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Research Article

The Association between Acetabular Fracture and Acetabular Retroversion: A Cross-Sectional Case-Control Study

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Abstract

Background: As previously demonstrated, acetabular fracture type can vary depending on acetabular version. However, there is limited research on the prevalence of acetabular retroversion (AR) in patients with acetabular fracture; hence, this study aims to investigate the association between AR and acetabular fracture.

Methods: In this case-control study, 197 male and female patients were selected (103 patients with acetabular fracture and 94 patients without acetabular fracture). Data were extracted by interview and review of the medical records. The acetabular version was measured by computed tomography (CT) scan using the central axial cut. The data were analyzed and the results were reported to be significant at $P < 0.05$.

Results: The mean central version angle was lower in the group with acetabular fracture compared to the other group ($11.64° \pm 9.19°$ vs. $16.27° \pm 6.37°$; $P < 0.001$). There were more retroverted acetabula in the group with fractures than in the group with intact acetabulum (38% vs. 20%; $P = 0.005$). It was found that acetabular version increased with age, and there was a correlation between age and acetabular version ($r = 0.148$; $P = 0.051$). Furthermore, retroverted acetabula were more prone to posterior-type acetabular fractures; 32% of fractures in retroverted acetabula were posterior type, while only 18% of fractures in anteverted acetabulum were posterior type ($P = 0.021$).

Conclusion: This study showed an association between acetabular fracture and AR. The prevalence of retroverted acetabula in patients with acetabular fracture was greater than in traumatic patients with intact acetabula. Posterior type fractures were more prevalent in patients with retroverted acetabula than in those with anteverted ones.

Keywords: Acetabulum; Bone Retroversion; Hip Fractures; Bone; Hip

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Background

Acetabular fractures are uncommon but important, because they are associated with reduced function, hospitalization, and life-threatening conditions (1). The overall incidence of this type of fracture has been estimated to be 3 to 11 cases per 100000 people annually (2, 3). The most common mechanisms are traffic accidents as high-energy trauma among younger people and falls at the ground level as low-energy trauma in the elderly (3).

Acetabular fractures occur in different patterns depending on the mechanism of injury, bone density, and the orientation of the pelvis and femur during the trauma. Another factor that must always be considered is hip morphology (4). The acetabular version, a crucial morphological property of the hip, is the orientation of the acetabulum on the horizontal plane. This is normally 12° to 20° anteversion in the middle level of acetabulum. Orientations of less than this are considered as retroversion (5). Acetabular retroversion (AR) is an anatomic variant that affects 5% to 20% of the normal population (6). AR causes anterior hyper-coverage of femoral head by the acetabulum; thus changing load transmission across the hip. Studies have shown that AR leads to a higher risk of hip osteoarthritis, femoroacetabular impingement, and posterior hip dislocation resulting from trauma (7, 8).

Although the relationship between acetabular version and acetabular fracture types has been previously discussed, the prevalence of AR in patients with acetabular fracture remains poorly characterized. Therefore, this study aimed to investigate and identify the potential associations between acetabular fracture incidence and AR, as well as the correlation between different acetabular fracture types and AR.

Methods

This case-control study was performed on samples drawn from both high- and low-energy trauma patients with and without acetabular fracture admitted to the Emergency Department of Sina Hospital, located in Tehran City, Iran, between March 2006 and December 2021. The exclusion criteria included the presence of a pathologic fracture, cancer, smoking, poor quality imaging (e.g., due to artifacts or rotation), and unwillingness of the patient or their family to participate in the study. Age was not considered as an exclusion criteria during patient selection. The study protocol, which adhered to current ethical and personal data protection guidelines, was approved by the local ethics committee (IR.TUMS.SINAHOSPITAL.REC.1399.020).

A total of 197 male and female patients were selected randomly using a computer-generated random number sequence. Group A comprised 103 patients with acetabular fracture and group b comprised 94 patients without acetabular fracture according to radiologic findings.

Data extraction, including patient demographic data and medical history, was performed through a combination of patient interview and a review of the medical records using the hospital information system (HIS). Patients' diagnostic images [pelvic computed tomography (CT) scans and X-rays] were extracted from the picture archiving and communication system.

