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FULL PAPER

Analysis of the sacroiliac joint vacuum phenomenon in paediatric patients

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Objective: To assess the incidence of the sacroiliac joint vacuum phenomenon (SIJ VP) in paediatric patients and the relationship between the presence of VP and clinical factors such as age, sex and body mass index (BMI).

Methods: We retrospectively reviewed clinical data and imaging findings of 60 patients who underwent abdominopelvic CT (AP CT) between January and June 2015. Patients were divided into VP group and non-VP group based on the presence/absence of VP, and the groups were compared. In addition, other degenerative changes in the SIJ were recorded.

Results: The SIJ VP was detected in 19 (31.6%) patients. There were no significant differences in sex distribution between VP and non-VP groups ($p = 0.781$). The age of

the VP group was significantly higher than that of the non-VP group ($p < 0.001$). After adjusting the BMI for age, there was no significant association between high BMI and the presence of SIJ VP ($p = 0.326$). Other degenerative changes were not noted in any of the patients.

Conclusion: The SIJ VP is not an uncommon finding in paediatric patients. The prevalence of SIJ VP in paediatric patients is similar to its prevalence in adults. The SIJ VP is related to patient age, but not to sex or BMI in children and young adolescents.

Advances in knowledge: AP CT can provide information about the SIJ, if it is required to assess the SIJ in paediatric patients.

INTRODUCTION

The sacroiliac joint vacuum phenomenon (SIJ VP) is not an uncommon finding in adults.^{1–3} When radiologists face abdominopelvic CT (AP CT), little attention is paid to the SIJ. However, AP CT can provide information about the SIJ, if we attempt to observe the SIJ.^{1–3} The SIJ VP has been reported in approximately 31–34% of adults.^{1,4} In addition, it is observed more frequently in females and in patients older than 60 years.¹ Moreover, it is considered an age-related morphological variant, and obesity is believed to affect such degenerative changes in the SIJ.⁴ To our knowledge, there has been no report on the SIJ VP among only paediatric patients, and data are lacking on its prevalence and clinical significance in this group. Based on our experience of reviewing AP CT images, we recognized that the SIJ VP is not unusual among paediatric patients as well. We hypothesized that the prevalence of SIJ VP among paediatric patients is similar to that among adults. The present study aimed to investigate the radiological findings of the SIJ using AP CT images and assess the incidence of the SIJ VP among paediatric patients. Furthermore, the

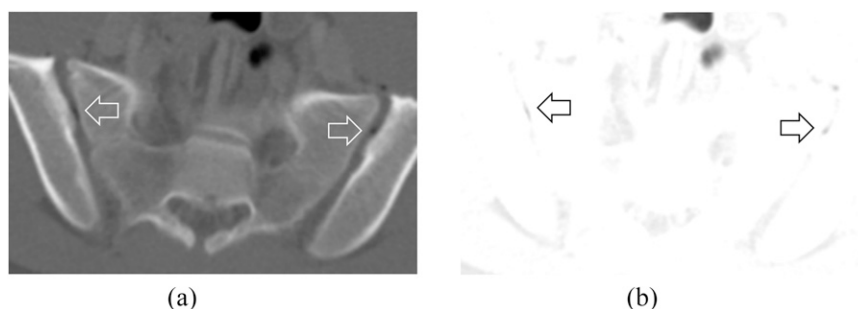
study assessed the relationship between the presence of the SIJ VP and clinical factors such as age, sex and body mass index (BMI).

METHODS AND MATERIALS

Patients

This study was approved by the institutional review board of our institution. We retrospectively reviewed the clinical data and imaging findings of 64 patients who underwent height and weight measurements and who underwent AP CT for various indications between January and June 2015 in our institution. Among the 64 patients, 4 patients were excluded [2 patients had malignant tumours: Wilms' tumour of the kidney ($n = 1$) and dysgerminoma of the ovary ($n = 1$); and 2 patients had underlying acute leukemic leukemia]. Finally, the medical records of 60 patients (male:female, 30:30; mean age, 9.9 ± 3.9 years; range, 2–15 years) were analyzed. BMI was calculated using the following equation: BMI = weight (in kilogram)/height (in metre).² The Korean Center for Disease Control and Prevention reference data were used to determine sex- and

Figure 1. A 10-year-old male with sacroiliac joint (SIJ) vacuum phenomenon (arrows) in both sides. Bone window (a) and lung window (b) axial CTs are showing the presence of gas density in the SIJ.



age-specific percentile cut-off values for BMI.⁵ Patients with BMI between the 85th and 95th percentiles were defined as “overweight”, and those with BMI >95th percentile were defined as “obese”. Patients who were “overweight” or “obese” were considered to have high BMI and others were considered to have normal BMI.

Image acquisition

All 60 patients underwent AP CT in a 64-channel multi-detector CT scanner (Sensation 64; Siemens Medical Solutions, Forchheim, Germany). Patients were sedated with an oral sedative (chloral hydrate, 50 mg kg⁻¹ body weight). The tube voltage and current varied based on the weight of each patient. The other scanning parameters were as follows: rotation time, 0.35 s; slice thicknesses, 3 mm; and field of view of 203 × 203–356 × 356 mm.

