Arthroplasty Today 26 (2024) 101322

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

Relative Acetabular Retroversion and Its Association With Earlier-Onset Symptomatic Osteoarthritis of the Hip

Arash Rezaei, MD, PhD[a, *], Stojanovic Michael, MD[b], Ahmed Eldib, MD[b], Lalit Puri, MD[b]

[a] Department of Orthopedic Surgery, University of Illinois – Chicago, Chicago, IL, USA
[b] Department of Orthopaedic Surgery, NorthShore Orthopaedic & Spine Institute, Skokie, IL, USA

ARTICLE INFO

Article history:
Received 6 August 2023
Received in revised form
23 September 2023
Accepted 21 January 2024
Available online xxx

Keywords:
Acetabular retroversion
Acetabular anteversion
Hip osteoarthritis
Total hip arthroplasty

ABSTRACT

Background: Hip osteoarthritis is associated with an aging population with the average total hip arthroplasty patient in the U.S. approximately 65 years of age. Although there is an association between femoroacetabular impingement and early arthritis, there is a paucity of data attributed to variation in native acetabular version and early onset osteoarthritis. We investigated that whether patients with relative acetabular retroversion are predisposed to earlier hip osteoarthritis.

Methods: Five hundred sixteen charts of patients undergoing THA by a single surgeon between March 2018 and May 2022 were reviewed (221 male and 295 female subjects; mean age 66.7 years [standard deviation (SD) 9.8]). Patients with advanced dysplasia, who are post-traumatic, septic, have inflammatory arthritis, and osteonecrosis were excluded. Operative hip anteversion was measured using three-dimensional computed tomography. A univariate analysis was used to correlate the age of male and female subjects with anteversion angles of $\leq 15^\circ$ and $>15^\circ$. The effect of age and gender on version angle was studied using a multivariate linear regression model.

Results: In patients with anteversion $\leq 15^\circ$, both male ($P = .006$) and female subjects ($P = .015$) presented at significantly lesser age (male: 98, avg. age: 63.7, SD: 8.7; female: 62, avg. age: 64.8, SD: 9.8) than those with anteversion $>15^\circ$ (male: 123, avg. age: 67.2, SD: 10.2; female: 233, avg. age: 68.2, SD: 9.8). Male subjects had lower anteversion than female subjects with age held constant ($P < .001$), and older patients had increased anteversion with gender held constant ($P < .001$).

Conclusions: This study suggests that patients with a relatively decreased version angle ($\leq 15^\circ$) are more likely to present with earlier-onset symptomatic hip osteoarthritis.

Introduction

Osteoarthritis (OA) is the third most common diagnosis made by general practitioners in older patients [1]. The prevalence of hip OA is continuously rising due to an aging population and obesity, with the average total hip arthroplasty (THA) patient in the United States approximately 65 years of age [2]. Although the etiology of primary OA of the hip is not fully understood, several research studies have suggested a relationship between abnormal hip biomechanics and hip OA, particularly in terms of femoral neck anteversion, acetabulum anteversion (AA), developmental dysplasia of the hip, and femoroacetabular impingement [3-14]. It has been stipulated that the posterior and superior aspects of the acetabulum are subject to high loads during activities of daily living and normal gait [15]. In a patient with a lesser degree of AA, the posterior acetabulum is relatively deficient, leading to higher contact stresses on the posterior cartilage, which could result in expedited wear [16]. A retroverted acetabulum can also cause impingement between the anterior femoral neck and anterior edge of the acetabulum, causing symptoms such as decreased range of motion and pain [16]. While there are several studies having reported AA among different racial and ethnic groups, little attention has been given to the association between age and acetabular version—particularly, how this may contribute to osteoarthritic change at an earlier age [17-21]. Our hypothesis suggests that patients with relative acetabular retroversion are predisposed to earlier presentation with symptomatic hip OA. Furthermore, we aim to investigate any potential disparities between female and male patient populations.

* Corresponding author. University of Illinois Chicago, 835 S. Wolcott Avenue, M/C 844, Chicago, IL 60612, USA. Tel.: +1 469 396 5956.
E-mail address: Arashrezaei2012@gmail.com

https://doi.org/10.1016/j.artd.2024.101322

Material and methods

This is a retrospective observational study with institutional review board approval conducted at a single institution, evaluating patients who underwent primary THAs for end-stage OA. All patients had computed tomography (CT) scans completed as part of their standard preoperative preparation for a robotically assisted THA. Each patient was under the care of a single senior surgeon (L.P.) between March 2018 and May 2022, and only patients with primary OA of the hip that went on to THA met inclusion criteria. Patients were excluded if their CT scan was inadequate for determining acetabular anteversion or if their pathology was secondary to other etiology such as advanced dysplasia (Crowe 3 or 4), post-traumatic arthritis, septic arthritis, osteonecrosis, or inflammatory arthritis. After exclusions, 516 CT scans (221 male and 295 female subjects) were selected for further analysis.

