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Postpartum radiographic changes in pelvic morphology and its relation with symptoms of pregnancy-related symphysis pain

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Summary

Introduction: The etiology of pregnancy-related pubic symphysis pain (PSP) is usually considered as the change in pelvic biomechanics during pregnancy. However, the biomechanical changes that occur during puerperium, and the difference of radiographic dimensions in women with different types of PSP remains unknown. *Materials and Methods:* Fifty women with self-reported PSP were included. Two conventional X-ray radiographic dimensions obtained on the delivery day and one-month postpartum were compared by using paired *t*-test. Based on the self-reported VAS at one-month postpartum, variables between pain-recovery and non-recovery groups were also compared. *Results:* The comparison between pre- and post-values indicates a reduced distance between FLAMs (239.1 *vs*. 237.0 mm), PS separation (7.9 *vs.* 6.5 mm), and PS translation (4.1 *vs*. 3.1 mm). No significant differences were observed in the distance between FLAMs, width of PS separation, or pubic symphysial surface (PSS) angle between the recovery and non-recovery groups. However, the non-recovery group exhibited a significantly large change in PS translation at one-month postpartum than the recovery group (-1.8 *vs*. -1.1 mm). *Conclusions:* The pelvic radiography demonstrated a 'closure' alteration in the pelvic cavity diameter one-month postpartum with a decrease in the distance between FLAMs and shortened PS separation. The difference in radiographic diameters between groups was not clearly evident.

Key words: Pregnancy-related pubic symphysis pain (PSP); Pelvic biomechanics during pregnancy; Radiography.

Introduction

Pregnancy-related pelvic girdle pain is recognized as a very common problem in recent years involving a variety of dysfunctions in the pelvic area. Among these dysfunctions, pubic symphysis pain (PSP) with a reported prevalence from 8.3% to 45% in pregnant woman [1-4] has been widely studied [5]. The adverse effects on the quality of life and the mental health [6] were reported in previous studies. Although the etiology of PSP is primarily speculated as the instability of pelvis resulting from a biomechanical change during pregnancy [7], there are still many factors that remain to be investigated.

Recent findings of the radiology research suggest that the degree of the pubic symphysis separation was commonly regarded as the clinical indicator of PSP [5, 8], despite several studies suggesting no correlation between the radiographic findings and the severity of pain [9-11]. However, few research studies have focused on the PSP after delivery. It was reported that a prolonged recovery time of PSP, for as long as two years [12], was likely to be correlated with the risk factor of old age [13], early onset of pain during gestation [14], and longer duration of labor [15], but still no study had investigated if changes in the pelvic alignment after delivery had an effect on the severity or the duration of PSP. So far, the widely used methods of examining abnormal in the pubic area are advanced MRI and diagnostic ultrasound to discover marrow edema or hemorrhage [16], which was probably caused by the trauma during delivery. However, these minute damages that could affect the prognosis of PSP could not be detected using the conventional X-ray films. Therefore, the present authors hope to discover the latent relationship between the morphological changes on radiography and the symptom in patients, which could provide more helpful insights to predict the clinical prognosis of postpartum PSP. They hypothesized that the diameter of pelvic cavity would decrease after childbirth and the radiographic information could be theoretically consistent with the clinical findings of PSP. For these reasons, the present study aimed to clarify the radiographic changes of pelvic morphology during puerperium. Furthermore, the authors also intend to evaluate the differences in radiographic dimensions on conventional X-ray films between women with or without full recovery of PSP a month post-delivery.

