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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2021;10(2):524-8

The prevalence of radiographic femoroacetabular impingement morphology in adolescent spine patients

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Received 01 April 2021; Accepted 12 April 2021
Available online 24.04.2021 with doi: 10.5455/medscience.2021.04.108

Abstract

Changes in spinal alignment may alter hip biomechanics and predispose hip pathologies. Only a few studies have examined the relationship between adolescent spinal deformities and femoroacetabular impingement syndrome of the hip. The purpose of this study is to define the prevalence of femoracetabular impingement radiographic findings among adolescent spine patients. We evaluated 230 hips of 115 patients with adolescent idiopathic scoliosis as a study group. One hundred hips of 50 volunteers were analyzed as a control group. Radiographic images were analyzed for anteroposterior alpha angle, Tönnis angle (TA), center-edge angle (LCEA), crossover sign (COS), ischial spine sign (ISS), coxa profunda (CP), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and lumbar lordosis (LL). Of the 330 hips, 57.3 % demonstrated at least one parameter suggesting impingement morphology, whereas 23% showed at least two parameters. Evidence of coxa profunda was seen in 35.5% of the hips, while a negative Tönnis angle was seen in 57.3% and a center-edge angle indicative of acetabular overcoverage was seen in 23%. An acetabular crossover sign was detected in 13.9% of the hips, while an abnormal anteroposterior alpha angle was found in 12.1% of the hips studied. Statistical analysis revealed that the radiographic signs of femoroacetabular impingement syndrome among adolescent scoliosis patients were significantly higher than the control group. There was a difference between the two groups for sacral slope ($p<0.021$) in terms of spinopelvic parameters measured. Other than that, no statistically significant correlation was found between spinopelvic parameters and femoroacetabular impingement morphology. In conclusion, the prevalence of radiographic impingement morphology in scoliotic adolescents is higher than in healthy populations. Spinopelvic parameters were not statistically different between the two groups. Further prospective studies with a larger sample size may be more appropriate to assess the relationship between the FAI morphology and spinopelvic parameters in spinal deformity patients.

Keywords: Adolescent idiopathic scoliosis, femoracetabular impingement, morphology, acetabular version, sagittal spinal alignment

Introduction

Femoro-acetabular impingement (FAI) is a known cause of hip pain that can possibly lead to acetabular chondrolabral damage and has been advocated as a causative factor in the development of osteoarthritis [1]. The true prevalence of these abnormalities in morphology during the growing years and adolescence that eventually lead to symptomatic femoroacetabular impingement is unknown [2]. Although there has only been limited research in this area, sagittal balance about the lumbo-sacral pelvic junction (LSPJ) may play an important role in hip disorders [3].

Trunk balance in patients with spinal deformity manifests with specific anatomical and functional features different from healthy individuals [4]. The role of the pelvic area in sagittal balance is evident for spinal surgeons, who consider sacral slope, pelvic incidence, and pelvic tilt in their planning and analyses [5]. Changes in pelvic tilt may alter acetabular coverage in terms of lateral center-edge angle, acetabular crossover, or Tönnis angle [6]. Recent studies have also shown a relationship between lordosis and hip pathologies [7]. We conducted a radiographic study designed to evaluate FAI within the context of the LSPJ. The purpose of this study was to investigate the prevelance of radiographic femoro-acetabular impingement morphology among asymptomatic scoliosis patients and determine the relationship with spinal deformity.

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Material and Methods

This retrospective cross-sectional study was approved by our institutional review board (IRB-GO13/497). An age-matched population of 115 AIS patients scheduled for scoliosis surgery and 50 patients as a control group was randomly selected from our database. Patients who had completed a standard pre-operative work-up during the period from July of 2011 to September of 2014 were included in this study. After a complete description of the study was provided to the subjects, written informed consent was obtained. The Declaration of Helsinki was taken into account for this study.

The study group (n=165) consisted of adolescent idiopathic scoliosis patients (n=115) between 15.9±4.0 years of age, and the control group consisted of healthy volunteers (n=50) 14.4±3.5 years of age.

For radiographic examinations, a standardized protocol was used for all participants. Antero-posterior and lateral standing plain radiographs recorded from C7 to the femoral head were obtained for each participant. Participants were instructed to stand with their feet together in a natural upright posture, without spinal rotation, with arms hanging by their sides for frontal views and arms horizontal resting on supports for sagittal views [8].

