI, and SUI was not objectively confirmed. Also, the sample size was small, the participants may have been a relatively health-conscious population, and most had mild SUI; thus, the generalizability of this study is limited.

In conclusion, trunk muscle mass and thoracic kyphosis angle relate to SUI and subjective SUI severity in community-dwelling older women. In a future study, we will perform an additional evaluation of PFM function to reveal the relationships between PFM and the trunk muscles or spinal alignment. Focusing on the trunk muscle mass and thoracic kyphosis angle in addition to the PFMs may be useful for treating older women with SUI.

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DISCLOSURE

The authors declare they have no conflict of interest.

ETHICS APPROVAL

The Research Ethics Committee of Nagoya University School of Medicine approved this study (18-506).

CONSENT TO PARTICIPATE

All participants provided written informed consent.

CONSENT FOR PUBLICATION

All participants gave consent to publish their medical details.

AUTHOR'S CONTRIBUTIONS

Saki Iguchi: manuscript writing, data collection or management. **Tomoe Inoue-Hirakawa**: manuscript writing/editing, protocol development. **Ippei Nojima**: manuscript editing, project development. **Taiji Noguchi**: manuscript editing, project development. **Hideshi Sugiura**: manuscript editing, project development.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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