Original Article

Correlation Between Combined Femoral and Acetabular Anteversion and Functional Outcome in Total Hip Arthroplasty Patients

Yadnik Jadhav[1], Ujjwal Wankhede[2], Yashwant Risbud (late)[3], Monica Patil[4]

[1]FRCS Ortho, Hip and arthroplasty fellow, Imperial College Healthcare NHS trust. [2]Consultant Trauma and Arthroplasty surgeon, Arihant Multispecialty Hospital, Nagpur, Maharashtra, India. [3]Associate Professor, Department of Orthopaedics, B.J Govt Medical College, Pune, Maharashtra, India. [4]Consultant Radiologist, Department of Radiodiagnosis, Milton Keynes University Hospital.

Abstract

Background: A total hip arthroplasty (THA) is a very successful operation, but a proper positioning of both the femoral and acetabular components has been found to influence functional performance and stability. A new focus has now moved on from the alignment of the components in isolation, and this has been replaced by the notion of combined anteversion that will be used to indicate the cumulative alignment of the two components as well as the influence on hip biomechanics. The objective is to measure combined anteversion of the femur and acetabulum with the help of computed tomography (CT) in individuals that undergo THA and to test its relationship with the postoperative functional outcome measured according to the Harris Hip Score (HHS). **Material and Methods:** This was a prospective observational study that involved 40 patients that had primary THA. Measuring the anteversion of the femoral and acetabular components in postoperative CT scans and the ensuing combination of the two was done. Anteversion was grouped in three categories between patients. HHS was used to evaluate functional outcomes during 7 days, 6 weeks, and 3 months of postoperative time. One-way ANOVA with the post hoc Tukey test was used as the statistical analysis. **Results:** 57.5% of patients had combined anteversion of 40° to 70°. This population exhibited much better mean HHS at each follow-up time than the <40° or the >70° population ($p < 0.001$). There was no major distinction in HHS between the extreme groups. There were significant improvements in functional grading with the majority of patients realizing good to excellent results after 3 months and one year and mainly within the optimum combined anteversion range. **Conclusion:** Femoral anteversion together with acetabular anteversion has a significant impact on early functional outcome of THA. The sustenance of combined anteversion in a 40-70° range has been found to be related to better postoperative functioning. Combined anteversion CT-based evaluation could also help to optimize the position of components and enhance the outcome of patients.

Keywords: Total hip arthroplasty; Combined anteversion; Femur anteversion; Acetabulum anteversion; Harris Hip Score.

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Introduction

Total hip arthroplasty (THA) is generally considered to be among the most effective orthopedic surgeries that offer significant pain relief, functionality, and the enhancement of the quality of life of patients experiencing degenerative, inflammatory, traumatic, and avascular processes of the hip joint. Although its success rate has been very high, its complications like dislocation, impingement, accelerated wear, instability, and poor functional results still present a great target and cause of patient dissatisfaction and revision surgery.[1,2] Out of the various parameters that affect the outcome after the operation of the THA, proper positioning of the femur and the acetabulum components has been repeatedly highlighted as a factor that defines the success and lifespan of the implants.

The concept of safe zone has traditionally been used to position components when used in THA, particularly the acetabular cup positioning, as the specific ranges of cup inclination and anteversion were suggested to minimize the risk of dislocation based on the observation of Lewinnek et al.[3] However, later research proved that even dislocations and non-good functional results may be achieved when the component is located in such so-called safe zones and it is arguable that analysis of acetabular orientation alone could be inadequate.[4] This has increased the desire to assess the interrelationship of a position of both the femur and acetabular components instead of the position of individual components.

The principle of combined anteversion, the product of the anteversion of the femoral stem and the acetabular cup, has become more dominant as a more holistic and biomechanical valid parameter in THA. It was first suggested by Widmer that the best and optimal hip stability and range of motion (impact free) is possible when the femur and acetabular components are matched in a complementary fashion instead of maintaining

Address for correspondence: Dr. Yadnik Jadhav, FRCS Ortho, Hip and arthroplasty fellow, Imperial College Healthcare NHS trust.
E-mail: ?@gmail.com

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predetermined 5 independent target angles.[5] The combined concept of anteversion focuses on the active interrelationship process between the femur head, neck, acetabular liner and the surrounding soft tissues during functional motions of flexion, extension and rotation.

