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Abstract

Background:
Accurate component positioning is the key for successful outcome after total hip arthroplasty (THA). Positioning acetabular and femoral components in a safe zone of 25°–50° on the basis of combined anteversion (CA) has shown to reduce instability and impingement. This safe zone was described for THAs performed through the posterior approach and has not been validated for other surgical approaches.
Methods:

Seventy patients who underwent unilateral uncemented THA were included in the study; 35 patients—using posterior approach and the remaining 35—using trans-gluteal approach. All patients included had a stable and impingement-free THA at a mean follow-up of 39.2 ± 9.5 months. CT scan was performed to assess component positioning by calculating CA. The values were compared between the two groups to study possible differences.

Results:

CA in the trans-gluteal group was significantly lower (32° ± 3.7° vs 38.4° ± 4.6°, $P < .001$) compared to posterior group. The difference in CA was due to the differences in acetabular anteversion, which was significantly low in the trans-gluteal group than the posterior group (22.1° ± 3.6° vs 27.8° ± 4.2°, $P < .001$). The mean femoral anteversion was similar in both groups. All trans-gluteal hips fell within the safe zone of 20°–40°, and all posterior hips fell within the safe zone of 25°–50°.

Conclusion:

A safe zone of 25°–50° is valid for THAs performed from the posterior approach but not universally applicable. For trans-gluteal approach, a safe zone of 20°–40° is better to provide a stable and impingement-free THA. CA varies with the surgical approach. THAs performed through the trans-gluteal approach can be stable and impingement-free with lesser CA compared to THAs performed through the posterior approach.

Keywords (separated by '-')	Hip arthroplasty - Component positioning - Anteversion - Combined anteversion - Acetabular version
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ORIGINAL ARTICLE

Choice of surgical approach influences the combined anteversion needed for a stable and impingement-free total hip arthroplasty

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Abstract

Background Accurate component positioning is the key for successful outcome after total hip arthroplasty (THA). Positioning acetabular and femoral components in a safe zone of 25°–50° on the basis of combined anteversion (CA) has shown to reduce instability and impingement. This safe zone was described for THAs performed through the posterior approach and has not been validated for other surgical approaches.

Methods Seventy patients who underwent unilateral uncemented THA were included in the study; 35 patients—using posterior approach and the remaining 35—using trans-gluteal approach. All patients included had a stable and impingement-free THA at a mean follow-up of 39.2 ± 9.5 months. CT scan was performed to assess component positioning by calculating CA. The values were compared between the two groups to study possible differences.

Results CA in the trans-gluteal group was significantly lower (32° ± 3.7° vs 38.4° ± 4.6°, $P < .001$) compared to posterior group. The difference in CA was due to the differences in acetabular anteversion, which was significantly low in the trans-gluteal group than the posterior group (22.1° ± 3.6° vs 27.8° ± 4.2°, $P < .001$). The mean femoral anteversion was similar in both groups. All trans-gluteal hips fell within the safe zone of 20°–40°, and all posterior hips fell within the safe zone of 25°–50°.

Conclusion A safe zone of 25°–50° is valid for THAs performed from the posterior approach but not universally applicable. For trans-gluteal approach, a safe zone of 20°–40° is better to provide a stable and impingement-free THA. CA varies with the surgical approach. THAs performed through the trans-gluteal approach can be stable and impingement-free with lesser CA compared to THAs performed through the posterior approach.

Keywords Hip arthroplasty · Component positioning · Anteversion · Combined anteversion · Acetabular version

Introduction

Instability and impingement are the two most common reasons for the failure of a total hip arthroplasty (THA). Both instability and impingement are most commonly due to errors on part of the surgeon in component positioning [1]. Combined anteversion (CA), which is the sum of acetabular and femoral anteversion, has been proposed and accepted as a valid tool to assess safe component positioning during THA. The term combined anteversion was first used by McKibbin [2] in infants and was subsequently popularized by Dorr [3] in hip arthroplasty. It has been shown that CA within the safe zone of 25°–50° protects against impingement and instability. It has been well reported that anterior-based surgical approaches lower dislocation rates compared to posterior approach for THA. Dorr in his report gave a cut-off of > 50° of CA for a posteriorly done THA to dislocate anteriorly [4]. This value cannot be extrapolated and has not been validated to THAs that are performed using an anterior- or lateral-based surgical approach. All descriptions of CA are based on the posterior approach. With this background, we performed a retrospective analysis to compare the values of CA in patients who underwent THA using either a modified Hardinge approach (trans-gluteal approach with anterior hip dislocation) or the posterior approach. Our hypothesis was that: (1) the safe zone of CA will vary with the surgical approach and (2) THA performed through the trans-gluteal approach will tend to require lower values of CA for being

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stable and free of impingement compared to hips performed through the posterior approach.