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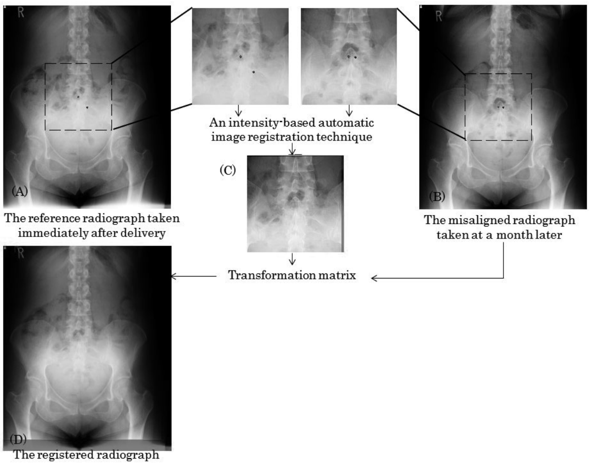

Figure 1. — The process of intensity-based automatic image registration is illustrated. The radiograph taken one month later (B) aligns with the reference radiograph that was taken immediately after the delivery (A), and then, images around sacrum are compared to define a transformation matrix (C). Finally, the registered radiograph is constructed (D).

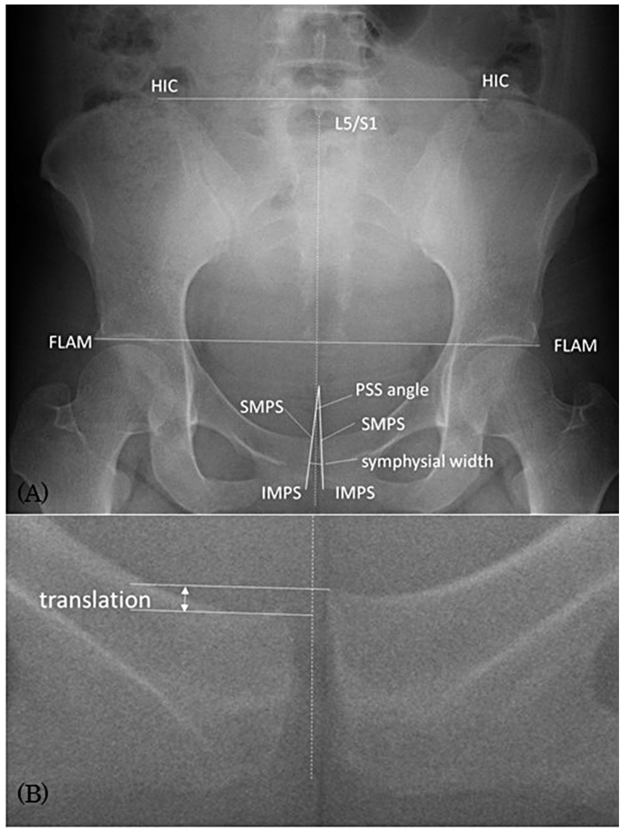

Figure 2. — Radiographic measurements. The highest point of iliac crest (HIC), the furthest lateral points of acetabular margin (FLAM), superior margin of the pubic symphysis (SMPS), and the inferior margin of the pubic symphysis (IMPS) are marked on each radiograph as shown (A). The pubic symphysial surface (PSS) angle is defined as the angle between two lines combined SMPS and IMPS on each side. The symphysial width is the distance between midpoints of SMPS and IMPS on each side. The distance between two lines perpendicular to the reference line (L5-midpoint of IMPSs) through the SMPS on the right and left represent the translation of pubic arches (B).

Materials and Methods

Fifty pregnant women with self-reported PSP were enrolled in this study. All participants visited an obstetrical clinic periodically over the study period. The exclusion criteria included the history of dementia, current neurologic problems, or any other type of cognitive dysfunction. A written informed consent was obtained from all participants. All experimental procedures were approved by the ethical committee of Kyoto University (approval number E2076).

Two anteroposterior pelvic radiographs were taken within 12 hours and one-month postpartum. Both radiographs were obtained with subjects standing upright in front of the film with X-ray source perpendicular to the long axis of the body. Distance between film and trunk was fixed at 0.3 m for each measurement.

In order to reduce the influence of different photographing conditions, two radiographs were aligned by an intensity-based automatic image registration technique. This technique involves designating one radiograph as the reference [17], and applying geometric transformations to the other radiograph so that it aligns with the reference. In this study, the reference was a radiographic image that was taken immediately after delivery.