Based on previously-described studies, anterior-posterior radiographs of the pelvis were assessed for the alfa angle (Figure1.a) [9], Tönnis angle (TA) (Figure1.b) [6], and center-edge angle (LCEA) (Figure1.c) [6.10]. Crossover sign (COS) was considered present when the anterior rim line was lateral to the posterior rim in the cranial part of the acetabulum and crossed the rim to become medial in the distal part of the acetabulum (Figure1.d) [11]. The ischial spine sign (ISS) was considered present when the ischial spine was evident as a prominence along the ilioischial line (Figure1.d) [12]. Coxa profunda (CP) was defined as the floor of the acetabulum touching or overlapping the ilioischial line medially (Figure1.e). Spino-pelvic parameters were assessed for pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and lumbar lordosis (LL) (Figure1.f) [13.15].

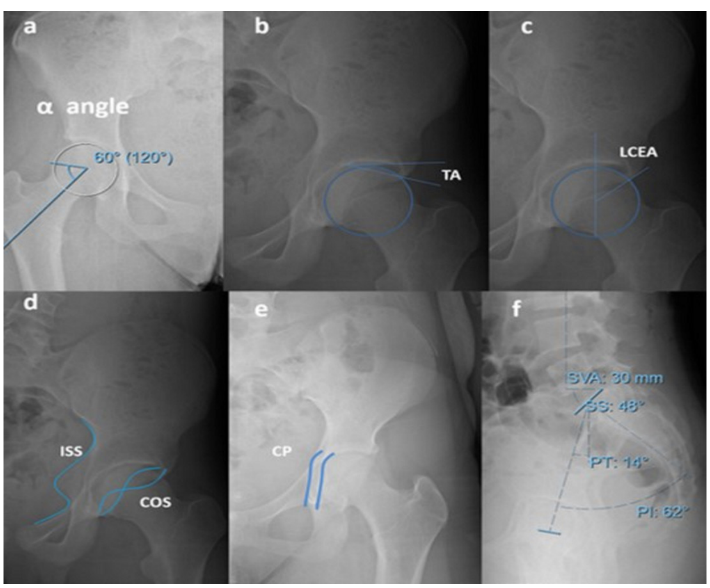

Figure 1. Radiographic measurements related to Femoracetabular impingement morphology; a) Radiograph showing an example of alpha angle measurement on Antero-posterior pelvic imaging. b) Tonnis angle. c) Measurement of LCEA. d) Crossover sign and Ischial spine sign evaluation. e) The assessment of coxa profunda. f) The evaluation of Spinopelvic parameters

Pelvic incidence is a morphological parameter. It is the angle measured from a perpendicular line to the mid-point of the sacral plate and extended to the centre of the femoral head [13]. Pelvic tilt is a positional parameter. It is the angle measured from a perpendicular line starting at the centre of the femoral head and extended to the midpoint of the sacral plate [14]. Sacral slope is a positional parameter and is the angle measured from the superior endplate of S1 and a horizontal axis [16].

Subjects that demonstrated a positive crossover sign or a lateral center-edge angle (LCEA) of more than 40 degrees, a negative Tönnis angle, and coxa profunda without an alpha angle were classified as having a pincer deformity [6, 17-19]. Subjects with an abnormal alpha angle (more than 60 degrees) and without a crossover sign or high LCEA were categorized as having a cam-type deformity [9, 20]. Finally, those with at least one—a cam (alpha angle) and pincer sign, crossover sign, or a lateral center-edge angle (LCEA)—were classified as mixed FAI. Exclusion criteria for this study were radiographic evidence of excessive pelvic rotation, insufficient radiographs, and patients with a history of hip joint surgery.

Statistical methods

Statistical analysis was made using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY). The normality assumptions were controlled by the Shapiro–Wilk test. Descriptive analyses were presented using mean±SD, median (range) or n(%), where appropriate. Categorical data were analyzed by Pearson chi-square. The differences between two groups were evaluated with the Mann-Whitney U test for non-normally distributed data while Student's t-test was used for normally distributed data. A p-value of less than 0.05 was considered statistically significant.

To ensure consistency, all measurements were performed by a single author, and another author performed interobserver reliability. To determine adequate sample size, G*Power 3.1.9 was used [21]. The effect size was determined as w = 0.223. With the 95% power and 0.05 alpha, the minimum sample size to be included in the study was calculated as n=262.

