Original Article Clinics in Orthopedic Surgery 2023;15:567-573 • https://doi.org/10.4055/cios22350

Acetabular, Femoral, and Combined Anteversion in a Province in South Korea: Computed Tomography-Based Study

Youngho Cho, MD, Jaeuk Shin, MD, Sangwoo Kim, MD

Department of Orthopaedic Surgery, Daegu Fatima Hospital, Daegu, Korea

Background: The purpose of this study was to investigate the femoral, acetabular, and combined anteversion of the hip joint in South Koreans using computed tomography (CT).

Methods: We measured anteversion using CT venograms taken from 2016 to 2020. Of the total 1,073 patients, 952 patients were included in the study except for those with pelvic fractures, previous femoral fractures, childhood hip joint disease, osteoarthritis, or hip dysplasia (lateral center-edge angle, < 20), foreigners, and hip and knee replacement patients. Measurements were taken twice by two orthopedic surgeons.

Results: The femoral anteversion in women was 10.64° ± 10.26° (≤ 49 years), 15.75° ± 9.40° (50–59 years), 10.81° ± 9.14° (60–69 years), 12.38° ± 8.55° (70–79 years), and 11.23° ± 8.44° (≥ 80 years). The femoral anteversion in men was 12.02° ± 11.38° (≤ 49 years), 10.62° ± 9.11° (50–59 years), 6.09° ± 9.95° (60–69 years), 6.57° ± 9.51° (70–79 years), and 5.53° ± 9.29° (≥ 80 years). The acetabular anteversion in women was 17.65° ± 6.58° (≤ 49 years), 19.24° ± 6.42° (50–59 years), 20.30° ± 6.25° (60–69 years), 22.38° ± 7.36° (70–79 years), and 23.34° ± 6.98° (≥ 80 years). The acetabular anteversion in men was 15.21° ± 8.14° (≤ 49 years), 17.68° ± 6.00° (50–59 years), 17.54° ± 5.93° (60–69 years), 18.68° ± 6.62° (70–79 years), and 18.19° ± 6.94° (≥ 80 years). The combined anteversion in women was 28.29° ± 14.30° (≤ 49 years), 34.99° ± 10.62° (50–59 years), 31.11° ± 11.52° (60–69 years), 34.76° ± 10.86° (70–79 years), and 34.57° ± 11.45° (≥ 80 years). The combined anteversion in men was 27.23° ± 15.11° (≤ 49 years), 28.30° ± 11.23° (50–59 years), 23.63° ± 11.77° (60–69 years), 25.25° ± 12.02° (70–79 years), and 23.72° ± 11.88° (≥ 80 years).

Conclusions: Femoral anteversion tended to decrease with age in men and acetabular anteversion tended to increase in both men and women. Combined anteversion showed a tendency to increase slightly in women.

Keywords: *Anteversion, Femur, Acetabulum, Combined*

The osseous structures that make up the hip joint are the femoral head and the acetabulum. Bone including the proximal femur and soft tissues such as ligaments and muscles contribute to hip joint stability. The orientation and torsion of both femur and acetabulum affect not only the function and range of motion of the native hip joint but also pathologic conditions such as osteoarthritis and femoroacetabular impingement.[1-4)]

Acetabular version refers to the angle between either a central horizontal line connecting the anterior and posterior walls or the averaged opening plane of the acetabulum to the sagittal plane.[5)] Average acetabular anteversion has been reported to range from 16° to 21°.[2,5-7)] Femoral version is the angular relationship of the proximal femoral head and neck axis to the distal femoral transcondylar axis.[8)] In adults without pathology, previous literature reported that femoral anteversion is usually between 15° and

Received November 1, 2022; Revised February 3, 2023;
Accepted February 3, 2023
Correspondence to: Youngho Cho, MD
Department of Orthopaedic Surgery, Daegu Fatima Hospital, 99 Ayang-ro, Dong-gu, Daegu 41199, Korea
Tel: +82-53-940-7324, Fax: +82-53-954-7417
E-mail: femur1973@gmail.com

Copyright © 2023 by The Korean Orthopaedic Association
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

20° in the frontal plane of the body.[9,10)]

McKibbin[11)] first proposed the concept that the stability of the hip joint is determined by the sum of the femoral and acetabular anteversion in a study of infant cadavers. A combined anteversion also determines the stability and wear characteristics of the replaced joint and ultimately affects the longevity of a total hip replacement.[12,13)] Studies on the femoral and acetabular version of the hip joint without disease in adult Koreans have been rarely reported.[14)] The purpose of this study was to investigate the femoral, acetabular, and combined anteversion of the hip joint in South Koreans using computed tomography (CT).