The acetabular version was measured at the middle level of the acetabulum (the median cut between the first and the last cut of the acetabulum in a fine-cut pelvic CT-scan of 0.8-mm in thickness) (Figure 1). A line connecting the most posterior portions of the acetabulum (ischial tuberosities) was drawn, and then a line perpendicular to the first line was considered as the reference line. The version angle was measured as the angle between the reference line and the line connecting the anterior and posterior edges of the acetabulum. For the purpose of this study, we used version angle of the unaffected side for case group, and mean angle of both sides for control group. Based on the previous literature, retroversion was defined as version angles of less than 10° anteversion (9, 10). To analyze the association between AR and acetabular fracture based on the acetabular version, the patients were divided into retroverted and anteverted groups.

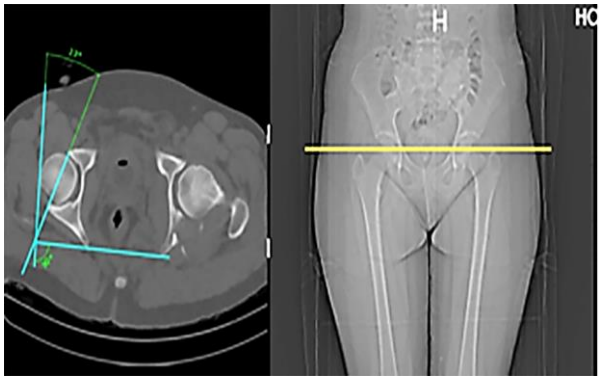

Figure 1. Calculation of acetabular version on computed tomography (CT) scan images; representative images demonstrating the method used

Two classification methods were used to assess patients for fracture type. The first method was the Letournel-Judet acetabular fracture classification, which divides injuries into ten patterns (anterior wall, anterior column, transverse, posterior column, posterior wall, both columns, anterior column + posterior hemitransverse, T-shaped, transverse + posterior wall, posterior column + posterior wall). In the second method, in order to minimize the number of subgroups and strengthen the statistical analysis, the ten patterns were combined into three groups: anterior (fractures that purely involve the anterior wall and anterior column), posterior (posterior wall, posterior column, and posterior wall + posterior column), and mixed type (all other fracture types). This approach was based on a previous study that investigated the role of AR in acetabular fracture types (11).

All the measurements were conducted by two experienced orthopedic hip surgeons to mitigate the effect of the measurement bias, and there was consensus between them. To analyze possible association between AR and acetabular fracture, the age, total fracture rates, and mean acetabular version degree for the entire population were collected from the databases used. The t-test was utilized to compare continuous variables such as the mean acetabular version degree. The relationship between continuous variables was assessed using Pearson's correlation coefficient to determine the association between age and mid-acetabular version degree. Categorical variables were compared using the chi-square test. Furthermore, multivariable logistic regression analysis was performed, with acetabular fracture status as the dependent variable and AR, age, and sex as covariates. P-values of ≤0.05 were considered statistically significant. Statistical analysis was performed using SPSS software (version 23.0, IBM Corporation, Armonk, NY, USA).

Informed consent forms were signed by all participants of the study. The data that support the results of this study are available from the corresponding author upon reasonable request. No funding was received for conducting this study.

Results

This study investigated two groups of patients. Group A included 103 patients with acetabular fracture (83 men and 20 women), while Group B comprised 94 trauma patients with intact acetabula (76 men and 18 women). The mean ages for Group A and Group B were 40.53 ± 16.21 and 44.26 ± 18.34, respectively; this difference between the two groups was not statistically significant (P = 0.132). The groups were also matched for sex (Group A: 80.6% men, 19.4% women; Group B: 80.9% men, 19.1% women; P = 0.96). Based on the Letournel-Judet acetabular fracture classification, the most common fracture type was posterior wall fracture.

Table 1. Baseline characteristics of patients

	Acetabular fracture group (n = 103)	Intact acetabulum group (n = 94)	P-value
Sex (men/women)	83/20	76/18	0.960
Age (year) (mean ± SD)	40.53 ± 16.21	44.26 ± 18.34	0.132
Central version (mean ± SD)	11.64° ± 9.19°	16.27° ± 6.37°	< 0.001
Retroverted acetabula [n (%)]	40 (38.0)	19 (20.0)	0.005

SD: Standard deviation

According to the three-group classification, the most prevalent fracture was the mixed type. The baseline characteristics of the patients and frequency of fracture types are shown in tables 1 to 3.