The date upon which THA surgery was conducted was used as a surrogate timeline marker for the patient's age at clinical presentation with symptomatic hip OA. The categorical parameters for the acetabular version ($\leq 15^\circ$ and $>15^\circ$) were determined based on historical studies that described currently accepted anatomic norms [5,22].

Acetabular anteversion was measured on the axial plane using a method proposed by Kim et al. [23]. First, the deepest part of the acetabulum was identified. This was typically where the medial wall of the acetabulum is most medial and often correlated with the CT cut showing the largest diameter of the femoral head. Another indicator is when the anterior acetabular wall showed congruence with the femoral head. A primary line was drawn horizontally through the apex of corresponding posterior walls, and a secondary line was drawn tangential to and connecting the apices of the anterior and posterior walls of the hip in question (Fig. 1a and b). The version angle was measured between a line perpendicular to the primary horizontal line connecting the bilateral posterior walls and the secondary line connecting the ipsilateral posterior and anterior wall apices. This value was recorded as the acetabular anteversion. An angle in relative retroversion was defined as an angle of less than 15°. All the measurements were performed by a fellowship-trained hip surgeon and a senior orthopedic resident. Twenty pelvises were randomly selected from the total group for reliability assessment for measurements of acetabular anteversion. The intraclass correlation coefficient was used to evaluate intra-observer and interobserver variabilities. Reliability was regarded as poor for less than 0.24, low for 0.25 to 0.49, moderate for 0.5 to 0.69, good for 0.70 to 0.89, and excellent for greater than 0.9.

Statistical analysis was performed by an independent statistician using the statistical package included in Microsoft Excel (Redmond, WA). For the comparison between patient's age and acetabular anteversion, an independent *t*-test was used. For the subgroup analysis, the correlation was applied to the male and female subgroups. $P < .05$ was considered to indicate statistical significance.

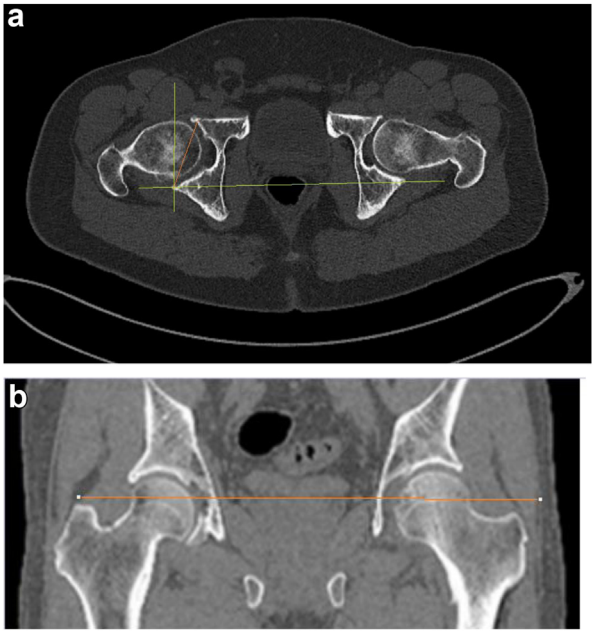

Figure 1. (a) Acetabular anteversion is measured on the orthogonal axial plane between a line perpendicular to the line connecting the posterior corner of the acetabuli and the line connecting posterior and anterior walls. (b) Coronal image shows how the orthogonal axial plane is determined where the acetabular cup is deepest and the medial wall of acetabulum is most medial.

Results

Overall, we found high agreement both within and between observers. The intraclass correlation coefficient of all the measurements was excellent and measured to be 0.92.

The mean age of the gender groups was statistically significant, with male subjects being younger at presentation than female subjects (Table 1).

Acetabular anteversion angles were also significantly different between male and female subjects, with pelvis of male subjects' pelvis demonstrating less anteversion ($16.6^\circ \pm 5.4^\circ$) than female subjects' pelvis ($20.4^\circ \pm 5.6^\circ$).

