Hip external rotation and extension angles for exposure and preparation of the proximal femur in direct anterior total hip arthroplasty: A cadaveric study

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ABSTRACT

Introduction: The direct anterior approach (DAA) to total hip arthroplasty (THA) has a known learning curve, largely due to difficulty achieving exposure and visualization of the acetabulum and proximal femur for joint preparation. There is paucity of information on limb positioning and the degree of angulation at which the limb is positioned for adequate visualization. This study aimed to identify the mean angles of limb positioning necessary for adequate exposure when using two Mueller retractors for femoral preparation using traditional table.

Materials & methods: A surgeon performed a DAA THA on 11 cadaveric hemipelvises, exposing the femoral canal with two simple, robust Mueller retractors. The degree of external rotation and extension of the hip was measured.

Results: Of the 11, the mean age was 77.6 years and mean BMI was 27.95. The mean external rotation angle was $56.5 \pm 13.5^\circ$. The mean extension angle was $19.9 \pm 6.6^\circ$.

Discussion & conclusion: The key technical step in this study incorporated a second robust Mueller retractor on the posterior aspect of the greater trochanter, providing maximum leverage to deliver the femur and achieve visibility while reducing angles of limb positioning thereby reducing complications, and ultimately lessening the learning curve.

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1. Introduction

Total hip arthroplasty (THA) is a well-established surgical procedure with multiple indications which include osteoarthritis, trauma, infection, and deformities. The rate at which THAs are being performed annually in the United States is projected to increase by 174% by the year 2030, which will yield an estimated 572,000 operations per year.¹ With such an increase in THAs, it is important for orthopaedic surgeons to be familiar with the advantages and pitfalls of each of the established surgical approaches.

Of the numerous approaches, the direct anterior approach

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(DAA) has been popularized in recent years for its reportedly improved short-term functional outcomes, including further immediate postoperative ambulation distance as well as those measured by the time-to-get-up-and-go test, the Harris Hip distance walk questionnaire, HOOS Sports & Recreation assessment, and the Lower Extremity Functional Score test.^{2,3} However, the DAA is a procedure with a known learning curve reported in the literature.^{4,5} Complications associated with this approach include lateral femoral cutaneous nerve (LFCN) injuries, femoral neck fractures, and ipsilateral ankle fractures, among others.^{6–8} The difficulty of the DAA THA is in large part due to exposure and reduced visualization inherent to the approach. To offset these difficulties, surgeons often place patient limbs at extreme angles, use various retractors, and other techniques to improve exposure.

Given the increasing rate of THA's being performed, the increasing popularity of the DAA, complications observed, and the recognizable difficulty of the DAA, it is of great research interest to ease the learning curve of this approach while simultaneously improving outcomes. Appropriate retractor placement might

minimize extreme limb positioning with a theoretical translation to reduce complications and lessen the learning curve associated with the DAA THA. This study highlights the importance of the retractor placement and aims to discover the mean external rotation and extension angles of the leg to expose the proximal femur in the DAA.

2. Materials & Methods

This study involved 11 fresh-frozen cadaveric hemipelves, each of which underwent a DAA THA performed by a senior orthopaedic surgeon. The specimens were placed in a supine position on a dissection table and stabilized throughout the procedure by assistants.

An incision was begun 3 cm distal and 3 cm lateral to the ASIS, extending distally and laterally to the level of the TFL fascia. After blunt dissection to the joint capsule, a capsulotomy was performed to obtain appropriate exposure of the hip. To control for the amount of soft tissue release, the anterior capsule as well as the inferior capsule were completely released. An in-situ osteotomy of the femoral neck was then performed, and the femoral head was extracted with a corkscrew in standard fashion. After exposure and reaming of the acetabulum, preparation of the femur was begun.