Table 2. Frequency of fracture types based on Letournel-Judet classification

Fracture type	n (%)
Anterior column	9 (8.7)
Posterior column	4 (3.9)
Anterior wall	1 (1.0)
Posterior wall	33 (32.0)
Transverse	14 (13.6)
Posterior column-posterior wall	4 (3.9)
Both columns	18 (17.5)
T-shaped	9 (8.7)
Anterior column-posterior hemitransverse	5 (4.9)
Transverse-posterior wall	5 (4.9)
Unknown	1 (1.0)

The results showed that there were more retroverted acetabula in the patients with ACETABULAR FRACTURE compared to the other group [40/103 (38%) vs. 19/94 (20%); P = 0.005].

Table 3. Frequency of fracture type based on group classification

Fracture type	n (%)
Anterior	10 (9.7)
Posterior	45 (43.7)
Mixed type	48 (46.6)

Additional analysis for each sex demonstrated a significantly higher prevalence of AR in men, but the difference between the two groups for women was insignificant (Table 4).

Table 4. Prevalence of retroverted acetabula by sex

Sex	Fracture type	Retroverted acetabula [n (%)]	P-value
Men	With fracture	32 (38.6)	0.005
	Without fracture	14 (18.4)	
Women	With fracture	8 (40.0)	0.506
	Without fracture	5 (27.0)	

The mean central acetabular version angle was significantly lower in Group A compared to Group B (11.64° ± 9.19° vs. 16.27° ± 6.37°; P < 0.001). Analysis with regard to sex showed that the difference in mean acetabular version between fractures types was significant among men (11.83 ± 9.14 percent), but was not significant among women (P = 0.07). These finding are summarized in table 5.

Table 5. Acetabular version by sex

	Group	N	Mean ± SD	P-value
All patients	With fracture	103	11.64° ± 9.19°	< 0.001
	Without fracture	94	16.27° ± 6.37°	
Men	With fracture	83	11.83° ± 9.14°	0.001
	Without fracture	76	16.28° ± 5.99°	
Women	With fracture	20	10.80° ± 9.59°	0.070
	Without fracture	18	16.20° ± 7.99°	

SD: Standard deviation

Additional analysis to determine the association between the acetabular version and age revealed that the acetabular version increased with advancing age, showing a borderline positive correlation (r = 0.148; P = 0.051) (Figure 2). In order to assess the association between the acetabular fracture type and AR, the three-group classification was used, and results showed that posterior-type fractures accounted for 32% of cases in the retroverted acetabula group, compared to only 18% in the anteverted acetabula group (P = 0.021). Furthermore, the association between age and fracture type was not significant (P = 0.120).

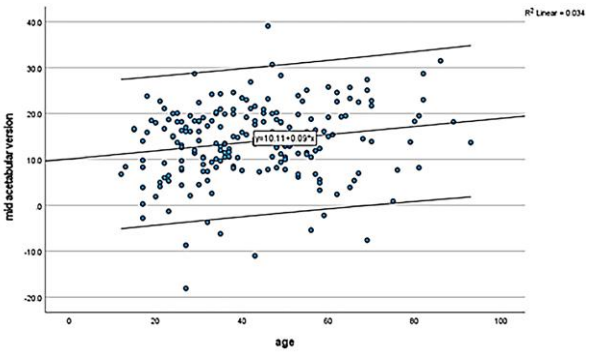

Figure 2. The correlation between age and acetabular version; the regression line demonstrates a progressive increase in acetabular version as age increases.

In adjusted binary logistic regression, adjusting for sex and age, odds ratio (OR) of AR for acetabular fracture was 2.4 [95% confidence interval (CI): 1.2-4.5; P = 0.008]. Age and sex were not significant predictors for acetabular fracture.