When analyzing the males and females individually, there was a significant statistical difference in age when comparing those with acetabular anteversion of less than or equal to 15° to those with acetabular anteversion of more than 15°. The average age was 63.7 years for 98 male hips that had acetabular anteversion of less than or equal to 15° and 67.2 years for 123 male hips that had acetabular anteversion of more than 15° (Table 2). The average age was 64.8 years for 62 female hips that had acetabular anteversion of less than or equal to 15° and 68.2 years for 233 female hips that had acetabular anteversion of more than 16° (Table 2).

A linear regression was performed to determine if the variables of gender and age were statistically significant (Table 3). Both gender and age demonstrate *P* values that were statistically significant with the other variable held constant. Males were associated with lower acetabular anteversion values as opposed to females, with age being held constant. Furthermore, patients with a higher acetabular anteversion value tended to be of an older age at symptomatic presentation (years) with gender being held constant.

Discussion

In this single-institution retrospective observational study, it was our goal to determine if patients with variation in acetabular version, particularly relative retroversion, were predisposed to earlier clinical presentation with symptomatic OA of the hip. After a review of 516 CT scans (221 males, 295 females), it was determined

Table 1
Demographic data, acetabular anteversion.

Variable	Overall	Male	Female	*P* value
Number of pelvises	516	221	295	
Age	66.7 ± 9.8	65.6 ± 9.7	67.5 ± 9.9	.031
Acetabular anteversion	18.8 ± 5.5	16.6 ± 5.4	20.4 ± 5.6	<.001

Table 2
Average age for normal and abnormal acetabular anteversion.

Sex	Acetabular anteversion				
		Overall	≤15°	>15°	*P* value
Male	Number of pelvises	221	98	123	
	Age	65.7 ± 9.7	63.7 ± 8.7	67.2 ± 10.2	.006
Female	Number of pelvises	295	62	233	
	Age	67.5 ± 9.9	64.8 ± 9.8	68.2 ± 9.8	.015

that the acetabular orientation among male subjects was less anteverted (16.6° ± 5.4°) than that of the female subjects' pelvis (20.4° ± 5.6°). Furthermore, not only did males demonstrate a lesser amount of anteversion in this cohort, but both males and females as separate groups showed a significant difference in age at presentation when their respective version was ≤15° (relative retroversion) vs those that were >15° (Table 2). In other words, both males and females tended to be older, on average, at clinical presentation when having an acetabular version >15°.

Although there is variability in a true universally accepted definition of "normal" acetabular version, there are various historical papers from which we derived our essential parameter of ≤15° or >15° Tönnis et al. studied both femoral and acetabular version and their respective relationships with pathology of the hip, using the limits of range of motion and onset of symptoms (ie, pain) to describe what many consider to be the normal boundaries of version today [5]. Similarly, Reynolds et al. studied the hip in a younger population presenting with symptoms of pain or impingement and concluded that significant symptoms were only present with a retroversion of greater than 15° [24].

Giori et al. conducted a study analyzing anteroposterior pelvis radiographs in 2 distinct groups: individuals who underwent THA (n = 131) and those from the general population (n = 99). Their research demonstrated a statistically significant relationship between acetabular retroversion and hip OA, with 20% of THA patients and 5% of individuals from the general population who had OA exhibiting acetabular retroversion. Similarly, our study's findings indicate that individuals with a relatively retroverted acetabulum are at an increased risk of experiencing an earlier onset of hip OA [25]. Although numerous studies attempt to describe the relationship of femoral and acetabular version and mechanics with various pathologies, there are little data directed specifically at the age- and gender-dependent effects of acetabular anteversion on OA of the hip [3-14]. Based on this information, younger male patients presenting with hip pain may have an underlying cause that could warrant surgical intervention sooner than expected. Through this understanding, arthroplasty surgeons may better direct their clinical investigation for new patients with a painful hip and ultimately use this evidence to assist in their decision-making process both preoperatively and intraoperatively.

There are several limitations to this study. First, this is a single-center single-surgeon retrospective study, which introduces selection and information bias in the patient population. Second, a power analysis was conducted prior to data collection and indicated that roughly 300 patients were needed in each of the female and male cohorts, so our study was slightly underpowered with 295 females and 221 males meeting inclusion criteria.

Table 3
Results of the regression analysis.