Image analysis

The AP CT images were retrospectively analyzed by one board-certified paediatric radiologist (SKY) with 7 years' experience, who was blinded to the clinical information. Axial CT images (Figure 1) were displayed at a picture archiving and communication system workstation with bone window settings (width, 2050 HU; level, 250 HU) and/or lung window settings (width, 1500 HU; level, -700 HU). The presence of linear gas density in the SIJ was considered positive for VP and recorded as right, left or both. The presence of other degenerative changes in the SIJ, such as a subchondral cyst, subchondral sclerosis and cortical erosion, was also evaluated. Patients were divided into VP group and non-VP group based on the presence/absence of VP, and the groups were compared.

Statistical analysis

All statistical analyses were performed using SPSS® v. 21.0 (IBM Corp., Armonk, NY) for Windows. Student's *t*-test and χ^2 test were used to determine the differences in age and BMI between

VP and non-VP groups and the differences between males and females. A *p*-value of <0.05 was considered statistically significant.

RESULTS

The characteristics of the patients are presented in Table 1. Of the 60 patients included in this study, the SIJ VP was detected in 19 (31.6%) patients. The patient age was significantly higher in the VP group than in the non-VP group (13.2 ± 2.0 vs 8.3 ± 3.6 years; $p < 0.001$) (Table 2, Figure 2). However, there was no significant difference in sex distribution between VP and non-VP groups ($p = 0.781$). In VP group, the mean patient age was significantly lower in the high-BMI subgroup than in the normal BMI subgroup (12 ± 2.3 vs 14 ± 1.1 years, $p = 0.043$).

BMI was greater in VP group than in non-VP group. However, after adjusting BMI for age, there was no significant correlation between high BMI and the presence of SIJ VP (Table 2). The proportion of patients with a high BMI was greater in the VP group than in the non-VP group; however, the difference was not significant (8/19 (42.2%) vs 12/41 (29.3%) patients; $p = 0.326$). Among 20 patients with high BMI, 8 (40%) patients showed the VP and among the 40 patients with normal BMI, 11 (27.5%) patients showed the VP. Of the 19 patients with the SIJ VP, 12 (63%) patients showed the VP on both sides and 7 (37%) patients showed the VP only on the left side. Subchondral cysts were noted in 6 (10%) patients, and 4 (66.7%) of these 6 patients had cysts combined with VP. Of these four patients, three patients were overweight and one patient was obese. Other degenerative changes, such as subchondral sclerosis and cortical erosion, were not reported in any of the patients.

DISCUSSION

The incidence of the SIJ VP has been reported to be approximately 31–34% in adults.^{1,4} Fafila et al⁴ reported age-related

Table 1. Patient characteristics

Characteristic	Males (<i>n</i> = 30)	Females (<i>n</i> = 30)	Total (<i>n</i> = 60)	<i>p</i> -value
Age (years)	10.2 ± 3.7	9.5 ± 4.1	9.9 ± 3.9	0.513
Height (cm)	140.0 ± 23.7	132.6 ± 24.7	136.3 ± 24.3	0.241
Weight (kg)	37.7 ± 15.9	34.8 ± 15.8	36.3 ± 15.8	0.486
BMI (kg/m ²)	18.3 ± 3.4	18.6 ± 2.8	18.5 ± 3.1	0.708

BMI, body mass index.

Table 2. Comparison of clinical findings between the vacuum phenomenon (VP) group and the non-VP group

Clinical findings	VP group (<i>n</i> = 19)	Non-VP group (<i>n</i> = 41)	<i>p</i> -value
Age (years, mean±SD, range)	13.2 ± 2.0 (8.8–15.7)	8.3 ± 3.6 (2.2–15.2)	<0.001
BMI (kg m ⁻²)	21.0 ± 2.6	17.3 ± 2.6	<0.001
Gender			
Male	10	20	0.781
Female	9	21	
BMI			
High BMI	8	12	0.326
Normal	11	29	

BMI, body mass index; SD, standard deviation.

changes in the SIJ and noted that neither subchondral cysts nor the VP were seen in patients younger than 30 years. However, they did not include patients younger than 15 years of age. In our study, 31.6% (19/60) of the patients were found to have the SIJ VP. Thus, the prevalence of the SIJ VP in paediatric patients was similar to that in adults. In addition, 63% (12/19) of patients with the SIJ VP were noted on both sides. In adults, this rate has been reported to be 85%.¹ The prevalence of the SIJ VP is reported to be high in elderly females (>60 years of age).¹ In the present study, there were no significant differences in sex distribution between VP and non-VP groups. In addition, the mean patient age was significantly higher in VP group than in non-VP group. Furthermore, concomitant VP and subchondral cysts were not noted in children under 8 years of age.