First, the senior surgeon completely released the superior posterior capsule from the greater trochanter to fully expose the proximal femur. The conjoint tendon was then also released as needed to enable delivery of the femur anteriorly and laterally. The knee was then placed into flexion, and the hip placed into extension and external rotation. The femur was then exposed by placing a simple robust Short Prong Mueller retractor (Stryker Corp., Mahwah, NJ) around the posterior medial proximal femur to gently retract the medial tissues and push the femur laterally. A second simple robust Mueller retractor was placed on the posterior aspect of the greater trochanter in anatomic alignment with the femur. In this position, the handle of the second Mueller retractor was pointing towards the position of the ipsilateral shoulder. The second retractor was used to elevate and present the femur anteriorly as well as retract the superior soft tissues concealing the femoral canal. The use and placement of retractors are demonstrated below in Fig. 1 and Fig. 2. The femur was then positioned using the least degree of external rotation and extension and maximum possible adduction necessary until the femoral canal could be adequately visualized and broached for an optimum size stem. At this

Fig. 1. View of osteotomized femoral neck in DAA THA with mueller retractors placed at the posterior medial proximal femur and posterior aspect of the greater trochanter. Image represents retractor placement prior to retraction and femoral elevation with the second mueller retractor (yellow star) at the posterior aspect of the greater trochanter.

Fig. 2. View of osteotomized femoral neck in DAA THA with mueller retractors placed at the posterior medial proximal femur and posterior aspect of the greater trochanter. Image represents retraction of tissues with elevation and exposure of the femoral canal with the second mueller retractor (yellow star) as described above.

confirmed position, the degree of external rotation and extension of the hip was measured with a goniometer and recorded. The remainder of the arthroplasty was completed following the standard technique.

3. Results

Eleven left sided hemipelves were included in this study, of which 6 were female and 5 were male. The mean age was 77.6 (range, 60 to 96) years. The mean height was 169.3 (range, 154.9 to 190.5) centimeters. The mean weight was 82.0 (range, 47.6 to 136.1) kilograms. The mean BMI was 27.95 (range, 19.8 to 43.8). The mean external rotation angle was $56.5 \pm 13.5^\circ$. The minimum and maximum external rotation angles recorded were 30° and 75° respectively. The mean extension angle was $19.9 \pm 6.6^\circ$. The minimum and maximum extension angles recorded were 0° and 23° respectively. These results are included in Table 1.

4. Discussion

The DAA THA is a favorable approach because of the reduced soft tissue disruption, reported rapid return to strengthening the normal gait, and lower rates of dislocation.^{2,3,9} Although the DAA has shown promise of better short-term outcomes, it is not without complications. Nerve injury during all approaches to the THA has a reported incidence ranging from 0.09% to 3.7%.³ A systematic review by Brown and Swanson et al. reported that surgical approach had no bearing on the incidence rate of all neurologic injury.¹⁰ However, there are complications with the DAA THA such as increased risk of lateral femoral cutaneous nerve (LFCN) injuries, ipsilateral ankle fractures, and intraoperative femur fractures. Bhargava's study retrospectively found that LFCN injuries, resulting in paresthesias, occurred at a rate of 14.8% with the DAA.⁷ Other stretch injuries to the neurovasculature are possible given the degree of extension and external rotation required for this approach. As expected however, complications occur less frequently as surgeon's gain experience with the direct anterior approach.

The steep learning curve of the DAA THA is widely demonstrated in the literature. Stone and Sibia et al. found that as surgeons gained experience with the procedure, they experienced fewer femoral complications as well as reduced total OR and procedure times.⁴ Hartford and Bellino et al. evaluated the first 500 DAA THA's performed by a single surgeon and found that major complication rates declined from 5% to 2% and periprosthetic fracture rates decreased

Table 1
Specimen characteristics and angle measurements.

Pt	Age/Gender	Height (cm)	Weight (kg)	BMI	Hip External Rotation Angle (degrees)	Hip Extension Angle (degrees)	Laterality
1	75/F	167.6	72.6	25.8	70	10	L
2	70/F	172.7	68.0	22.8	51	8	L
3	80/F	165.1	63.0	23.1	30	16	L
4	60/M	190.5	113.4	31.2	70	20	L
5	81/M	165.1	72.6	26.6	50	23	L
6	75/M	172.7	95.3	31.9	49	15	L
7	81/F	162.6	47.6	18.0	75	10	L
8	74/M	182.9	136.1	40.7	70	10	L
9	95/F	154.9	47.6	19.8	55	0	L
10	67/M	170.2	127.0	43.8	55	20	L
11	96/F	157.5	59.0	23.8	47	10	L

from 9% to 2% as the surgeon became more experienced.⁵ Furthermore, Soriali and Leonard et al. reported 21 femoral neck fractures and 1 greater trochanter fracture in the first 250 of 1764 procedures, occurring during femoral exposure and preparation.⁸ This further highlights the need to ease the learning curve as well as improve femoral canal exposure.