A number of researchers have postulated that optimum range of combined anteversion can help lessen the eventualities of prosthetic impingement, edge loading, instability, and dislocation whilst concurrently enhancing functional results.[6,7] This concept was further developed by Dorr and others who introduced intraoperative methods to measure and apply desired combined anteversion with emphasis put on its practical use in the most common type of THA.[8] The further development of surgical methods, navigation and imaging modalities have also improved the capacity of the surgeon in measuring and managing combined anteversion during surgery supporting its clinical relevancy.

Validated scoring systems, like the Harris Hip Score (HHS), which evaluates pain, function, range of movement and deformity, are generally used to measure functional outcome after THA. Although radiological outcome and dislocation rate have been used as a subject in a number of studies with regard to the positioning of the components, few studies have effectively managed to correlate combined anteversion of both the components with functional outcome scores at a specified time points after surgery.[9] This correlation is not insignificant, because the presence of optimal radiological alignment is not necessarily accompanied by the satisfactory functional results in the eyes of the patient.

Moreover, patient-specific variables like age, activity level, spinopelvic mobility, and acetabular structure add another variation in the optimal component positioning indicating that a standard target is possibly inapplicable to all patients.[10] It is in this regard that measurement of relationship between combined anteversion and functional outcome in a specified group of patients offers a good solution towards attainment of a trade-off between the stability and mobility following THA.

The present study aims to determine the combined femoral and acetabular anteversion in patients undergoing total hip arthroplasty using computed tomography (CT) scan and to evaluate the influence of combined femoral and acetabular anteversion on postoperative functional outcome, as assessed by the Harris Hip Score, in order to identify an optimal anteversion range associated with improved functional recovery following total hip arthroplasty.

Materials and Methods

Study Design and Setting: Prospective observational study conducted at Sassoon General Hospital.

Study period: July 2012 to July 2014.

Study Population: Patients admitted to Sassoon General Hospital who underwent total hip arthroplasty (THA) during the study period.

Sample Size: Total number of patients included in the study: 40.

Inclusion Criteria

1. Patients who underwent bilateral total hip arthroplasty for osteonecrosis of the femoral head.
2. Patients who underwent unilateral total hip arthroplasty for fracture neck of femur or osteonecrosis of the femoral head.

Exclusion Criteria

1. Patients with bilateral hip disease in varied stages.
2. Patients with developmental dysplasia of the hip.
3. Patients with fractures of the acetabulum or lower limb long bones.
4. Patients with bilateral hip disease who underwent unilateral total hip arthroplasty.

Statistical Analysis: For statistical analysis, data were initially entered into a Microsoft Excel spreadsheet and then analysed using SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism (version 5). Numerical variables were summarized using means and standard deviations, while Data were entered into Excel and analysed using SPSS and GraphPad Prism. Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests were used to compare independent groups, while paired t-tests accounted for correlations in paired data. Chi-square tests (including Fisher's exact test for small sample sizes) were used for categorical data comparisons. P-values ≤ 0.05 were considered statistically significant.

Results

A total of 40 patients were included in the study. The majority of patients belonged to the 51–60-year age group (25%), followed by the 21–30 and 31–40-year age groups (20% each). Patients aged 61–70 years constituted 17.5% of the study population, while only 5% were between 11–20 years of age.

Femoral component anteversion was most commonly observed in the 30°–50° range in 65% of patients, with a mean anteversion of 34.2° ± 7.0°. Lower femoral anteversion (<30°) and higher anteversion (>50°) were seen in 17.5% of patients each. Acetabular component anteversion showed a relatively even distribution, with 40% of patients having anteversion between 20°–30° (mean 24.3° ± 6.3°), while 30% each had anteversion <20° and >30°.

