Radiological evaluation of the posterior pelvic ring in paediatric patients
Results of a retrospective study developing age- and gender-related non-osseous baseline characteristics in paediatric pelvic computed tomography – References for suspected sacroiliac joint injury

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ABSTRACT

Introduction: The prevalence of paediatric pelvic injury is low, yet they are often indicative of accompanying injuries, and an instable pelvis at presentation is related to long-term poor outcome. Judging diastasis of the sacroiliac joint in paediatric pelvic computed tomography is challenging, as information on their normal appearance is scarce. We therefore sought to generate age- and gender-related standard width measurements of the sacroiliac joint in children for comparison.
Patients and methods: A total of 427 pelvic computed tomography scans in paediatric patients (<18 years old) were retrospectively evaluated. After applying exclusion criteria, 350 scans remained for measurements. Taking a standard approach we measured the sacroiliac joint width bilaterally in axial and coronal planes.
Results: We illustrate age- and gender-related measurements of the sacroiliac joint width as a designated continuous 3rd, 15th, 50th, 85th and 97th centile graph, respectively. Means and standard deviations in the joint width are reported for four age groups. There are distinct changes in the sacroiliac joint's appearance during growth. In general, male children exhibit broader sacroiliac joints than females at the same age, although this difference is significant only in the 11 to 15-year-old age group.
Conclusion: The sacroiliac joint width in children as measured in coronal and axial CT scans differs in association with age and gender. When the sacroiliac joint width is broader than the 97th centile published in our study, we strongly encourage considering a sacroiliac joint injury.

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Introduction

Pelvic injuries are rare in children: the latest literature reports their prevalence between 0.46% and 4.6% [1–3]. Nevertheless, paediatric pelvic injury is of major significance particularly in the severely injured child [4] as the long-term sequelae of paediatric pelvic injuries reveal complications and poor outcome that are related to instable pelvic injuries at presentation [5,6]. Paediatric pelvic fractures are also indicative of much more severe and life-threatening injuries to other systems [7,8].

While injuries to the anterior pelvis occur more often, fractures and/or disruption of the posterior pelvic ring are infrequently observed in children [9–11]. Antero-posterior X-ray is commonly applied for radiological assessment of the pelvis, but computed tomography is increasingly employed when initially examining paediatric trauma patients [12,13]. Pelvic CT scan should be the gold standard for fracture identification in the paediatric population [14,15], although the role of CT scanning in managing paediatric pelvic fractures is unclear [16]. CT scans have been shown to be superior to plain radiographs especially for assessing

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the posterior pelvic ring to detect fractures of the sacral/sacroiliac region or sacroiliac diastasis [14,16].

Focusing on the anterior pelvic ring, the standard CT appearance of the uninjured paediatric pubic symphysis during skeletal growth has been scrutinised in order to set a reference standard to compare suspected symphyseal disruption [17]. To our knowledge no study exists that defines age-dependent changes in the sacroiliac joint's width in children to serve as a reference standard for judging suspected sacroiliac joint (SIJ) diastasis.

The aim of this study was therefore to describe normal SIJ width measured from axial and coronal paediatric CT scans and relate these measurements to patient age and gender. This study was approved by our institutional ethics committee (EK 248/15).

Patients and methods

To conduct this study we retrospectively analysed all pelvic computed tomography scans taken at our institution for any cause in patients <18 years of age from July 2005 till December 2011. The pertinent scans were identified and retrieved from our institutional radiology database and analysed using the commercially available and validated IMPAX EE viewer (AGFA HealthCare N.V., Mortsel, Belgium) software. The software's windowing function was applied uniformly to all scans to best delineate osseous structures. The radiographic SI-joint width was measured using the electronically calibrated distance-measuring tool embedded in the viewer software.

All applicable CT scans were independently evaluated by one senior radiologist or senior orthopaedic surgeon together with a senior resident in the corresponding counter-specialty, forming two groups of investigators. The senior physician in each team possessed profound knowledge in reading paediatric CTs. First, CT scans were evaluated for these exclusion criteria: (1) a pelvic scan was considered incomplete if parts of the 5th lumbar vertebra or pelvis itself were missing, (2) signs of any congenital abnormality, (3) osseous injuries to the lower lumbar spine, pelvis or proximal

femur, (4) any motion or external artefact obscuring the image quality of the CT scans. After applying these exclusion criteria, each of the remaining scans was analysed independently by each group and a consensus decision was made within each group of investigators generating two independent measurements of SIJ width.