The preparation of the femoral canal and placement of the femoral implant is difficult as the femur must be elevated and translated anteriorly from the soft tissues. There are many methods used to ease the difficulty of this step such as limb positioning, superior capsulotomy, release of abductors, limb distraction, and the use of bone hooks, retractors, and angled instruments.^{11,12} During the preparation of the femur for trialing components, the surgical hip is often positioned in adduction, extension, and maximal external rotation. There are no documented or evidence-based guidelines for the degrees of extension, adduction, or external rotation necessary for this approach. Prior publications describe placing the femur in at least 90° of external rotation, slight adduction, and slight extension, but to the author's knowledge, there is no current evidence behind any reported range of motion and is largely anecdotal.^{6,9,12} With the proper placement of the second Mueller retractor and its use as elevation tool, our study found an average external rotation angle of $56.5 \pm 13.5^\circ$ and an average extension angle of $19.9 \pm 6.6^\circ$. The ROM we recorded during the procedure was less than the previously described 90° of external rotation, which was previously deemed to be necessary for adequate femoral expose in the DAA THA. In addition to reduced average external rotation and extension angles needed for adequate exposure, the Mueller retractor is sturdy and does not bend easily compared to other retractors. Given this, it aids not only in retracting the tissue but also in elevating the femur, further improving exposure.

A greater angulation with positioning may pose a theoretical increased risk of complications as shear stress on soft tissues provokes poorer wound healing, excessive positioning may cause neurovascular stretch injuries, and patient positioning may cause nonsurgical site injuries such as ipsilateral ankle fractures with the use of a fracture table.⁶ There is also a theoretically higher risk of breaking sterile field with excessive ROM and limb positioning, although this is largely speculation. With the use of Mueller retractors, we were able to adequately prepare the femoral canal and introduce femoral components while reducing the degree of extension and external rotation. Therefore, this technique may reduce the difficulty of the approach, thereby lessening the learning curve of the DAA THA while also improving patient outcomes.

4.1. Limitations

Several limitations to this study exist. This study is limited by its small sample size of eleven cadaveric specimens. In addition, this

study did not include a control group measuring angles with or without the use of the Mueller retractor. Given the cadaveric nature of this study, no clinical post-operative and follow up data was obtained. Additionally, results demonstrated in cadaveric hemipelvises may differ from those in a live clinical setting. Clinically, the position of patients may need to vary based on BMI and weight, which can alter the rotation angle of the pelvis. Although still possible to achieve, the angles in this study may be more difficult to reach when operating on patients who are obese or very tall. The leg portion of cadaveric specimens is also susceptible to twisting, which may alter the measured angles if it does occur. However, precautions were taken to ensure that the pelvis was always appropriately secured such that this error could be avoided. Furthermore, cadaveric hemi-pelves can be secured more easily in an experimental setting than humans can be on an operating table in the surgical setting. Additionally, differences in soft tissue release may theoretically contribute to differences in measured external rotation angles. However, the anterior capsule limits external rotation, and was released in every specimen.

5. Conclusion

Appropriate use and placement of the robust Mueller retractor is crucial for maximum visibility and may reduce angles of limb positioning, thereby potentially reducing complications of leg contamination, soft tissue damage and nerve injuries. Ultimately, this may lessen the learning curve for the DAA to THA, while simultaneously improving patient outcomes.

Declaration of conflicting interests

The Author(s) declare(s) that there is no conflict of interest. Within our study, the utilization of cadaveric specimens does not qualify as living individuals and therefore did not require IRB approval.

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Conflicts of interest

The contributing and corresponding authors have no conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2019.07.019>.

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