Methods

Informed consent for participation in the study and CT scans were obtained from all patients. The institutional review board approved the study. After screening of 188 patients for satisfaction of inclusion criteria, 70 patients (70 THAs) with a pain-free, well-functioning THA satisfying the inclusion criteria (35 using the posterior approach and 35 using the trans-gluteal approach) were recruited for the study. Patients were considered for inclusion if they had undergone unilateral primary uncemented THA for any reason, follow up—minimum 2 years post-surgery, no secondary surgeries to address any surgery-related complications, a Harris hip score of > 80 and excellent hip range of motion defined as (flexion > 100°, abduction > 20°, adduction > 15°, external rotation > 15° and internal rotation > 10°). Patients in both groups were comparable in age, sex and body mass index (Table 1). All patients had either metal/ceramic on highly cross-linked polyethylene liners. The largest possible head size and a neutral polyethylene liner were used in all cases. The CA was measured using computerized tomography scan (CT) by a blinded radiologist who had no knowledge about the study.

Surgical technique

Patients were operated in the lateral decubitus position. Standard techniques for surgical exposure were used using either the posterior or the trans-gluteal approach. Acetabulum first technique was followed. The trial socket was initially positioned parallel to the transverse acetabular ligament aiming for an inclination of 40°. Acetabular osteophytes if present were removed. The femoral component was positioned parallel to the posterior femoral neck plane. After trial reduction, hip was checked for stability by putting it through the range of motion. The hip was checked for impingement in extension, external rotation and abduction, flexion and internal rotation. If necessary, change in position of the trial socket was done to prevent impingement and improve stability through ROM. Every time the acetabular version was changed, it was made sure there was no bony or prosthetic impingement with hip ROM. When satisfied with the trial, the trial socket position was marked (Fig. 1) and was replicated with the definitive press fit socket. No attempt was made at measuring CA intraoperatively.

Table 1 Patient demographics

Parameter	Trans-gluteal group	Posterior group	*P* value
Age (years)	55.5 ± 12.2	57 ± 11.5	0.43
Sex			0.80
Males	19	20	
Females	16	15	
BMI	28.5 ± 4.9	28.1 ± 6	0.09
Hip ROM			
Flexion	117° ± 9.8°	115° ± 9°	0.44
Abduction	3.4°@29° ±	30° ± 5.9°	0.5
Adduction	18.6° ± 3.4°	19.6° ± 4.1	0.13
External rotation	29° ± 5.8°	29.5° ± 6.6°	0.35
Internal rotation	20.4° ± 4.5°	19° ± 3.8°	0.07
Harris hip score	90.2 ± 4.8	90.3 ± 4	0.45
Head size			
28 mm	10 patients	9 patients	
32 mm	10 patients	12 patients	0.87
36 mm	15 patients	14 patients	
Follow up (months)	39.4 ± 10.2	38.9 ± 9	0.42

Measurement of combined anteversion using CT

Follow-up CT examination was performed, and the calculation of femoral and acetabular component version was performed using the method described by Fujishiro et al. [5]. The acetabular version was using the axial CT cut passing through the center of the acetabulum. The angle between the line connecting the lateral anterior and posterior margins of the acetabular shell and the sagittal plane is defined as the plane perpendicular to a line connecting two identical points on either side of the pelvis. The femoral component version was calculated as the angle between the lines connecting the femoral head running through the center of the femoral neck and the line joining the posterior part of the medial and lateral femoral condyles (Fig. 2). Acetabular inclination was assessed on AP radiograph as described by Sutherland et al. [6].

Statistics

Statistical analysis was performed with Statplus for Mac, version 6. The variables assessed were distributed continuously or categorically. So, they were represented either as mean ± S.D or as frequencies, respectively. Two blinded radiologists interpreted the radiographic measurements, and an average of those two values was taken as final. Continuously distributed variables were analyzed using the independent T test. For categorical variables, a Chi–square test was performed. The level of significance was set at $P < 0.05$.