Variable	Value	Standard error	*P* value
Intercept	14.3	1.70	<.001
Gender	−3.6	0.49	<.001
Age	0.1	0.02	<.001

This study exclusively examined acetabular version as a potential factor. It is important to note that acetabular retroversion may not be the sole and definitive predisposing risk factor for hip OA. It could be influenced by other factors, including but not limited to trauma, congenital or developmental joint abnormalities, metabolic disorders, infections, endocrine issues, neuropathic conditions, and various anatomical abnormalities that can collectively contribute to the development of hip OA. Furthermore, it is worth mentioning that factors like femoral version or the combined version (ie, McKibbin Instability Index), which were not taken into account in this study, could potentially offer an additional layer of insight into how these patients may present with hip OA at a younger age. Several studies postulate that those with an increased or decreased acetabular version demonstrate a reciprocal change in the femoral version to maintain a combined version within normal parameters [8,9,12,22]. On the other hand, data collection on the femoral side could have provided further insight into why certain patient groups present older or younger with symptomatic hip OA. Had the number of subjects been greater, a subgroup analysis with more variables could have been possible. In addition, this study did not correlate CT scan measurements with other radiographic findings of abnormal acetabular version, such as the "cross-over sign." Although it is well known that radiographic evidence of pelvic abnormality is largely dependent on the quality of the image itself, this could have helped determine how much version on CT becomes evident on standard plain radiographs.

Conclusions

This study suggests that patients with a relatively decreased version angle (≤15°) are more likely to present with earlier-onset symptomatic hip OA than those with increased anteversion. Further study on the relationship between hip OA and the version of the acetabulum and/or proximal femur is warranted and may lead to better understanding of how this may lead a patient to clinical presentation at an earlier or later age.

Conflicts of interest

L. Puri is a paid consultant for Stryker; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101322.

CRediT authorship contribution statement

Arash Rezaei: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Stojanovic Michael:** Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Ahmed Eldib:** Investigation, Writing – original draft. **Lalit Puri:** Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Acknowledgments

We would like to express our sincere gratitude to Northshore University Health System for their generous funding and support of our research.

References

[1] Liu C-Y, Li C-D, Wang L, Ren S, Yu F-B, Li J-G, et al. Function scores of different surgeries in the treatment of knee osteoarthritis: a PRISMA-compliant systematic review and network-meta analysis. Medicine (Baltimore) 2018;97:e10828. https://doi.org/10.1097/MD.0000000000010828.

[2] Pollock M, Lanting B, Somerville L, Firth A. Outpatient total hip arthroplasty, total knee arthroplasty, and unicompartmental knee arthroplasty—a systematic review of the literature. Osteoarthritis Cartilage 2016;24:S433. https://doi.org/10.1016/j.joca.2016.01.784.

[3] Parker EA, Meyer AM, Nasir M, Willey MC, Brown TS, Westermann RW. Abnormal femoral anteversion is associated with the development of hip osteoarthritis: a systematic review and meta-analysis. Arthrosc Sports Med Rehabil 2021;3:e2047—58. https://doi.org/10.1016/j.asmr.2021.07.029.

[4] Barrack RL, Krempec JA, Clohisy JC, McDonald DJ, Ricci WM, Ruh EL, et al. Accuracy of acetabular component position in hip arthroplasty. J Bone Joint Surg Am 2013;95:1760—8. https://doi.org/10.2106/JBJS.L.01704.

[5] Tönnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. J Bone Joint Surg Am 1999;81:1747—70. https://doi.org/10.2106/00004623-199912000-00014.

[6] Moulton KM, Aly A-R, Rajasekaran S, Shepel M, Obaid H. Acetabular anteversion is associated with gluteal tendinopathy at MRI. Skeletal Radiol 2015;44:47—54. https://doi.org/10.1007/s00256-014-1991-6.

[7] McCarthy TF, Alipit V, Nevelos J, Elmallah RK, Mont MA. Acetabular cup anteversion and inclination in hip range of motion to impingement. J Arthroplasty 2016;31:264—8. https://doi.org/10.1016/j.arth.2016.01.067.

[8] Goronzy J, Franken L, Hartmann A, Thielemann F, Blum S, Günther K-P, et al. Acetabular- and femoral orientation after periacetabular osteotomy as a predictor for outcome and osteoarthritis. BMC Musculoskelet Disord 2020;21:846. https://doi.org/10.1186/s12891-020-03878-y.

[9] Hayashi S, Hashimoto S, Kuroda Y, Nakano N, Matsumoto T, Kamenaga T, et al. Anterior acetabular coverage and femoral head-neck measurements predict postoperative anterior impingement: a simulation study. J Orthop Res 2022;40:2440—7. https://doi.org/10.1002/jor.25258.

