RESEARCH PAPER

Correlation of pelvic incidence with radiographical parameters for acetabular retroversion: A retrospective radiological study

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ABSTRACT

Background: Pelvic incidence (PI) has been linked to several degenerative processes within the spinopelvic system. Acetabular retroversion is a recognised risk factor for osteoarthritis of the hip. We therefore hypothesised that these two factors might be part of a specific anatomical variant associated with degenerative changes. This study was performed to clarify this issue.

Methods: The pelvic incidence was measured on plain radiographs of 150 patients (75 males and 75 females) acquired between March 2025 and March 2026. A total of 300 X-ray images comprising both antero-posterior (AP) and lateral views of the pelvis were evaluated. The AP radiographs were used to assess the parameters of acetabular retroversion, including the prominence of the ischial spine sign (PRISS), the cross-over sign (COS) and the posterior wall sign (PWS), while lateral radiographs were used for the measurement of pelvic incidence. Both hips of every patient were evaluated, giving a total of 300 hips assessed for each retroversion parameter.

Results: The mean pelvic incidence was significantly lower in hips positive for the PRISS and the PWS. However, there were no significant differences between hips positive or negative for the COS.

Discussion: As hypothesised, the lower PI values in PWS and PRISS positive hips suggest a link between PI and retroversion of the acetabulum. Whether this is of any clinical relevance remains, however, unknown.

Conclusion: Acetabular retroversion is linked to PI. In hips where the prominence of the ischial spine sign and/or the posterior wall sign was present, the mean pelvic incidence value was lower.

Keywords: Pelvic incidence, Acetabular retroversion, Posterior wall sign, Cross-over sign, Prominence of the ischial spine sign, COS, PRISS, PWS.

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Background

The acetabulum in a human pelvis is anteverted. In a normal asymptomatic population the mean anteversion is around twenty degrees [1]. Retroverted acetabula have been associated with dysplasia of the hip and are considered a risk factor for femoral hip pain, impingement and osteoarthritis [2–7]. Furthermore, the degree of anteversion or retroversion is believed to contribute to the pattern in acetabular fractures and occurrence in stress fractures of the femoral head [8, 9]. There are several radiographical markers to identify and quantify acetabular retroversion in antero-posterior (a.p.) radiographs. These include the cross-over sign (COS), the posterior wall sign (PWS) and the prominence of the ischial spine sign (PRISS). The coexistence of the COS with the PRISS and/or the PWS is usually associated with increasing severity of the acetabular retroversion [10–12].

During the last ten years, pelvic incidence (PI) has been established as a parameter for pelvic orientation. Legaye et al. first described PI as a parameter for pelvic configuration independent from pelvic movement [13]. PI is the sum of the sacral slope and the pelvic tilt. Multiple studies analysed PI in normal healthy populations and compared them to patients with specific disorders. It was found that PI is a hugely variable parameter in normal healthy adults, with a mean value of around fifty degrees and increasing with advancing age [14–17]. There have been several studies linking PI to spinopelvic disorders such as spondylolisthesis and osteoarthritis of the hip (HOA). An increase in PI was seen in a group of patients with HOA compared to patients with lower back pain [18–20]. In addition, a strong association between PI and spinal parameters was discovered [21].

PI affects spinal orientation and curvature and correlates directly with lumbar lordosis (LL) [17]. An increase in PI is often accompanied by an increase in LL. It is believed that with increasing PI and an associated development of a more pronounced LL, an individual has a wider range of motion regarding pelvic flexion around the bicoxofemoral axis, compared to subjects with low PI and little LL. Thus, our hypothesis was that those subjects with lower PI have limited possibilities to compensate stresses within the spinopelvic system, resulting in pathological loading and consequently acetabular retroversion. A correlation between a radiological marker and acetabular retroversion that is recognised to be a risk factor for osteoarthritis would allow early detection of patients at risk for osteoarthritis of the hip due to a lack of compensatory capabilities at the spinopelvic transition.