Combined anteversion was predominantly within the optimal range of 40°–70° in 57.5% of patients, with a mean value of 61.8° ± 3.7°. Lower combined anteversion (<40°) was noted in 25% of patients (mean 32.3° ± 10.8°), while higher combined anteversion (>70°) was observed in 17.5% (mean 89.9° ± 21.9°).

Functional outcome as assessed by the Harris Hip Score (HHS) showed significant variation across the combined anteversion groups at all follow-up periods. At 7 days postoperatively, patients with combined anteversion between 40°–70° had significantly higher mean HHS (67.57 ± 2.84) compared to those with <40° (53.80 ± 2.86) and >70° (54.00 ± 2.94), with the difference being highly significant ($F = 111.65$, $p < 0.001$). Post hoc Tukey analysis revealed significant differences between the 40°–70° group and both extreme groups, while no significant difference was observed between the <40° and >70° groups.

A similar trend was noted at 6 weeks follow-up, where the mean HHS in the 40°–70° group (84.30 ± 3.51) was significantly higher than the <40° (65.50 ± 3.60) and >70° (65.14 ± 2.91) groups ($p < 0.001$). Post hoc analysis again demonstrated

statistically significant differences between the optimal combined anteversion group and the other two groups, with no significant difference between the extreme groups.

At 3 months follow-up, patients with combined anteversion of 40°–70° achieved the highest mean HHS (94.26 ± 2.14), which was significantly superior to those with <40° (78.30 ± 2.79) and >70° (78.43 ± 3.82) combined anteversion ($F = 177.21$, $p < 0.001$). Post hoc Tukey testing confirmed these findings, with highly significant differences between the optimal group and the remaining groups.

Grading of Harris Hip Scores revealed progressive improvement over time. By 7 days, most patients had been combined under the failed or poor category. Four to six weeks later, a majority of the patients had a good functional outcome and at a period of three months, 57.5% of the patients scored excellently, with the majority of the patients scoring very well on the combined range of 40 to 70 on the anteversion.

Table 1: Demographic Profile and Age-wise Distribution of Patients (n = 40)

Age Group (Years)	Number of Patients	Percentage (%)
11–20	2	5
21–30	8	20
31–40	8	20
41–50	5	12.5
51–60	10	25
61–70	7	17.5
Total	40	100

Table 2: Distribution and Descriptive Statistics of Component Anteversion

Component	Anteversion Range (°)	n	Percentage (%)	Mean (°)	SD (°)
Femoral	< 30	7	17.5	18	4.7
	30–50	26	65	34.2	7
	> 50	7	17.5	54.3	1.8
Acetabular	< 20	12	30	15	7.8
	20–30	16	40	24.3	6.3
	> 30	12	30	34.1	12.4

Table 3: Distribution and Descriptive Statistics of Combined Anteversion

Combined Anteversion (°)	Number of Patients	Percentage (%)	Mean (°)	SD (°)
< 40	10	25	32.3	10.8
40–70	23	57.5	61.8	3.7
> 70	7	17.5	89.9	21.9
Total	40	100	—	—

Table 4: Comparison of Harris Hip Score Across Combined Anteversion Groups

Follow-up Period	Combined Anteversion (°)	n	Mean HHS	SD	ANOVA Result
7 Days	< 40	10	53.8	2.9	F = 111.65
	40–70	23	67.57	2.8	p < 0.001 (HS)
	> 70	7	54	2.9	
6 Weeks	< 40	10	65.5	3.6	p < 0.001 (HS)
	40–70	23	84.3	3.5	
	> 70	7	65.14	2.9	
3 Months	< 40	10	78.3	2.8	F = 177.21
	40–70	23	94.26	2.1	p < 0.001 (HS)
	> 70	7	78.43	3.8	