[10] Weber M, Woerner M, Craiovan B, Voellner F, Worlicek M, Springorum H-R, et al. Current standard rules of combined anteversion prevent prosthetic impingement but ignore osseous contact in total hip arthroplasty. Int Orthop 2016;40:2495—504. https://doi.org/10.1007/s00264-016-3171-x.

[11] Malik A, Maheshwari A, Dorr LD. Impingement with total hip replacement. J Bone Joint Surg Am 2007;89:1832—42. https://doi.org/10.2106/JBJS.F.01313.

[12] Xu L-Y, Huang Y, Li Y, Shen C, Zheng G, Chen X-D. Increased combined anteversion is an independent predictor of ischiofemoral impingement in the setting of borderline dysplasia with Coxa Profunda. Arthroscopy 2022;38:1519—27. https://doi.org/10.1016/j.arthro.2021.10.028.

[13] Goudie ST, Deakin AH, Deep K. Natural acetabular orientation in arthritic hips. Bone Joint Res 2015;4:6—10. https://doi.org/10.1302/2046-3758.41.2000286.

[14] van Buuren MMA, Arden NK, Bierma-Zeinstra SMA, Bramer WM, Casartelli NC, Felson DT, et al. Statistical shape modeling of the hip and the association with hip osteoarthritis: a systematic review. Osteoarthritis Cartilage 2021;29:607—18. https://doi.org/10.1016/j.joca.2020.12.003.

[15] Pedersen DR, Brand RA, Davy DT. Pelvic muscle and acetabular contact forces during gait. J Biomech 1997;30:959—65. https://doi.org/10.1016/S0021-9290(97)00041-9.

[16] Kiyama T, Naito M, Shiramizu K, Shinoda T. Postoperative acetabular retroversion causes posterior osteoarthritis of the hip. Int Orthop 2009;33:625—31. https://doi.org/10.1007/s00264-007-0507-6.

[17] Hoaglund FT, Low WD. Anatomy of the femoral neck and head, with comparative data from Caucasians and Hong Kong Chinese. Clin Orthop Relat Res 1980:10—6.

[18] Saikia KC, Bhuyan SK, Rongphar R. Anthropometric study of the hip joint in northeastern region population with computed tomography scan. Indian J Orthop 2008;42:260—6. https://doi.org/10.4103/0019-5413.39572.

[19] Maheshwari AV, Zlowodzki MP, Siram G, Jain AK. Femoral neck anteversion, acetabular anteversion and combined anteversion in the normal Indian adult population: a computed tomographic study. Indian J Orthop 2010;44:277—82. https://doi.org/10.4103/0019-5413.65156.

[20] Jiang N, Peng L, Al-Qwbani M, Xie G-P, Yang Q-M, Chai Y, et al. Femoral version, neck-shaft angle, and acetabular anteversion in Chinese han population: a retrospective analysis of 466 healthy adults. Medicine (Baltimore) 2015;94:e891. https://doi.org/10.1097/MD.0000000000000891.

[21] Kobayashi T, Morimoto T, Yoshihara T, Sonohata M, Rivière C, Mawatari M. The relationship between pelvic incidence and anatomical acetabular anteversion in female Japanese patients with hip osteoarthritis: a retrospective iconographic study. Surg Radiol Anat 2021;43:1141—7. https://doi.org/10.1007/s00276-021-02710-z.

[22] Lerch TD, Antioco T, Meier MK, Boschung A, Hanke MS, Tannast M, et al. Combined abnormalities of femoral version and acetabular version and McKibbin Index in FAI patients evaluated for hip preservation surgery. J Hip Preserv Surg 2022;9:67—77. https://doi.org/10.1093/jhps/hnac016.

[23] Kim J, Choi J-A, Lee E, Lee KR. Prevalence of imaging features on CT thought to Be associated with femoroacetabular impingement: a retrospective analysis of 473 asymptomatic adult hip joints. Am J Roentgenol 2015;205:W100—5. https://doi.org/10.2214/AJR.14.13130.

[24] Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum. J Bone Joint Surg Br 1999;81-B:281—8. https://doi.org/10.1302/0301-620X.81B2.0810281.

[25] Giori NJ, Trousdale RT. Acetabular retroversion is associated with osteoarthritis of the hip. Clin Orthop 2003:263—9. https://doi.org/10.1097/01.blo.0000093014.90435.64.