The hypothesis was that PI correlates with acetabular retroversion in the way that, with decreasing PI, the probability for acetabular retroversion increases as well. The aim of this study was to clarify this issue using plain radiographs of the pelvis.

Methods

This was a retrospective radiological study conducted over a period of one year, between March 2025 and March 2026, in the Department of Orthopaedic, Chettinad Hospital and Research Institute, Kelambakkam, Tamilnadu, India. A total of 150 patients (75 males and 75 females, aged 18–82 years) who had undergone conventional plain radiographs of the pelvis during their hospital visit or admission were included. For each patient, both an antero-posterior (AP) and a lateral view of the pelvis were available, giving a total of 300 X-ray images that were retrospectively reviewed and analysed.

All radiographs were obtained as part of routine clinical evaluation and were retrieved from the institution's Picture Archiving and Communication System (PACS). The AP radiographs were used to evaluate the conventional radiographical parameters of acetabular retroversion, namely the cross-over sign (COS), the posterior wall sign (PWS) and the prominence of the ischial spine sign (PRISS). The lateral radiographs were used to measure the pelvic incidence (PI). Both hips of each patient were assessed, providing a total of 300 hips evaluated for each retroversion parameter.

Exclusion criteria included previous osseous lesions involving the pelvis or proximal femur, previous osteosynthesis, prosthesis of the hip, congenital deformities of the spine or pelvis, and radiographs of suboptimal technical quality (significant pelvic rotation, tilt, or inadequate exposure).

Pelvic incidence (Fig. 1)

The PI is the sum of the pelvic tilt and the sacral slope. It is measured on the lateral radiograph of the pelvis by finding the mid-point between the femoral heads, followed by measuring the angle between the line from this mid-point to the middle of the upper edge of S1, and a line perpendicular to the upper edge of S1 [21] (Fig. 1). As lateral plain radiographs were available for all patients, the PI was measured directly on these images, which represents the standard and most reproducible technique for this measurement. Representative examples of PI measurement on lateral radiographs from our cohort are shown in Fig. 1, with two patients demonstrating relatively low PI values (39.1° and 27.0°).

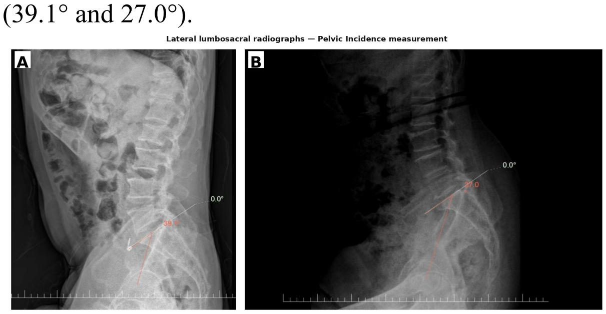

Fig. 3 Examples of pelvic incidence measured on lateral radiographs. (A) PI = 39.1° in a patient with a relatively low pelvic incidence. (B) PI = 27.0° in another patient demonstrating a markedly low PI value.

***Fig. 1** Examples of pelvic incidence measured on lateral radiographs from our study cohort. (A) PI = 39.1° in a patient with a relatively low pelvic incidence. (B) PI = 27.0° in another patient demonstrating a markedly low PI value.*

Cross-over sign (Fig. 2b)

The cross-over sign is considered positive when the anterior edge of the acetabulum is no longer medial to the posterior edge. Acetabular retroversion typically starts by being accentuated at the cranial part of the anterior edge. On antero-posterior radiographs this is seen as an intersection of the two edges [10].

Prominence of the ischial spine sign (Fig. 2)

The prominence of the ischial spine sign is positive when the ischial spine is situated medially to the pelvic ring, projecting into the small pelvis. Representative examples of bilaterally positive PRISS from our cohort, showing the ischial spines protruding medially into the pelvic ring, are demonstrated in Fig. 2.