The width of the SIJ was measured on axial and coronal CT sections as depicted in Fig. 1. First, triplanar reconstruction images were generated from axial CT scans. The sagittal plane was then used to define the centre of the 1st sacral vertebra (S 1) as shown in Fig. 1A, whilst in the corresponding axial images, the width of the SIJ at the S 1 level was measured bilaterally at the anterior margin (Fig. 1C). The linea terminalis of the pelvic brim was visualised on the coronal plane, and coronal SIJ width was measured bilaterally at the inferior margin as depicted in Fig. 1B.

Statistical analysis

Inter-investigator-team agreement was analysed with Pearson's r for axial and coronal measurements separately. Values from 0 to 0.2 were considered very poor, from 0.21 to 0.4 poor, from 0.41 to 0.6 moderate, from 0.61 to 0.8 good and from 0.81 to 1 very good, respectively. Scatter plots for correlation between measurements of both investigator teams were generated for axial and coronal measurements indicating a line with a slope of 1 that would account for perfect agreement.

To detect differences between female and male children in different age groups, the Student's t-test was applied to the data from both investigator teams regarding axial and coronal measurements. Age groups were compiled to form cohorts presumably before beginning (0–5 years and 6–10 years), within (11–15 years) and at the end of puberty (16–17 years). Means and standard deviations of every combination of gender and age group were calculated.

To detect differences between the right and left SIJ width, the paired Student's t-test was applied to measurements from one
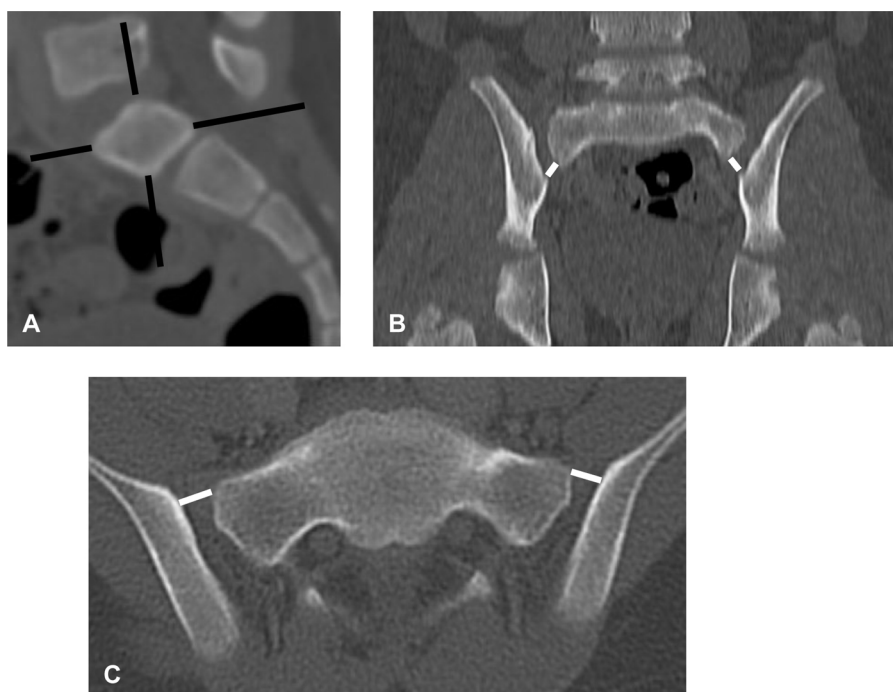

Fig. 1. Bilateral measurements of SIJ width.
Multiplanar reconstructions were generated from axial CT scans; symmetrical alignment done by adjusting the axis. For axial measurements of the SIJ (C), the S 1 vertebra was centred (A). For coronal measurements of the SIJ, the linea terminalis was visualised symmetrically (B). Representative measurements are depicted as white bars in B and C.