METHODS

This study was approved by the Institutional Review Board of Daegu Fatima Hospital (No. DFE2022-09-004), which waived informed consent.

From 2016 to 2020, a total of 1,073 lower extremity computed tomography (CT) venograms were taken in our hospital. A CT venogram was taken to evaluate deep vein thrombosis before surgery in patients with hip fractures and to identify the cause of lower extremity swelling or edema in non-traumatic patients. Patients who had pelvic fractures, previous femoral fractures, childhood hip joint disease, or hip dysplasia (lateral center-edge angle, < 20), foreigners, those with osteoarthritic changes such as osteophytes in the femoral head or in the acetabular edge, and hip and knee replacement patients were excluded. Except for the above-mentioned patients, 952 patients were enrolled and their CT venograms were retrospectively analyzed. There were 453 women and 499 men. Among the 453 women, 38 were under the age of 49 years, 59 in their 50s, 135 in their 60s, 116 in their 70s, and 105 in their 80s or more. Among the 499 men, 87 were under the age of 49 years, 91 in their 50s, 117 in their 60s, 108 in their 70s, and 96 in their 80s or more (Table 1). The CT scans were performed using a 128 channel Siemens Somatom Definition flash (Siemens Healthineers, Erlangen, Germany). The patients remained in a supine and straight position during the scan. The image used in this study had a slice thickness of 5 mm.

Table 1. Basic Demographics of Current Study

Age (yr)	Female (n = 453)	Male (n = 499)
≤ 49	38	87
50–59	59	91
60–69	135	117
70–79	116	108
≥ 80	105	96

Jamali et al.[7)] described the acetabular version as cranial, central, and caudal and we measured the central version in the current study. Acetabular and femoral versions were measured by previously described methods.[15,16)] To measure the acetabular anteversion, the image passing the center of the femoral head was selected. The acetabular anteversion was measured by the following method. A line connecting both ischial spines was drawn and another line was drawn perpendicular to the first line along the acetabular posterior edge. Then, a line connecting the acetabular anterior and posterior edges was drawn. The angle between the second and third lines was defined as the acetabular anteversion (Fig. 1).

Femoral version was measured using the Weiner method.[16)] We selected two images that showed the widest femoral neck and both condyles of the distal femur. A line connecting both posterior condyles of the distal femur was drawn and another line passing through the center of the femoral neck was drawn. The angle between the two lines was determined as femoral version (Fig. 2). Combined anteversion was determined as the sum of the acetabular and femoral versions.

Two orthopedic surgeons (JS and SK) independently performed measurements of femoral and acetabular versions twice with an interval of 1 week. The average value of the four measurements was used in this study. The unaffected side was measured in hip fracture patients,

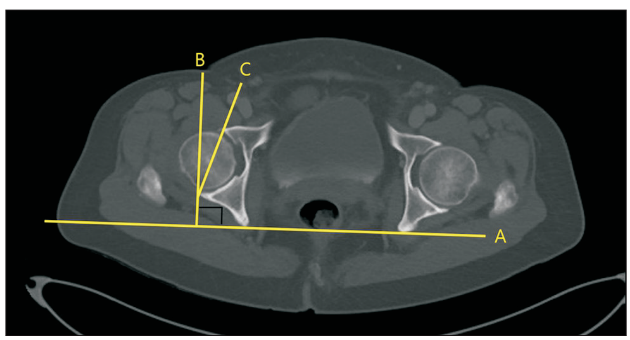

Fig. 1. Computed tomography through the center of the femoral head. Line A is a line connecting both ischial spines. Line B is a perpendicular line to line A. Line C is a line connecting the acetabular anterior and posterior edges. The angle between line B and lines C was defined as the acetabular anteversion.