As shown in Figure 1, the images around sacrum were cut off. The image metrics take two radiographs and provide a scalar value that describe the degree of similarity between two images. The optimizer defines the methodology for minimizing or maximizing the metrics similarity. The transformation matrix that brings the misaligned radiograph was defined.

An experienced examiner assessed the processed images using Amira 5.4.3 software. The present authors identified the plane coordinates of bilateral highest point of iliac crests (HIC), bilateral furthest lateral points of acetabular margins (FLAM), bilateral superior margin of the pubic symphysis (SMPS), bilateral inferior margin of the pubic symphysis (IMPS), and spinous process of L5 (Figure 2A). The authors failed to measure the anterior superior iliac spine or the pubic tubercle as more than half of the images showed illegible borderlines.

The distance between bilateral HIC and FLAM was calculated using the distance formula. The midpoints of ipsilateral SMPS and IMPS were recognized, and the length of line that combined the midpoint of both sides was defined as the symphysial width. The pubic symphysial surface (PSS) angle was defined as the angle between two lines combined with SMPS and IMPS on each side. The vertical motion of the symphysial surface was evaluated using the method described in previous study [18] by drawing a reference line through the spinous process L5 to the midpoint of bilateral IMPS. Two lines, perpendicular to the reference line, were then drawn to the superior margin of the PS on the left and right sides. The distance between two pedal points was then recorded as the translation of the PS (Figure 2B).

The PSP was assessed with visual analogue scale (VAS). Each participant separately reported the degree of pain in the area of symphysis pubis on a 0-10 Numeric Pain Rating Scale. The questionnaire was obtained at 12, 24, 30, 36 weeks after gestation, the

Table1. — *The demographic characteristics of each comparative group.*

Variables	Total (n=50)	PSP recovery (n=37)	PSP non-recovery (n=12)	*p* value
Age (years)	32.8 ± 4.5	32.3 ± 4.7	34.3 ± 3.8	0.177
Height (meters)	158.0 ± 7.0	156.9±7.2	161.0 ± 5.7	0.085
Weight before pregnancy (kg)	53.2 ± 10.0	53.0 ± 11.0	53.8 ± 6.5	0.808
BMI (kg/m^2)	21.2 ± 3.6	21.5 ± 4.4	20.7 ± 1.8	0.419
Birth weight (g)	3089 ± 437	3073 ± 399	3139 ± 558	0.667
Primipara no. (%)	14 (28.6)	12 (32.4)	2 (16.7)	0.293
Natural delivery no. (%)	44 (89.8)	32 (86.5)	12 (100)	0.179

The age, height, weight before pregnancy, BMI, and birth weight, were compared between PSP recovery and non-recovery groups by unpaired t-test. The number of primipara and natural delivery in two groups were compared using chi-square test. No significant result was found in any comparison.

Table 2. — *Comparison of pelvimetry dimensions at the delivery day and at 1 month postpartum.*

Variables	Postpartum	1 month postpartum	*p* value
Distance between HICs (mm)	164.9 ± 21.4	164.9 ± 21.6	0.957
Distance between FLAMs (mm)	239.1 ± 14.1	237.0 ± 15.2	0.004*
PS separation (mm)	7.9 ± 2.0	6.5 ± 1.4	<0.001*
PS translation (mm)	4.1 ± 1.6	3.1 ± 1.2	<0.001*
PSS angle (°)	13.0 ± 8.1	13.5 ± 7.9	0.413

HIC: the highest point of iliac crest; FLAM: the furthest lateral points of acetabular margin; PS: pubic symphysis; PSS: pubic symphysial surface.
*All the variables compared by paired t-test analysis * $p < 0.05$*

delivery day (within 12 hours after delivery), and one month after parturition. VAS ≥ 1 was defined as the PSP.