Table 5: Harris Hip Score Grading at Different Follow-up Periods

HHS Score	Grade	7 Days	6 Weeks	3 Months
< 60	Failed	17	0	0
60–69	Poor	15	15	0
70–79	Fair	8	2	10
80–89	Good	0	20	7
90–100	Excellent	0	3	23

Discussion

In this study we found that patients with combined anteversion (CA) within the 40°–70° range had significantly superior early and mid-term functional outcomes by Harris Hip Score (HHS) at 7 days, 6 weeks and 3 months compared with patients with CA < 40° or > 70°. This pattern—better function and fewer early adverse functional outcomes when CA lies within a defined "optimal" window—is concordant with the combined-anteversion concept introduced to balance cup and stem orientations to maximize impingement-free range of motion and stability. A combined perspective of cup and stem anteversion was first formalized mathematically and clinically by Widmer who suggested the idea of an optimal combined target to minimize dislocation and impingement risk.[11] Equally, Dorr and co-workers proved the amplification of intraoperative

evaluation and steering to reach a desired collective anteversion enhanced the placement of components and consequently, clinical achievement.[12]

Multiple clinical series also indicate that functional results are echoed in our results. In cases of THA, Li et al. found that the positioning of components in relation to combined-anteversion principles (i.e.: putting all components at 40°-70o) resulted in a reduction of postoperative mean HHS with a significantly improved mean and good to excellent HHS of the majority of cases at mid-term follow up, which also compares to the large improvements in HS in our group, 40° -70°. Greater retrospective cohort sizes and technique papers that explicitly focused on combined anteversion ranges (usually quoted as something like 25 -50 degrees or 37-42 degrees depending on which formula was used) have reported lower rates of dislocation and a better functional score when CA was held within their range.[14,15] The range of our best interval (40-70 degrees) is a bit wider than previous suggestions; perhaps due to variations in calculation of CA (radiographic versus intraoperative navigation versus formulae like these: Widmer, An example is that tighter target ranges (42° to 37/25 to 50/25 degrees depending on the stem/cup design) are commonly observed in studies with Widmer equation or with navigation results, but acceptable outcomes with a broader CA range are in reportedly broad clinical series with a variety of different femoral types.[11,16]

Recent studies focus on highlighting the fact that CA is among the potentially interacting factors determining outcome: acetabular and femoral offsets, cup inclination and prosthetic head/neck geometry and patient-specific bony anatomy all moderate dislocation risk and functional recovery. Hidaka et al. highlighted the interplay of combined anteversion with offset variables, showing that CA alone does not wholly account for dislocation or functional differences.[17] Ohmori and co-workers used 3-D impingement modelling to show that different CA “patterns” produce different impingement-free angles, supporting the idea that an optimal CA must be interpreted alongside component design and bony morphology.[18]

Compared with multicentre and navigated series (which often report lower variability in postoperative component orientation), our study’s strengths include a clear stratification of CA groups and serial HHS assessments demonstrating early and progressive functional separation of groups. Limitations that may account for differences versus some published cohorts include the relatively small sample size (n = 40), the 3-month follow up window (shorter than many outcome studies), and absence of 3-D CT-based postoperative measurements in all patients—factors that can increase measurement variability and reduce external comparability. Several contemporary technique papers, including those describing handheld accelerometer navigation, suggest that intraoperative CA assessment may reduce outliers and further improve clinical outcomes; future studies using navigation or larger samples would help confirm whether narrowing the CA target yields even better HHS trajectories. [19,20]

In summary, our results support the clinical relevance of maintaining combined anteversion within an optimal window to achieve superior early functional recovery after hip arthroplasty, while underscoring that CA should be considered together with other implant and patient-specific variables when planning component orientation.