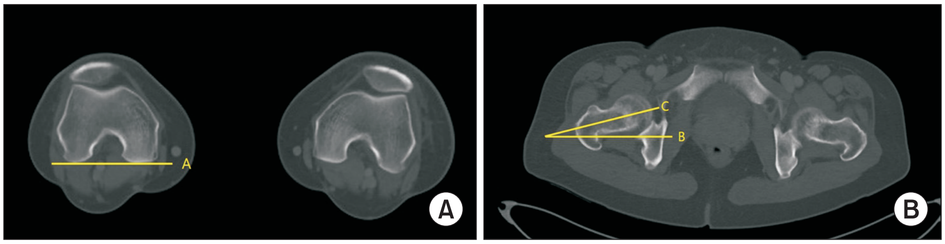

Fig. 2. (A) Computed tomography through the posterior femoral condyle of the distal femur. Line A is the line connecting both posterior condyles. (B) Computed tomography through the widest femoral neck. Line B is a parallel line of line A. Line C is a line passing through the center of the femoral neck. The angle between line B and C is femoral version.

Table 2. Intraclass Correlation Coefficient of Each Measurement

Measurer	Version	Intraclass correlation coefficient
Intra-measurer 1	Femoral version	0.971
	Acetabular version	0.970
Intra-measurer 2	Femoral version	0.978
	Acetabular version	0.960
Inter-measurer, 1st measure	Femoral version	0.983
	Acetabular version	0.969
Inter-measurer, 2nd measure	Femoral version	0.971
	Acetabular version	0.962

Table 3. Femoral Anteversion (°)

Age (yr)	Female (n = 453)	Male (n = 499)	*p*-value
≤ 49	10.64 ± 10.26	12.02 ± 11.38	0.525
50–59	15.75 ± 9.40	10.62 ± 9.11	0.001
60–69	10.81 ± 9.14	6.09 ± 9.95	< 0.001
70–79	12.38 ± 8.55	6.57 ± 9.51	< 0.001
≥ 80	11.23 ± 8.44	5.53 ± 9.29	< 0.001

Values are presented as mean ± standard deviation.

and measurers randomly selected and measured one side in the non-traumatic patient group. An intraclass correlation coefficient (ICC) was obtained to check interobserver and intraobserver reliability. Based on the 95% confidence interval of the ICC estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 are indicative of poor, moderate, good, and excellent reliability, respectively.[17)]

Mann-Whitney *U*-test was used for continuous variables. Statistical significance was accepted if the *p*-value was < 0.05. We used the literature of Schober et al.[18)] for the interpretation of the *r*-value. According to the literature, a coefficient of < 0.1 indicates a negligible correlation and 0.10 to 0.39 is interpreted as a weak correlation. A simple regression analysis was performed to identify correlation values. Data analysis was performed using IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA).

Table 4. Acetabular Anteversion (°)

Age (yr)	Female (n = 453)	Male (n = 499)	*p*-value
≤ 49	17.65 ± 6.58	15.21 ± 8.14	0.106
50–59	19.24 ± 6.42	17.68 ± 6.00	0.132
60–69	20.30 ± 6.25	17.54 ± 5.93	< 0.001
70–79	22.38 ± 7.36	18.68 ± 6.62	< 0.001
≥ 80	23.34 ± 6.98	18.19 ± 6.94	< 0.001

Values are presented as mean ± standard deviation.

RESULTS

Table 2 shows the ICCs related to inter-measurer and intra-measurer reliability. The femoral anteversion angle in women was 10.64° ± 10.26° (≤ 49 years), 15.75° ± 9.40° (50–59 years), 10.81° ± 9.14° (60–69 years), 12.38°± 8.55° (70–79 years), and 11.23° ± 8.44° (≥ 80 years). The femoral anteversion angle in men was 12.02° ± 11.38° (≤ 49 years), 10.62° ± 9.11° (50–59 years), 6.09° ± 9.95° (60–69 years), 6.57° ± 9.51° (70–79 years), and 5.53° ± 9.29° (≥ 80 years) (Table 3).