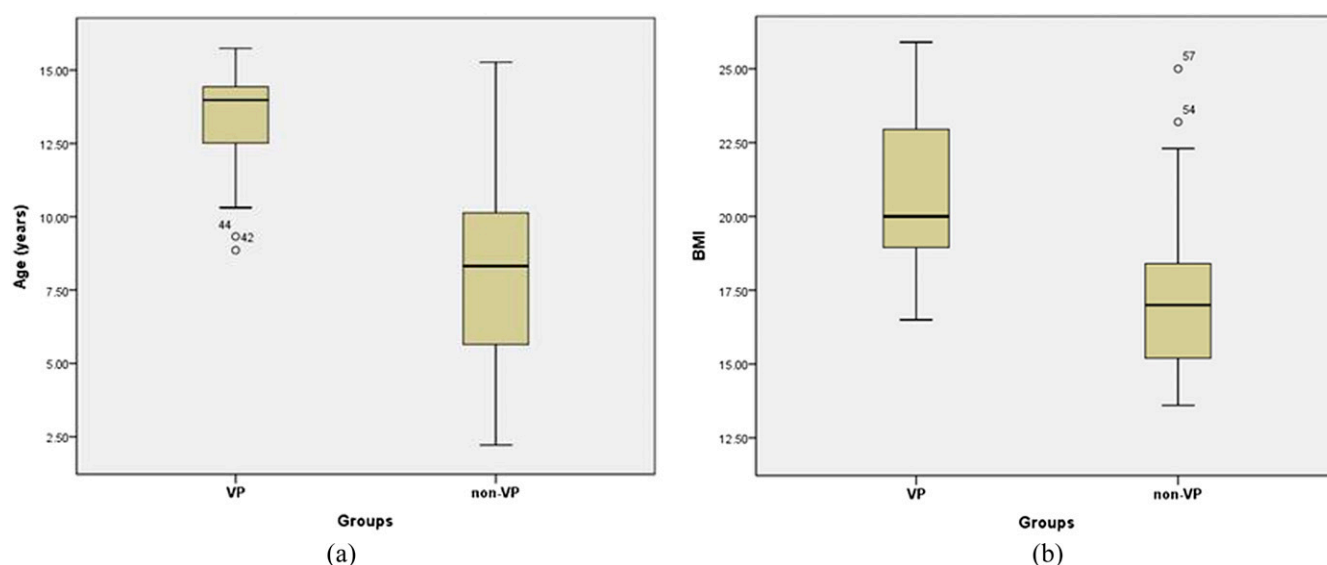
In adults, obesity is considered to affect the degenerative changes in the SIJ.⁴ In children, age should be considered when calculating BMI. In our study, we considered patient age and obtained the BMI percentile for each patient. The raw calculated BMI was greater in VP group than that in non-VP group; however, when

we analyzed the BMI percentile, there was no significant correlation between BMI and VP.

The SIJ VP was primarily observed in patients older than 11 years, and of the 19 patients with the VP, only 4 (21%) patients were younger than 11 years. Of these four patients, three patients were overweight and 1 patient was obese. Among patients with VP, the mean age was lower in those with high BMI than that in those with normal BMI. Therefore, we assume that the VP could be considered a degenerative change, even in patients younger than 15 years of age. If the VP is noted in children under 11 years, we can consider that the most likely risk factor is high BMI.

There have been studies that assessed the clinical significance of the SIJ VP in adults.^{6–8} However, VP was not found to be significantly associated with trauma or sacral insufficiency fractures. In our study, there was no patient who underwent AP CT for post-trauma evaluation. SIJ pain is one of the causes of back pain in children, but its exact incidence is unknown.⁹ We

Figure 2. Box plots of (a) age and (b) body mass index (BMI) for vacuum phenomenon (VP) group vs non-VP group. The median age is higher and the median BMI is greater in the VP group than in the non-VP group (both *p* < 0.001).



hypothesize that degenerative changes in the SIJ in children and adolescents could be associated with SIJ-related pain or low back pain. To our knowledge, the present study is the first to analyze the SIJ of a paediatric population using CT and to include only paediatric patients. Even if the clinical significance is unclear, radiologists should be aware of any findings that can be obtained from CT images. Assessment of the SIJ on AP CT images can provide structural information.

The present study has some limitations. First, we did not compare our findings with the symptoms associated with the SIJ because of the retrospective nature of the study and therefore, it was difficult to evaluate the related symptoms in each patient. However, there was no description of low back pain on retrospective review of the medical records of each patient. The purpose of our study was to assess the prevalence of VP in paediatric patients. Second, we did not measure the Hounsfield units of intra-articular gas, as we were unable to set cut-off

values for intra-articular gas. Thus, we employed strict visual evaluation using either bone window settings or lung window settings for assessment of VP. Third, our sample size was small. Further studies in larger populations are required to assess the prevalence of the SIJ VP and to determine the association between degenerative changes in the SIJ and low back pain among children and adolescents.

CONCLUSION

In conclusion, the SIJ VP is not an uncommon finding in paediatric patients. The prevalence of SIJ VP in paediatric patients is similar to its prevalence in adults. In addition, the SIJ VP is related to patient age but not to the sex or BMI in children and young adolescents.

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