Results

All patients at the time of assessment were pain-free, functional and independent without complaints. There were 39 males and 31 females. None of the patients had faced any

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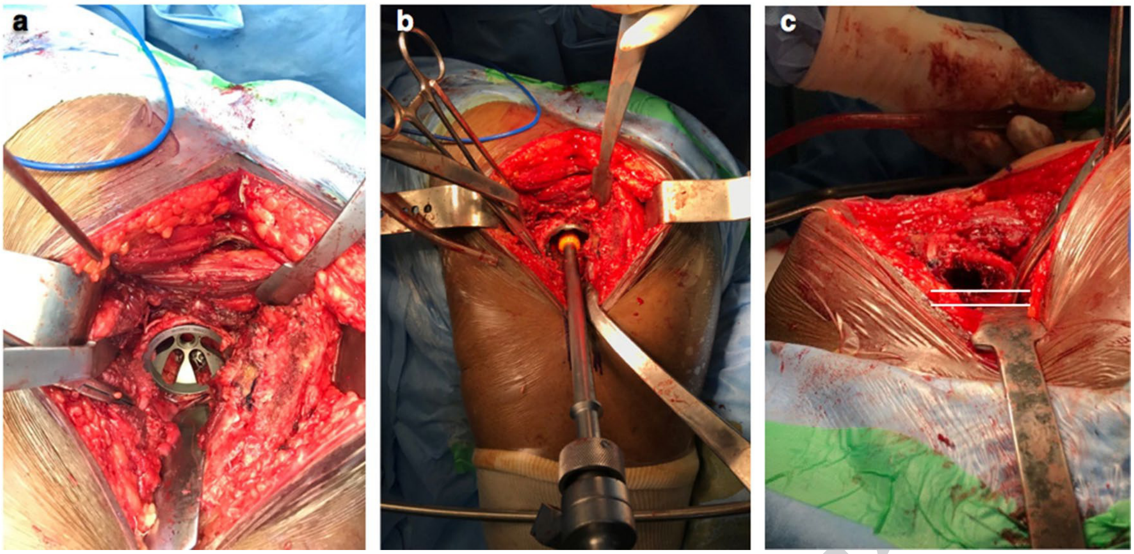

Fig. 1 The intraoperative technique used for component positioning irrespective of surgical approach. **a** Positioning the cup trial parallel to the transverse acetabular ligament, **b** after trial reduction and adjustments in cup position if required, the final trial position is marked and replicated, **c** preparation for femoral implantation parallel to the posterior femoral neck plane

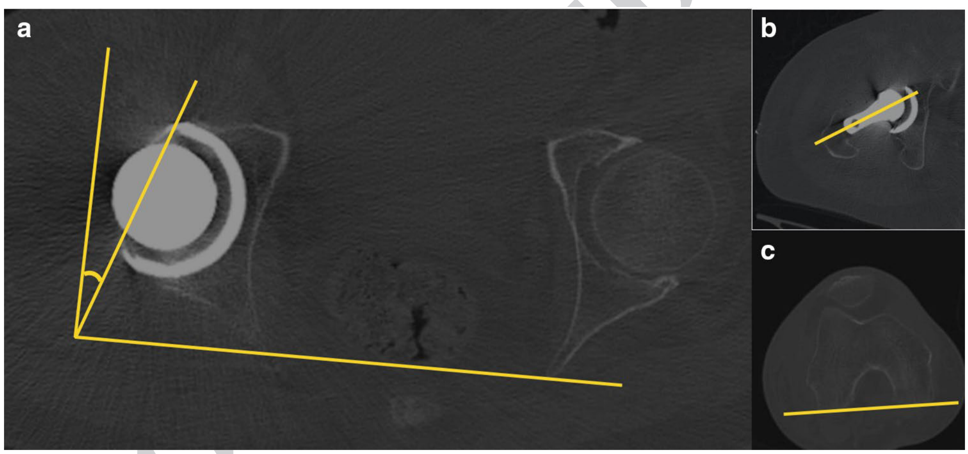

Fig. 2 Technique for CT measurement of acetabular and femoral component version according to Fujishiro et al. **a** Acetabular component version is measured between a line joining the lateral AP margins of the socket and the sagittal plane, measured as a perpendicular to a line connecting two identical points on either side of the pelvis. **b** & **c** Femoral component version is measured as the angle between a line joining the prosthetic head and the proximal femur running through the neck of the prosthesis and a line joining the posterior aspect of the medial and lateral femoral condyles

issues or complications in the postoperative and follow-up period. The mean follow-up at the time of assessment was 39.2 ± 9.5 months. The mean Harris hip score at the time of assessment was 90.3 ± 4.5 (Table 1). The mean CA was 35.2° ± 5.2°. The mean CA in the trans-gluteal group was significantly lower compared to the posterior group (Fig. 3). The difference in CA was mainly due to the differences in acetabular component anteversion, which was significantly high in the posterior group, whereas the mean femoral component version was similar in both groups (Figs. 4, 5). The mean socket inclination was 36.88° ± 4.6° and was similar in both groups. We could not appreciate any gender differences in CA measurements (Table 2).