The acetabular anteversion angle in women was 17.65° ± 6.58° (≤ 49 years), 19.24° ± 6.42° (50–59 years), 20.30° ± 6.25° (60–69 years), 22.38° ± 7.36° (70–79 years), and 23.34° ± 6.98° (≥ 80 years). The male acetabular anterior angle was 15.21° ± 8.14° (≤ 49 years), 17.68° ± 6.00° (50–59 years), 17.54° ± 5.93° (60–69 years), 18.68° ± 6.62°

(70–79 years), and 18.19° ± 6.94° (≥ 80 years) (Table 4).

The combined anteversion in women was 28.29° ± 14.30° (≤ 49 years), 34.99° ± 10.62° (50–59 years), 31.11° ± 11.52° (60–69 years), 34.76° ± 10.86° (70–79 years), and 34.57° ± 11.45° (≥ 80 years). The combined anteversion in men was 27.23° ± 15.11° (≤ 49 years), 28.30° ± 11.23° (50–59 years), 23.63° ± 11.77° (60–69 years), 25.25° ± 12.02° (70–79 years), and 23.72° ± 11.88° (≥ 80 years) (Table 5). Figs. 3-5 show the distribution of all patients' data.

Table 5. Combined Anteversion

Age (yr)	Female (n = 453)	Male (n = 499)	*p*-value
≤ 49	28.29 ± 14.30	27.23 ± 15.11	0.714
50–59	34.99 ± 10.62	28.30 ± 11.23	< 0.001
60–69	31.11 ± 11.52	23.63 ± 11.77	< 0.001
70–79	34.76 ± 10.86	25.25 ± 12.02	< 0.001
≥ 80	34.57 ± 11.45	23.72 ± 11.88	< 0.001

Values are presented as mean ± standard deviation.

DISCUSSION

The hip joint is a complex ball and socket joint consisting of the femoral head and acetabulum. Detailed anatomy of the hip joint is important for the diagnosis and treatment of pathology. The version of the acetabulum and proximal femur plays the most important role in the primary osseous stability of the hip joint. Table 6 has shown varying ranges of femoral and acetabular versions according to race, gender, and country.[14,15,19-23] There is one study on the femoral and acetabular versions assessed in a small

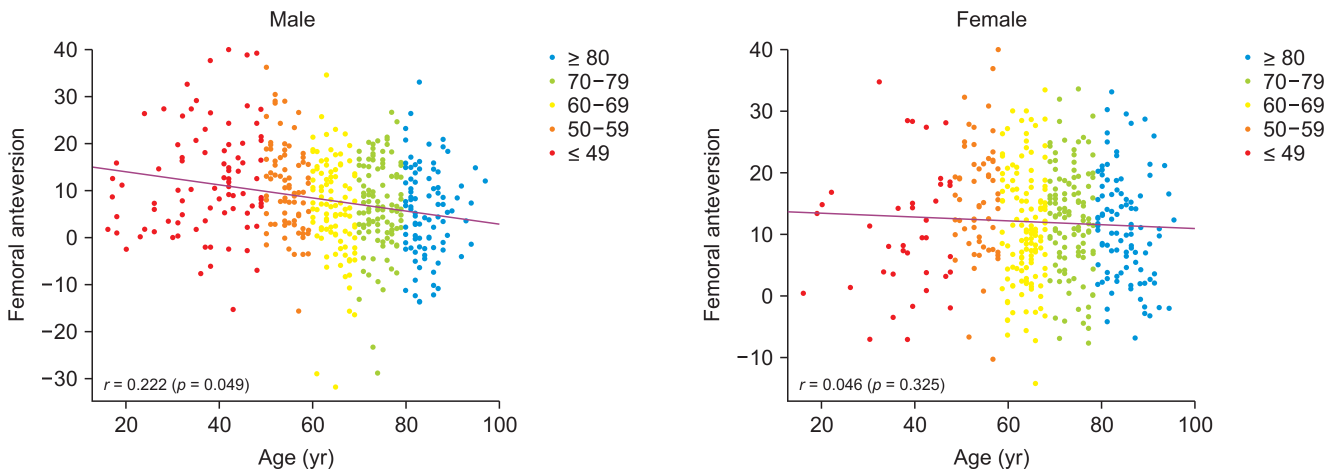

Fig. 3. Femoral version of all patients according to age and sex.