Subjects were divided into recovery and non-recovery groups, women with self-reported VAS =0 at one-month postpartum were assigned to the recovery group. Conversely, women that still had pain a month later were assigned into the non-recovery group. For further investigation on the PSP changes in all periods, the time-dependent VAS curve with average values was drawn for subjects who underwent a natural delivery. The largest value of VAS obtained from the questionnaires given four different times during the period of pregnancy was compared with the VAS value obtained immediately after delivery, to identify a labor-induced pain aggravation. The recovery and non-recovery groups were also represented separately in two time-dependent curves.

Data analysis was performed using SPSS (version 22.0). The normality of all the variables was examined with the Shapiro-Wilk test. The paired *t*-test was utilized to assess the radiographic differences between the delivery day and one-month postpartum (all the variables were confirmed as parametric data). To verify differences in demographic characteristics between the pain recovery and the non-recovery groups, the age, height, weight before pregnancy, BMI, and birth weight were compared by unpaired *t*-test (all the variables were parametric data). The proportion of subjects that had primipara and natural delivery were compared using chi-square test. To evaluate differences between groups, with and without full pain recovery in a month after parturition, the unpaired *t*-test was used for parametric variables, whereas the Mann-Whitney U test was used for non-parametric variables. The proportion of women with increased PSP immediately after delivery was compared with chi-square test between two groups. *P* values less than 0.05 were considered statistically significant.

Results

Fifty women with pubic symphysis pain PSP were included in the comparison of radiographic data between the day immediately postpartum within 12 hours and one-month postpartum. In comparison between the PSP recovery and non-recovery groups, one participant was excluded from the analysis due to the missing data one month postpartum. In the time-dependent pain analysis, six women were excluded from the comparison as they underwent an unnatural delivery of cesarean section, vacuum extraction, or forceps delivery.

The demographic characteristic of each compared group is listed in Table 1. The age, height, weight before pregnancy, body mass index, birth weight, parity, and the pain recovery state were recorded in separate groups. No significant difference was found with any variable.

The radiograph-measured dimensions obtained immediately after delivery and at one-month postpartum were compared in all the subjects. The length between both sides of FLAMs was significantly lower at one-month postpartum than just after delivery ($p = 0.004$). The width of PS separation also illustrated a significant shortening a month after parturition ($p < 0.001$). In the axis direction of pelvis, one-month postpartum images exhibited a significantly low translation of PS when compared with the immediately postpartum images ($p < 0.001$). There were no significant changes in the distance between HICs or the PSS angle (Table 2).

To investigate the associations between PSP recovery and

Table 3. — *Comparison of postpartum and alternation on variables of each pelvimetry dimension.*

Dimensions immediately after delivery	PSP recovery (n=37)	PSP non-recovery (n=12)	*p* value
Distance between HICs/height (mm/m)†	103.1 ± 10.2	105.7 ± 15.4	0.674
Distance between FLAMs/height (mm/m)	150.9 ± 7.1	152.7 ± 7.1	0.450
Width of PS separation (mm)	7.7 ± 2.0	8.2 ± 2.2	0.577
Width of PS translation (mm)†	3.9 ± 1.6	4.5 ± 1.4	0.218
PSS angle (°)	13.2 ± 8.7	12.4 ± 6.0	0.777
Alteration at one month after delivery			
Distance between HICs (mm)	0.2 ± 3.5	-0.7 ± 5.5	0.096
Distance between FLAMs (mm)	-1.8 ± 5.2	-2.9 ± 3.5	0.476
Width of PS separation (mm)	-1.2 ± 1.3	-1.7 ± 1.5	0.302
Width of PS translation (mm)	-1.1 ± 0.8	-1.8 ± 1.2	0.029*
PSS angle (°)	0.5 ± 3.9	0.6 ± 4.8	0.789

** p < 0.05. Parametric variables compared by unpaired t-test; Non-parametric variables (†) compared by Mann-Whitney U test.*