Posterior wall sign (Fig. 2)

The posterior wall sign is described as the phenomenon when the posterior acetabular edge no longer lies laterally in respect to the centre of the femoral head on a.p. radiographs.

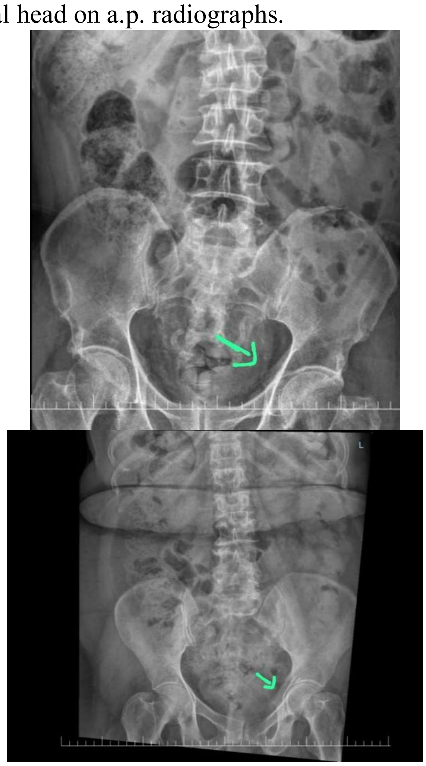

***Fig. 2** Prominence of the ischial spine sign on antero-posterior pelvic radiographs in two patients from our cohort. Red arrows indicate the ischial spines projecting medially into the pelvic ring, demonstrating positivity of the prominence of the ischial spine sign (PRISS) bilaterally.*

Statistical analysis

All data was recorded in an Excel database (Microsoft Corp., Washington, DC, USA) and exported to SPSS 22.0 (SPSS Inc., Chicago, IL, USA) for statistical analysis. Differences in means were assessed using a non-parametric Mann–Whitney test. A p-value of less than 0.05 was considered statistically significant.

Ethics

For radiological measurements of the pelvis and the spine on humans, an application for ethical approval was submitted to the Institutional Human Ethics Committee of Chettinad Academy of Research and Education. This application was approved. Because of the nature of the study, which included solely retrospective clinical data collection from radiographs already obtained for routine clinical care, the need to obtain informed written consent was waived.

Results

PI was assessed in all 150 individuals (75 males and 75 females). The mean PI was 50.7° with a standard deviation of 10.8°. There was no statistically significant difference in mean PI between male and female patients. Representative low-PI cases from our cohort are illustrated in Fig. 3. From the 300 AP radiographs, both hips of every patient could be evaluated, giving a total of 300 hips assessed for COS, PWS and PRISS.

Of the 300 hips evaluated for the COS, 17.7 % (53 hips) were found to have the sign present. With the PWS, 4.0 % (12 hips) were positive, and with the PRISS, 3.0 % (9 hips) were positive. Examples of positive PRISS are shown in Fig. 4. When evaluated for differences in mean pelvic incidence in regard to the presence or absence of the cross-over sign, there was no significant correlation between PI and the appearance of a cross-over sign (p = .184). For PWS and PRISS, there was a statistically significant difference in mean PI between parameter positive and parameter negative hips (PWS p = .024; PRISS p = .003). The mean PI was 45.4° when the posterior wall sign was present, and in the presence of the prominence of the ischial spine sign it was 41.0° (Table 1).