Discussion

This study was designed to investigate the association between acetabular fracture and AR. Secondary objectives included determining the association between AR and acetabular fracture types, as well as the potential relationship between age and acetabular version. Our results showed that the mean acetabular version in the central level was significantly lower in traumatic patients with acetabular fracture compared to traumatic patients without acetabular fracture. There were also more retroverted acetabula (defined as version of less than 10° at central level of acetabulum) in the group with acetabular fracture compared to the group with an intact acetabulum. Subgroup analysis by sex revealed no significant differences in mean acetabular version or the prevalence of AR among women. In contrast, a statistically significant difference was observed among the male patients. Moreover, this study showed that posterior type fractures were more prevalent in patients with retroverted acetabula. Additionally, a borderline correlation was found between increasing age and acetabular version.

The present findings suggest that AR might represent a factor associated with susceptibility to acetabular fracture. Recognition of this anatomic variation may help identify individuals who are susceptible to specific fracture patterns following traumatic injury. Although AR alone is unlikely to predict fracture occurrence, it may contribute to risk stratification when considered alongside patient- and injury-related factors.

Previous studies have shown multiple risk factors for acetabular fractures. One group of risk factors is related to the geometric and anatomical characteristics of the hip joint, femur, and acetabulum. Other risk factors are the incidence of high-energy trauma, low body weight, dementia, alcohol consumption, cigarette smoking, and vision impairment, which do not relate to hip anatomy (12-14). Among the structural risk factors of acetabular fracture, one study showed that the neck-shaft angle was significantly smaller in patients with fractured acetabula. Moreover, an association between femoral neck axis length (FNAL) and acetabular fracture has been observed (15). Although many studies have investigated the relationship between AR and femoroacetabular impingement, hip osteoarthritis, and posterior hip dislocation, no research to date has specifically explored the association between AR and acetabular fracture.

In addition, the present study confirmed a relationship between the acetabular version and acetabular fracture types. Werner et al., for example, analyzed the relationship between fracture type and acetabular version and showed that more anteverted acetabula were associated with anterior fractures and more retroverted ones were prone to posterior fractures (11). This finding was confirmed by our study. Some studies have shown that a retroverted acetabulum predisposes more patients to posterior hip dislocation. For instance, Novais et al. studied 27 adolescent patients who had sustained posterior hip dislocation during sports and recreational activities, comparing their acetabular version to that of 27 age-matched controls without hip conditions. Their results showed that acetabular anteversion was significantly lower in patients with posterior hip dislocation compared to those without acetabular fracture at different acetabular levels (16).

The relationship between age and acetabular version has been shown in previous studies. Klasan et al. measured the acetabular version in 404 patients and showed that its incidence increased with advancing age (6). Kopydlowski et al. measured the acetabular version of 240 cadaveric specimens at the cranial, central, and caudal levels. Their study demonstrated that the acetabular versions of younger patients were significantly less anteverted at the cranial level, but not at the central and caudal levels (17). Our study failed to confirmed this trend and showed a borderline correlation between age and acetabular version (Figure 2). The exact implication of this phenomenon has yet to be determined.

Several limitations of this study should be acknowledged. First, the relatively small sample size may limit the generalizability of our findings. Second, due to the retrospective nature of the study, we were unable to account for the specific mechanisms or the severity of the initial trauma. Furthermore, a quantitative assessment of inter-observer reliability was not performed. While these limitations exist, our study provides preliminary evidence of an association between AR and acetabular fractures; however, prospective studies are warranted to confirm these findings. Additionally, the acetabular version was measured only at the central level, and global retroversion was not assessed. The statistical analysis could not be adjusted for other risk factors of acetabular fractures such as mechanism of trauma, past medical history, and socio-economic factors due to the lack of data in these areas. A primary strength of this study is that, to the best of our knowledge, it represents one of the first investigations to examine the relationship between AR and acetabular fracture, and our findings highlight the potential influence of AR on acetabular fracture.

Conclusion

This study showed an association between acetabular fracture and AR. Retroverted acetabulum was more common in patients with acetabular fracture than in trauma patients with intact acetabula. The mean acetabular version at the middle level also was less anteverted in patients with acetabular fracture. Furthermore, the acetabular version was found to affect the fracture type; specifically, retroverted acetabulum was more prone to posterior type fractures. Moreover, there was an association between an increase in age and acetabular version, with mid-level acetabular version showing a slight trend toward increased values as age advanced.

Conflict of Interest

The authors declare no conflict of interest in this study.

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