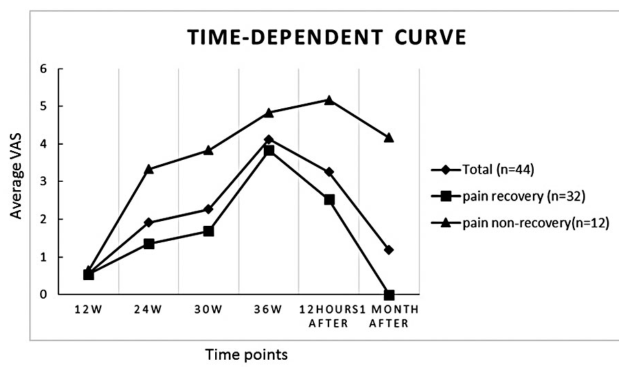

Figure 3. — Time-dependent curve of the average values of VAS. The average VAS values at six time points: 12, 24, 30, 36 weeks after gestation, and 12 hours and one month after delivery were recorded in the line chart for each group. The average VAS declined immediately after parturition in the recovery group while it increased temporarily in the non-recovery group. The result of chi-square test exhibits a significantly large proportion of subjects with increased PSP in the non-recovery group than the recovery group.

imaging data, the radiographic dimensions at the delivery day and the alteration of each variable a month later were compared between the pain recovery and non-recovery groups (Table 3). The pain recovery group exhibited an alteration of 1.1 ± 0.8 mm shortening on the PS translation, which was significantly smaller than in the non-recovery group of 1.8 ± 1.2 mm shortening a month after delivery (p = 0.029). No significant differences were found on the variables of distance between FLAMs, width of PS separation or PSS angle.

Further investigations focused on the cause of PSP and the time-dependent changes in VAS scores were recorded for participants with a natural delivery and compared between women with and without PSP recovery (Figure 3). The authors observed a reverse trend between groups in that the average VAS increased in the group of non-recovery PSP but declined in the PSP recovery group. The non-recovery group exhibited significantly large proportion of the subjects with increased PSP after parturition of 75.0% (9/12) than the recovery group of 28.1% (9/32) (p = 0.005).

Discussion

To the best of the present authors' knowledge, this is the first study to investigate the relationship between the postpartum PSP and the pelvic radiographs after delivery. The authors found the alteration on pelvic cavity diameters as anticipated; however, they failed to identify the strength of the relationship between radiographic information and the clinical symptoms. Additionally, they found some interesting results that potentially identified the reason for the retention of prolonged PSP symptoms.

Since the authors thought the spotting on ischial tuberosity and anterior superior iliac spine was difficult, they did not assess the interspinous diameter or the subpubic angle, which was widely used for the pelvic cavity measurements in previous studies [19]. In this study, contour of the pubic arch and the iliac crest was too smooth to locate precisely in many subjects. Alternatively, the length between FLAMs and the PSS angle were utilized as the indicators for evaluation since it is much easier to recognize an acute angle point of outlines like FLAM, SMPS or IMPS. They assumed that the PSS angle might reflect the degree of symphysial separation, and the distance between FLAMs might have the function similar to the indicator of interspinous diameter on the assessment of pelvic width.

The results in Table 2 show a significant shortening of the length between FLAMs at one-month postpartum than that on parturition day, which indicates a 'closure' of the alternation on pelvic biomechanics. Although the present results are different from previous findings, a study by Huerta-Enochian *et al.* [20] compared the MRI images obtained at 37 weeks of gestation and three months postpartum to find a difference of -0.37 cm at the circumference of pelvis inlet, which were similar to the results in the present study. Regarding the PS, as described in some case reports [21-23], the separation naturally recovered during the postpartum period. In the present study, the plain radiographic images illustrated a decrease in the PS width and translation in one-month postpartum group, indicating a better articular conjunction and symmetry in the area of pubic arch.