Results

A total of 330 hips of 165 patients were retrospectively analysed. The study group consisted of 115 AIS patients with 230 hips. The control group consisted of 50 volunteers with 100 hips. The mean age was 15.6±2.6(10-20) years (Table 1).

The intragroup comparison of all variables is shown in Table 2. The mean Tönnis angle was 1.5±5.0 (-7 ÷ 24) degrees, and the mean center-edge angle was 36.2±7.0 (15÷51) degrees. The alpha angle for all hips was 55.3±14.2 (37÷74) degrees. The mean value of the pelvic incidence was 57.4±10 (29.0÷89.0) degrees, pelvic tilt was 14.6±6.0 (0-30) degrees, sacral slope was 46.1±9.5 (16÷54.8) degrees, and lumbar lordosis was 50.3±19.5 (17-77) degrees. Interobserver agreements were almost perfect for CP (ICC: 0.87), COS (ICC: 0.85), ISS (ICC: 0.89), LCEA (ICC: 0.98), TA (ICC: 0.97), and alpha angle (ICC: 0.91) on all radiographs.

In our radiographic assessment for signs of FAI, 117 hips demonstrated coxa profunda (35.5%), 46 hips (13.9%) a crossover sign, and 50 hips (15.2%) an ischial spine sign. 189 hips had a negative Tönnis angle (57.3%), 40 hips had an alpha angle of >65 degrees (12.1%), and 53 hips had a center-edge angle of >40 degrees (23%).

As shown in Table 3, the radiographic analysis revealed that hips with signs of a femoracetabular impingement showed a higher Tönnis angle (p=0.001), alpha angle (p=0.001), center-edge angle (p=0.001), coxa profunda (p=0.001), crossover sign (p=0.001), and ischial spine sign (p=0.001) compared to the control group. The correlations between the pelvic parameters showed that in patients who had femoracetabular impingement, only SS values were different between the study group and the control group (Table 2).

Discussion

Abnormal morphology or biomechanics in the spine or pelvis inherently affect each other by way of the lumbosacral junction [7]. Changes in the spinopelvic alignment could lead to over or lesser acetabular coverage. As a result, symptomatic or asymptomatic femorasetabular impingement may occur [22-24].

Our study compared spinopelvic parameters in asymptomatic scoliosis patients and asymptomatic individuals with radiographic evidence of FAI. We were able to demonstrate that there was a significant difference between the two groups in the radiographic manifestations of femoracetabular impingement syndrome. We could not find a relationship between FAI morphology and spino-pelvic parameters.

Table 1. Patients' characteristics

	Total	Non-Scoliosis	Scoliosis	p
Age	15.6±2.6(10-20)	15.9±4.0 (12-20)	14.4±3.5 (10-18)	0.088
Gender				
Female	132(80)	37(74)	95(82.6)	0.002
Male	33(20)	13(26)	20(17.4)	

Table 2. Comparison of parameters according to groups

Variables	Total		Non-Scoliosis		Scoliosis		p
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	
X-ray							
Tönnis angle	1.5±5.0	0(-7 ÷ 24)	3.13±5.0	2(-5 ÷ 24)	0.86±4.4	0(-7 ÷ 18)	<0.001
α-angle	55.3±14.2	48(37÷74)	52.8±9.8	65(41÷69)	56±15	47(37÷74)	<0.001
Lateral CEA	36.2±7.0	38(15÷51)	34.2±4.0	41(24÷46)	37±7.3	37(15÷51)	<0.001
Pelvic incidence	57.4±10	57(29.0÷89.0)	57.4±5.5	57(47÷67.0)	57.4±13	57(29.0÷89.0)	0.628
Pelvic tilt	14.6±6.0	14(0-30)	13.7±2.3	14(11-16)	14.9±10	15(0-30)	0.138
Sacral slop	46.1±9.5	40(16÷54.8)	54.5±5.5	44(35-54.8)	42.5±11.0	35(16-70)	<0.021
Lumbar lordosis	50.3±19.5	48(17-77)	51.9±11.5	52(34-71)	49.6±23.0	48(17-77)	0.233