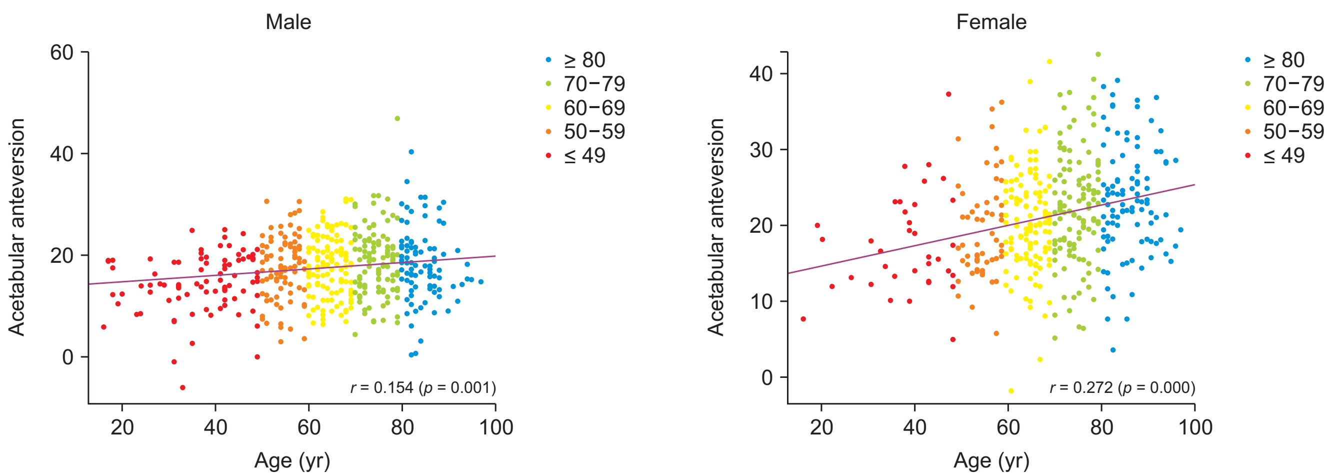

Fig. 4. Acetabular version of all patients according to age and sex.