Two patients in the trans-gluteal group had a CA of less than 25° compared to none in the posterior group. No patients had a CA of > 50° in either groups. Four patients in the posterior group had a CA of > 45° compared to none in the trans-gluteal group.

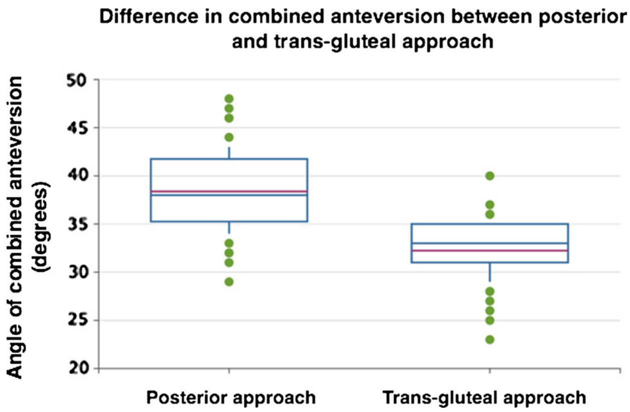

Fig. 3 Box plot showing the distribution and difference in combined anteversion values in the posterior and the trans-gluteal groups

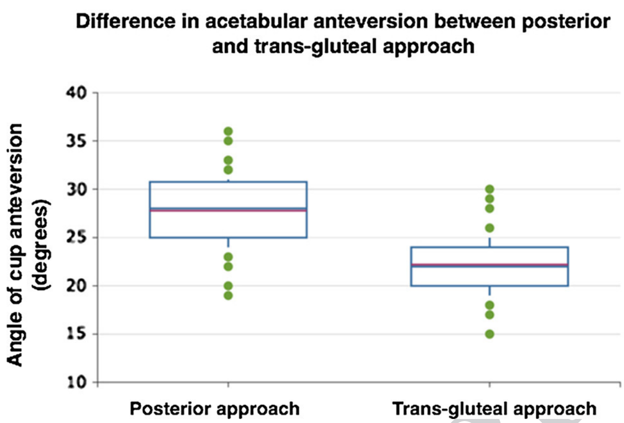

Fig. 4 Box plot showing the distribution and difference in acetabular component anteversion values in the posterior and the trans-gluteal groups

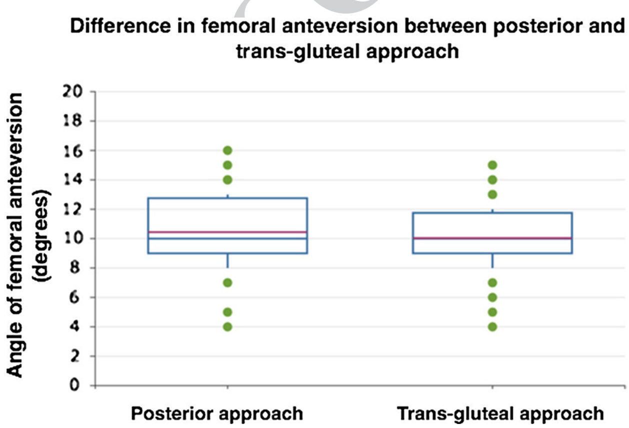

Fig. 5 Box plot showing the distribution and difference in femoral component anteversion values in the posterior and the trans-gluteal groups

Discussion

The accurate spatial orientation of femur and acetabular components with regard to anteversion and acetabular inclination has been shown to be important for satisfactory function after THA [7]. Combined anteversion, which is the sum of femoral and acetabular component versions, has been shown to be more useful value to assess component orientation rather than individual version values [8]. Traditionally acetabular anteversion of 20°–25° is recommended based on an assumption that you antevert the femoral component by around 15°. However, this is not true as the femoral canal geometry is more constricting when you use cementless stems and can vary from 15° of retroversion to 30° of anteversion [9]. The acetabular component positioning being more flexible in terms of adjusting version, it becomes important to look at anteversion as a combined value rather than individual values to assess adequacy of component positioning [10].