Table 3. Comparison of abnormal indices according to groups

	Total	Non-Scoliosis	Scoliosis	p
X-ray				
Coxa profunda	117(35.5)	20(20)	97(42.2)	0.001
Crossover sign	46(13.9)	5(5)	41(17.8)	0.001
ISS	50(15.2)	3(3)	47(20.4)	0.001
Tönnis angle≤0	189(57.3)	29(29)	160(69.6)	<0.001
LCEA≥40	53(23)	11(11)	42(18.3)	<0.001
α-angle>65	40(12.1)	3(3)	37(16.1)	<0.001

Of the 330 hips, 57.3% demonstrated at least one parameter suggesting impingement morphology, while 23% showed at least two signs. Evidence of coxa profunda was seen in 35.5% of the hips. In comparison, a negative Tönnis angle was seen in 57.3%, and a center-edge angle indicative of acetabular over coverage was seen in 23%. An acetabular crossover sign was detected in 13.9% of the hips, while an abnormal anteroposterior alpha angle was found in 35.5% of the hips. In the scoliosis group there was a statistically significant negative Tönnis angle (69.6% vs 29%; p=0.001), alpha angle (16.1% vs 3%; p=0.001), center-edge angle (18.3% vs 11%; p=0.001), neck-shaft angle (34%/- ; p=0.001), coxa profunda (42.2% vs 20%; p=0.001), crossover sign (17.8 % vs 5%; p=0.001), and ischial spine sign (20.4% vs 3%; p=0.001), demonstrating a higher incidence of the presence of radiographic signs of femoracetabular impingement.

Previous studies have reported a correlation between lumbar lordosis and acetabular coverage [7, 25, 26]. However, in our study, we did not find a statistically significant relationship between these parameters.

The study by Hu et al. of direct radiographs of 90 asymptomatic scoliosis patients detected radiological cam-type impingements in 5.6% of the population. In the same study, radiographical pincer-type impingement findings were present in 15%. Our study concluded that the prevalence of FAI-related morphologic features in adolescent scoliosis population was comparable to normal populations without scoliosis [27].

E. Nielsen et al. reported in their study that the incidence of acetabular over coverage may be higher in patients with spinal deformity than in the general population [28].

Previous studies showed that, in patients with radiographical FAI manifestation, decreased PI and increased PT are the more common findings [29, 30].

Our study demonstrated increased FAI morphology in scoliosis patients. This was also observed in previous studies, which demonstrated that the incidence of acetabular over coverage may be significantly higher in a scoliosis population than in the general population [27, 28]. Further longitudinal studies examining the incidence of hip morbidity in AIS patients should be conducted to evaluate the clinical significance of this finding.

Our study is not without limitations. Due to the constraints of radiographs available for a retrospective review, this study used plain radiographs for pelvic measurements that were obtained from an anterior-posterior and lateral scoliosis radiographs for scoliosis evaluation, not from an orthogonal pelvic radiograph, which may be affected by pelvic tilt, rotation, and patient distance from the beam source [31]. The alpha angle is measured anteroposteriorly so that the osseous outgrowth, which develops on the superio-lateral aspect of the femur head-neck junction, can be analyzed. Since the vast majority of patients had skeletal immaturity, we do not know how their future growth will affect these values. Besides, we used only standing radiographs, which have been shown to provide decreased measures of LCEA relative to standard supine films [32, 33]. It is possible these limitations introduced random error into the measurements, and actual values may be even higher than those presented in the study.

The participants were not assessed by CT scan to avoid exposing them to a high dose of radiation exposure. In order to reach a sufficient number of asymptomatic hips to analyze the prevalence of FAI in our population, we used pelvis radiographs. On the other hand, FAI is a dynamic problem, and more research is needed to correlate this dynamic state with static radiographs [34]. Despite these limitations, the results of this general population-based study clearly demonstrated the radiographic signs of FAI in patients with spinal deformity.

Conclusion

The results of this study support a significant association between spinal deformity and the presence of femoroacetabular impingement morphology. Spinopelvic parameters were not correlated with FAI morphology in either group. In further studies, the relationship between spinopelvic alignment and FAI radiology should be evaluated with sagittal and coronary equilibrium, attention should be paid to pelvic orientation, and other radiological examinations should be made.

Conflict of interests

Each author certifies that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article.

Financial Disclosure

All authors declare no financial support.

Ethical approval

Ethics comittee approved the study This retrospective cross-sectional study was approved by our institutional review board (IRB-GO13/497).

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