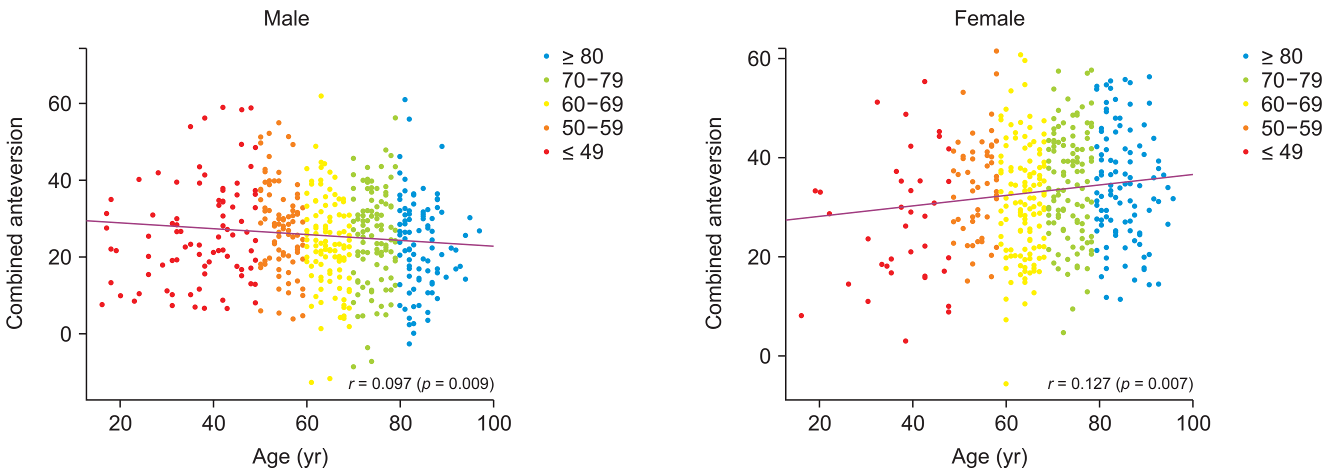

Fig. 5. Combined version of all patients according to age and sex.

Table 6. Acetabular and Femoral Version in Previous Reports

Study	Nation	Number	Femoral version (°)	Acetabular version (°)
Reikeras et al. (1983)[15]	Norway	47	13 ± 7	17 ± 6
Maheshwari et al. (2010)[19]	India	86	8 (6.5–10.0)	19 (16–22)
Buller et al. (2012)[20]	USA	115	4.7 ± 7.8 (Lt), 4.5 ± 8.5 (Rt)	26.4 ± 6.1 (Lt), 26.9 ± 5.8 (Rt)
Jiang et al. (2015)[21]	China	466	10.62	18.79
Klasan et al. (2019)[22]	Germany	404	-	M: 14.3 ± 5.2, F: 19.31 ± 5.04
Kim et al. (2019)[14]	South Korea	232	M: 5.3 ± 7.6 (Rt), 1.5 ± 9.2 (Lt) F: 10.3 ± 8.2 (Rt), 7.9 ± 8.2 (Lt)	M: 15.3 ± 6.1 (Rt), 15.3 ± 6.6 (Lt) F: 16.8 ± 5.4 (Rt), 16.3 ± 5.8 (Lt)
Yamatani et al. (2021)[23]	Japan	245	-	M: 14.3 ± 5.2, F: 18.8 ± 5.4
This study	South Korea	952 (F: 453, M: 499)	9.8 ± 9.9 (F: 11.9 ± 9.2, M: 7.9 ± 10.1)	19.2 ± 7.2 (F: 21.2 ± 7.1, M: 17.5 ± 6.8)

Values are presented as mean (range) or mean ± standard deviation.
Lt: left, Rt: right.

number of relatively young South Koreans.[14] We measured a total of 952 Korean people without hip joint problems using CT images. To the best of our knowledge, there has been no report based on such a high number of cases in Korean people with a wide range of ages.

The degree of acetabular opening in the sagittal plane is acetabular version, which is usually in anterior direction. However, focal or global acetabular retroversion is associated with hip joint pathology including femoroacetabular impingement, labral tear, chondral damage or osteoarthritis.[3,4] Previous studies reported a wide range of acetabular versions from 14.3° ± 5.2° to 26.9° ± 5.8°.[14,15,19-23] In the present study, acetabular version showed a tendency to increase with age, which was more prominent in women. In people 60 years or older, there was also a statistically significant difference between men and women. Although the exact cause of this could not be found, the authors assumed that the cause was the decrease in lordosis of the lumbar spine, which is more prominent in women with increasing age. It was thought that decreasing lordosis of the lumbar spine would increase acetabular version while rotating the pelvis posteriorly. The fact that various reports have reported wide ranges of acetabular versions is also thought to be based on the various ages of the study subjects.