The major drawback of CA is that there is no reliable way to measure it intraoperatively other than variable anatomical landmarks and tests like the coplanar test in conventional THA [11]. Coplanar test was described by Ranawat [12], where CA is calculated by the amount of internal rotation of the hip required to bring coplanarity between femoral head and the socket. This technique is subject to interpretation bias and is applicable to THAs performed from the posterior approach as described by the author. Computer navigation does allow the surgeon to verify CA during surgery [4], but it is not routinely available, expensive and may not be a cost-effective tool. Thus, the accuracy in measuring CA intraoperatively is variable unless computer navigation is used. However, it is still a great parameter to assess the adequacy of component placement and helps in decision making when faced with the problem of postoperative instability or impingement.

The reported acceptable safe zone based on CA has ranged from 25° to 50° [3, 13]. The safe zone can vary with regard to sex, race [14, 15] and more importantly the surgical approach. The previous descriptions of CA do not take the surgical approach and the influence of soft tissues into account on instability following a THA. The safe zone of 25°–50° of CA was based on posterior approach after de-functioning of the posterior soft tissue restraints. This safe zone may not be valid for THA performed through other lateral- and anterior-based surgical approaches. Our results show that the safe zone based on CA varies significantly for THAs performed through a trans-gluteal approach compared to a posterior approach. The variation is predominantly in the acetabular component version. The CA values in the trans-gluteal group ranged from 23° to 40° in our study. One hundred percentage of the patients

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Table 2 Results

Variable	Trans-gluteal group	Posterior group	*P* value
Combined anteversion (CA)	32° ± 3.7°	38.4° ± 4.6°	< 0.001
Acetabular component anteversion	22.1° ± 3.6°	27.8° ± 4.2°	< 0.001
Femoral component anteversion	9.9° ± 2.6°	10.4° ± 2.6°	0.46
Acetabular component inclination	37.4° ± 3.9°	36.5° ± 4.5°	0.23
Gender-specific CA	Males (both groups) 34.6 ± 5.4	Females (both groups) 35.6 ± 5.1	0.21

in this group fell within a safe zone of 20°–40° with only two patients having CA values of less than 25°. This indicates the effect of intact posterior soft tissues in preventing posterior instability. On the contrary, the CA ranged 29°–48° in the posterior group, falling perfectly within the safe zone of 25°–50°.

Though the idea of positioning the acetabular component in different degrees of anteversion based on the surgical approach is not new, it has never been objectively studied before using CA as a parameter in the clinical setting. This is the first study to our knowledge to study the effect of surgical approach on combined anteversion in THA. The study, however, has limitations. It was retrospective and the adequacy of sample size was not evaluated, so the results have to be interpreted with caution. Though we chose patients carefully accounting for instability, impingement and hip function, we relied on clinical assessment and it would be impossible to rule out subtle ongoing prosthetic or bony impingement. The study design was not appropriate for recommending or defining a separate safe zone for the trans-gluteal approach, since only patients with well-functioning hips were included. These findings, however, can serve as pilot data for a randomized control trial to validate the results. Extrapolating the CA values for any anterior-based surgical approach may not be acceptable since approaches such as direct anterior and the anterolateral do not violate anterior musculature to the extent needed for the trans-gluteal approach. Previously published Indian data also have shown lower values of CA in the Indian population. The mean CA value of 35.2° ± 5.2° reported in our study is lower than what is reported from other population [16]. This is, however, in accordance with values seen in Indian population, which is 3°–5° less than the western population with more significant differences seen in the femoral anteversion compared to acetabular anteversion [17].

Conclusion

Based on the published values, recommending a CA of 25°–50° as a safe zone to prevent instability and impingement cannot be universally accepted. CA does vary significantly with the surgical approach. Stable and impingement-free THAs performed through the trans-gluteal approach show significantly less CA values compared to well-functioning THAs performed through the posterior approach.

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Compliance with ethical standards

Conflict of interest The first author is an editorial board member with (i) Indian Journal of Orthopedics and (ii) European Journal of Orthopedic Surgery and Traumatology. Other authors have no conflicts of interest.

Informed consent Informed written consent from all participating patients was obtained.

Ethical approval Our institutional review board approved the study.

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