Previous studies reported that pain resolves in the majority of patients within a month postpartum [2, 24, 25]. According to this conclusion, the present authors set an observational point at one-month postpartum. Borg-Stein and Dugan [26] reported an exaggerated large symphysial gap of 21 mm, which was considered to be associated with a delayed recovery at nine months. Unfortunately, neither the PS width nor PSS angle was recognized a significant difference among the groups in the present findings. On the other hand, the women whose pain recovered within a month demonstrated greater changes on the vertical translation of PS than the non-recovery group. The present authors postulate that the greater fluctuation in pubic translation by successive measurements possibly reflects the structural instability and the laxity of ligaments in surrounding tissues, resulting in a longer duration of the recovery time.

The biomechanical changes during pregnancy were considered to be the major reason that leads to the development of PSP. The increasing fetal size was currently correlated with the presence of PS separation and pain [27, 28]. In this study, the authors found a considerable number of the women reporting an aggravation on the level of pain immediately after parturition. According to previous research, pelvic floor muscles are stretched over three times its resting length during labor [29], which could be correlated to the strain or weakening of pelvic floor muscles. The present authors assumed that the increased PSP might be an indicator of tiny tearing on the surrounding muscles or ligaments, and the present results (Figure 3), although with small sample size, demonstrated a large difference on the proportion of participants with increased PSP immediately after delivery between the recovery (28.1% 9/32) and the non-recovery (75.0% 9/12) groups. Moreover, previous studies reported that the peak symptoms of PSP were likely to emerge at the third trimester between 24 and 36 weeks of pregnancy [30-32], which was basically consistent with the present results.

There are differences of opinion on the issue of whether the PSP during puerperium is related to symphysial width. Several studies [28, 33, 34] exhibited an average of 1.3-4.3 mm increase in pubic separation in the pain group compared to the pain-free group. However, there are also studies that suggest no significant difference between these two groups [35, 36]. The present research provided a novel insight of the differences in imaging results that could identify the actual reason causing pain, for example, the acute diastasis of PS at delivery which was reported at the incidence rate ranging from 1/30,000 to 1/300, as one of the important causes of PSP [37]. The common diagnosis of PSP was based on radiography and a comprehensive pain analysis over the period before and after childbirth. However, in the present authors' opinion, the pain conditions should be assessed more carefully to verify if the pain occurred during pregnancy or after labor. The present results suggest that the increased pain during parturition could potentially affect the prognosis of PSP and may be a risk factor for a prolonged recovery time.

There are several limitations in this study. First, the small sample size limited the findings. For more persuasive results, it is necessary to expand the scale of participant recruitment. Second, the authors used the anteroposterior plain films which can only reflect the alignment changes on the frontal plane, while changes on the other dimensions, such as anteroposterior diameter of pelvic outlet, could also be associated with the PSP [20]. Third, the authors speculated that the VAS score would include the subjective bias inevitably since the pain tolerance varied in different participants. A relatively objective assessment method such as the palpation in the region of pubis should be taken. Lastly, numerous studies have certified the radical differences in pelvic anatomy among African-American and white women [38-40]. For that reason, the present authors are uncertain if these findings apply to the populations in other countries. Further studies are warranted to conduct more sophisticated investigations involving large-scale participants, 3D image analysis, and more comprehensive evaluation on the PSP.

In conclusion, the conventional pelvic radiography method illustrated 'closure' biomechanical changes one-month postpartum with the features of reduced distance between FLAMs and shortened width of the PS separation. There were no significant differences regarding the PS width or the PSS angle between those with and without pain recovery. However, the women with the PSP that lasted more than a month demonstrated a larger reduction on the PS translation than the recovery participants. Furthermore, women that underwent natural birth illustrated a large difference on the VAS value immediately after labor between the recovery and non-recovery groups, which provided a possible reason of the prolonged PSP recovery time. Further studies that include more sample size are needed to examine if the labor-related PSP would be an isolated risk factor for a prolonged pain recovery time.

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