Femoral version is the angular relationship of the proximal femoral head and neck axis to the distal femoral transcondylar axis.[8] It is known that the femoral version is about 30° at birth and then decreases as we grow up to about 15° in adulthood.[24] However, our study showed slightly different results. In women, the mean femoral version was in the range of about 10° to 15° with a wide range of standard deviations. In men, the mean femoral version was in the range of about 5° to 10° and had a wide range of standard deviations. Femoral version was higher in women than in men as in previous studies.[8,25] It is known that growth plate fusion occurs at an earlier age in women than men; therefore, a shorter growth period could be a cause of the higher femoral version in women.[26] In particular, the femoral version showed a weak positive correlation with age in men ($r = 0.222$, $p = 0.049$). This is a new finding from our study suggesting that femoral version changes are over after growth and we could find only one report in the English literature related to this phenomenon.[27] It seemed to decrease in women, but no statistical significance could be found ($r = 0.046$, $p = 0.325$). During the skeletal growth, torsional deformation will occur for the following reasons: since the epiphyseal plate is least resistant to torsion, a torsional load will lead to a rotational deflection of the growth columns around the circumference of the epiphyseal plate.[28] After skeletal maturity, habitual position during daily activity changes in the soft tissue surrounding the hip, shortening the hip joint capsule and muscles on one side and lengthening the hip joint capsule and muscles on the other side. These asymmetrical changes in soft tissue around the hip will likely create uneven torsional forces placed on the femur.[29]

A combined anteversion is a sum of the femoral and acetabular anteversion. It determines the stability and wear characteristics of the replaced joint and ultimately affects the longevity of total hip replacement.[15-17] In the current study, combined anteversion showed distinct differences between men and women. In other words, there was no significant difference between men and women under the age of 49 years but a significant difference over the age of 50 years. Combined anteversion in men did not show significant changes with age ($r = 0.097$, $p = 0.009$). However, in women, it showed a weak tendency to increase with age ($r = 0.127$, $p = 0.007$). In a previous study, men had lower combined anteversion than women (29.6° vs. women 33.5°).[6] A finite element study of THA investigated combined anteversion to find an optimal combination to avoid impingement and concluded it was 37.3°.[30] Another study reported that the combined anteversion with computer navigation was within the safe zone of 25° to 50°.[31] As shown in this study, individual combined anteversion showed a very diverse range, so it is thought that it would be useful to measure the native combined anteversion of patients before total hip replacement to avoid impingement and dislocation.

Our study has several limitations. The first is that as this study was conducted in a relatively small population who visited a single institution, it may be less representative than that of a nationwide multicenter study. The second is that despite independent measurement by the two experienced measurers, measurement errors cannot be completely excluded. In addition, we did not consider body laterality, body mass index, height and weight, and spinal disorders such as degenerative kyphosis or scoliosis, which may affect the acetabular and femoral geometry. Although more than 900 patients were included in this study, it is difficult to generalize the results because the number of patients in each age group is small. This is an area that needs to be clarified through further studies in the future. However, to the best of our knowledge, our study is the first report about femoral, acetabular, and combined anteversion with a large number of cases among Korean people with a wide range of ages.

In conclusion, femoral anteversion tended to decrease with age in men and acetabular anteversion tended to increase in both men and women. Combined anteversion showed a tendency to decrease slightly with age in men and increase in women.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Youngho Cho https://orcid.org/0000-0002-1527-7761
Jaeuk Shin https://orcid.org/0000-0002-6759-9666
Sangwoo Kim https://orcid.org/0000-0003-1708-4901

REFERENCES

1. 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(6):e2047-58.
2. Murray DW. The definition and measurement of acetabular orientation. J Bone Joint Surg Br. 1993;75(2):228-32.
3. Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum: a cause of hip pain. J Bone Joint Surg Br. 1999;81(2):281-8.

4. Tonnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. J Bone Joint Surg Am. 1999;81(12):1747-70.

5. Kohnlein W, Ganz R, Impellizzeri FM, Leunig M. Acetabular morphology: implications for joint-preserving surgery. Clin Orthop Relat Res. 2009;467(3):682-91.

6. Maruyama M, Feinberg JR, Capello WN, D'Antonio JA. The Frank Stinchfield Award: Morphologic features of the acetabulum and femur: anteversion angle and implant positioning. Clin Orthop Relat Res. 2001;(393):52-65.

7. Jamali AA, Mladenov K, Meyer DC, et al. Anteroposterior pelvic radiographs to assess acetabular retroversion: high validity of the "cross-over-sign". J Orthop Res. 2007;25(6):758-65.