Table 1 *Mean PI for hips with positive and negative parameters for acetabular retroversion. n (+/−), number of hips with positive or negative parameter; PI (+/−), mean pelvic incidence of positive and negative hips; STD, standard deviation; Sig., p-value indicating whether the difference in mean PI was statistically significant*

	n	n(+) PI/STD(+)	n(−)	PI/STD(−)	Sig.
COS	300	53 — 49.1 / 10.4	247	51.0 / 10.7	.184
PWS	300	12 — 45.4 / 12.0	288	50.9 / 10.6	.024
PRISS	300	9 — 41.0 / 8.4	291	51.0 / 10.6	.003

Discussion

A previous study showed that pelvic tilt positively correlated with increased acetabular coverage [23]. Pelvic tilt, however, is a positionally variable parameter. To our knowledge, limited work has been done on the relationship of pelvic incidence as a positionally non-altering parameter and acetabular coverage on plain radiographs. A high PI leads to a higher lumbar lordosis in most cases, and thus, to a higher manoeuvrability around the bicoxofemoral axis [21]. We postulated that a lower adaptability within the spinopelvic system and a decreased potential to retrovertedly rotate the pelvis around the bicoxofemoral axis in particular, would lead to degenerative changes within the hip as well as to acetabular retroversion. This would indicate an inverse correlation between PI and the occurrence of parameters for acetabular retroversion; in other words, lower PI values of parameter positive hips.

The prevalence of COS positive hips in our study was 17.7 %. It is hard to compare this directly to other studies as COS tends to be interpreted quite variably across different observers and centres. With respect to PRISS and PWS the prevalence of 3.0 % and 4.0 % respectively was comparable to that previously reported in some series, although lower than reported in others [12].

Indeed we could observe that where PRISS and PWS were present the PI values were significantly lower than in hips where those signs were absent. This suggests that a decrease in PI and acetabular retroversion are linked. However, we would refrain from postulating a direct causal dependency, as correlations are not easily interpreted within the complex spinopelvic system. The failure to produce any significant results with the COS parameter may be partly explained by the fact that all signs of a cross-over, even if they were very cranial, were counted as hips positive for COS. The problem is that there is to date no accepted cut-off in terms of cross-over ratio that differentiates between a clinically significant cross-over and a cross-over that might be visible at the very top of the acetabular dome but has no clinical impact.

This leads us to the limitations of this study. First, although plain radiographs are the standard imaging modality for evaluating acetabular retroversion using these established radiographical signs, the accuracy of the measurements is dependent on correct patient positioning during image acquisition. Even minor pelvic tilt or rotation may influence the appearance of the COS, PRISS and PWS. Although radiographs of suboptimal quality were excluded, subtle positional variability cannot be entirely ruled out. Secondly, there was no formal interobserver control performed in this study, meaning that although different parameters were measured by different observers, each individual parameter was measured by one person only. Thirdly, this was a single-centre retrospective study with a relatively limited sample size of 150 patients, which may limit the generalisability of the findings to broader populations. Any further studies should look at the relationship between COS and PI using a defined cross-over ratio cut-off, which may select hips with a clinically significant degree of retroversion. It would also be interesting to look at the correlation between the degree of retroversion measured directly as a continuous value and the pelvic incidence in larger, multicentre cohorts.

Conclusion

Hips where PRISS or PWS were present showed significantly lower PI values than hips where those radiological signs were absent. This suggests that lower PI values correlate with retroversion of the acetabular dome. Further research should focus on the correlation between the degree of retroversion and the PI values, ideally with prospective designs and larger study populations.

Abbreviations

PI: pelvic incidence; COS: cross-over sign; PWS: posterior wall sign; PRISS: prominence of the ischial spine sign; AP / a.p.: antero-posterior; HOA: osteoarthritis of the hip; LL: lumbar lordosis; PACS: Picture Archiving and Communication System.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

JHA: Data collection, retrieval of radiographs from PACS, measurement of pelvic incidence on lateral radiographs and assessment of all parameters of acetabular retroversion (COS, PWS, PRISS) on AP radiographs, statistical analysis, interpretation of results and drafting of the manuscript. VM: Study conception and design, overall supervision of the project, interpretation of results, critical revision and proofreading of the manuscript, and corresponding author responsibilities. TR: Verification of radiographical measurements, interpretation of results and proofreading of the manuscript. PKK: Study supervision, interpretation of results and proofreading of the manuscript. All authors read and approved the final manuscript.

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