Conclusion

The present study demonstrates a significant correlation between combined femoral and acetabular anteversion and functional outcome following total hip arthroplasty. Patients with combined anteversion within the range of 40°–70° consistently achieved superior Harris Hip Scores at early and intermediate follow-up periods compared to those with lower or higher combined anteversion values. Extremes of combined anteversion were associated with poorer functional recovery, highlighting the importance of balanced component positioning rather than isolated assessment of femoral or acetabular orientation. The results support the clinical implications of the combined anteversion concept in the parsimonious increase of biomechanics of the hip, hip stability, and early postoperative functionality. Regular evaluation of the combined anteversion with the help of the computed tomography can help the surgeons to obtain the best placement of implants and improved functional results. Further studies with larger sample sizes and longer follow-up are recommended to validate these findings and to determine their impact on long-term implant survival and patient satisfaction.

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Conflicts of interest

There are no conflicts of interest.

References

1. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. Lancet. 2007;370(9597):1508–1519.
2. Ethgen O, Bruyère O, Richy F, Dardennes C, Reginster JY. Health-related quality of life in total hip and total knee arthroplasty: a systematic review. J Bone Joint Surg Am. 2004;86(5):963–974.
3. Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am. 1978;60(2):217–220.
4. Callanan MC, Jarrett B, Bragdon CR, Zurakowski D, Rubash HE, Freiberg AA, et al. The John Charnley Award: risk factors for cup malpositioning. Clin OrthopRelat Res. 2011;469(2):319–329.
5. Widmer KH. A simplified method to determine acetabular cup anteversion from plain radiographs. J Arthroplasty. 2004;19(3):387–390.
6. Yoshimine F, Ginbayashi K. A mathematical formula to calculate the range of motion in total hip arthroplasty. J Biomech. 2002;35(7):989–993.
7. Jolles BM, Zangger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty. J Arthroplasty. 2002;17(3):282–288.
8. Dorr LD, Malik A, Dastane M, Wan Z. Combined anteversion technique for total hip arthroplasty. Clin OrthopRelat Res. 2009;467(1):119–127.
9. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. J Bone Joint Surg Am. 1969;51(4):737–755.

10. Esposito CI, Carroll KM, Sculco PK, Padgett DE, Jerabek SA, Mayman DJ. Total hip arthroplasty patients with fixed spinopelvic alignment are at higher risk of dislocation. J Arthroplasty. 2018;33(5):1449–1454.
11. Widmer KH. Compliant positioning of total hip components for optimal range of motion. Int Orthop. 2004;28(4):230–233.
12. Li J, Zheng W, Sun G, et al. Total hip arthroplasty using combined anteversion principles: clinical outcomes and component positioning. J OrthopSurg Res. 2013;8:45.
13. Loppini M, Grappiolo G. Femur-first surgical technique: a non-computerized approach and review of combined anteversion literature. Hip Int. 2017;27(2):124–130.
14. Chang JD, Kim IS, Bhatt S, Lee SS. Revision total hip arthroplasty using imageless navigation: application of Widmer's combined anteversion concept. J Arthroplasty. 2017;32(6 Suppl):S203–S207.
15. Ohmori T, Takatori Y, Ichinohe S, et al. Optimal combined anteversion pattern for impingement-free range of motion after total hip arthroplasty. J Orthop Sci. 2019;24(1):142–147.
16. Hidaka R, Matsubara M, Takao M, et al. Clinical effects of combined anteversion and offset on hip stability and outcomes. J Orthop Transl. 2024;44:78–86.
17. Ohmori T, Takatori Y, Endo H, et al. Three-dimensional impingement simulation analysis of combined anteversion in total hip arthroplasty. Clin Biomech (Bristol, Avon). 2020;72:1–7.
18. Perico DA, Bollars P, Innocenti M. Combined anteversion technique using an accelerometer-based navigation system: early clinical results. Arthroplasty Today. 2023;9:101078.
19. Qiao H, Wang Q, Zhang Y, et al. Impact of prosthetic angle variations in combined anteversion technique on surgical failure rates in developmental dysplasia of the hip. J Arthroplasty. 2025;40(1):12–20.
20. Ranawat CS, Maynard MJ. Modern techniques of cemented total hip arthroplasty. Orthop Clin North Am. 1992;23(2):237–247.