8. Kate BR. Anteversion versus torsion of the femoral neck. Acta Anat (Basel). 1976;94(3):457-63.

9. Fabry G, MacEwen GD, Shands AR Jr. Torsion of the femur: a follow-up study in normal and abnormal conditions. J Bone Joint Surg Am. 1973;55(8):1726-38.

10. Herzberg W, Meitz R, Halata Z. Antetorsion of the femur neck: a variable of the trochanter minor? Unfallchirurg. 1991;94(4):168-71.

11. McKibbin B. Anatomical factors in the stability of the hip joint in the newborn. J Bone Joint Surg Br. 1970;52(1):148-59.

12. D'Lima DD, Chen PC, Colwell CW Jr. Optimizing acetabular component position to minimize impingement and reduce contact stress. J Bone Joint Surg Am. 2001;83 Suppl 2 Pt 2:87-91.

13. Patil S, Bergula A, Chen PC, Colwell CW Jr, D'Lima DD. Polyethylene wear and acetabular component orientation. J Bone Joint Surg Am. 2003;85 Suppl 4:56-63.

14. Kim BS, Kim ST, Wi SM, Choi WR, Kim DS. Normal Korean femoral neck anteversion, acetabular anteversion and combined anteversion measured with computed tomography. J Korean Orthop Assoc. 2019;54(3):261-8.

15. Reikeras O, Bjerkreim I, Kolbenstvedt A. Anteversion of the acetabulum and femoral neck in normals and in patients with osteoarthritis of the hip. Acta Orthop Scand. 1983;54(1):18-23.

16. Weiner DS, Cook AJ, Hoyt WA Jr, Oravec CE. Computed tomography in the measurement of femoral anteversion. Orthopedics. 1978;1(4):299-306.

17. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016;15(2):155-63.

18. Schober P, Boer C, Schwarte LA. Correlation coefficients: appropriate use and interpretation. Anesth Analg. 2018;126(5):1763-8.

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(3):277-82.

20. Buller LT, Rosneck J, Monaco FM, Butler R, Smith T, Barsoum WK. Relationship between proximal femoral and acetabular alignment in normal hip joints using 3-dimensional computed tomography. Am J Sports Med. 2012;40(2):367-75.

21. Jiang N, Peng L, Al-Qwbani M, 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(21):e891.

22. Klasan A, Neri T, Sommer C, et al. Analysis of acetabular version: retroversion prevalence, age, side and gender correlations. J Orthop Translat. 2019;18:7-12.

23. Yamatani Y, Munemoto M, Ando E, Shigematsu H, Kawate K, Tanaka Y. Sex differences in reference values of hip acetabular measurements using computed tomography in Japanese adults and the effect of aging on the measurement parameters. J Orthop Sci. 2021;26(6):1029-35.

24. Scorcelletti M, Reeves ND, Rittweger J, Ireland A. Femoral anteversion: significance and measurement. J Anat. 2020;237(5):811-26.

25. Lerch TD, Todorski IA, Steppacher SD, et al. Prevalence of femoral and acetabular version abnormalities in patients with symptomatic hip disease: a controlled study of 538 hips. Am J Sports Med. 2018;46(1):122-34.

26. Grumbach MM, Styne DM. Puberty: ontogeny, neuroendocrinology, physiology, and disorders. In: Larsen PR, Kronenberg HM, Melmed S, Polonsky KS, eds. Williams textbook of endocrinology. 10th ed. Philadelphia: Elsevier; 1992. 1115-626.

27. Pierrepont JW, Marel E, Bare JV, et al. Variation in femoral anteversion in patients requiring total hip replacement. Hip Int. 2020;30(3):281-7.

28. Ogden JA. Skeletal injury in the child. Philadelphia: Lea and Febiger; 1982. 16-40.

29. Cibulka MT. Determination and significance of femoral neck anteversion. Phys Ther. 2004;84(6):550-8.

30. Widmer KH, Zurfluh B. Compliant positioning of total hip components for optimal range of motion. J Orthop Res. 2004;22(4):815-21.

31. Amuwa C, Dorr LD. The combined anteversion technique for acetabular component anteversion. J Arthroplasty. 2008;23(7):1068-70.