JAJS VOLUME 5 NUMBER 3 SEPTEMBER-DECEMBER 2018 PAGES 139-202

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Knee & Shoulder Arthroscopy And Arthroplasty ISKSAA

JOURNAL OF ARTHROSCOPY AND JOINT SURGERY

JAJS

Official Journal of the International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty (ISKSAA)

Indexed In Scopus & Embase

Volume 5 Number 3 September-December 2018

E-ISSN: 2214-9635
P-ISSN: 2542-6001

Available online at www.sciencedirect.com

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ISKSAA International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

ISKSAA (**I**nternational **S**ociety for **K**nowledge for **S**urgeons on **A**rthroscopy and **A**rthroplasty) is a society of orthopaedic surgeons from around the world to share and disseminate knowledge, support research and improve patient care in Arthroscopy and Arthroplasty. We are proud to announce that ISKSAA membership is approaching the **1750** mark (India & Overseas) making it the fastest growing Orthopaedic Association in the country in just 5 years of its inception . With over **335000 hits from over 159 countries** on the website **www.isksaa.com** & more and more interested people joining as members of ISKSAA, we do hope that ISKSAA will stand out as a major body to provide opportunities to our younger colleagues in training, education and fellowships.

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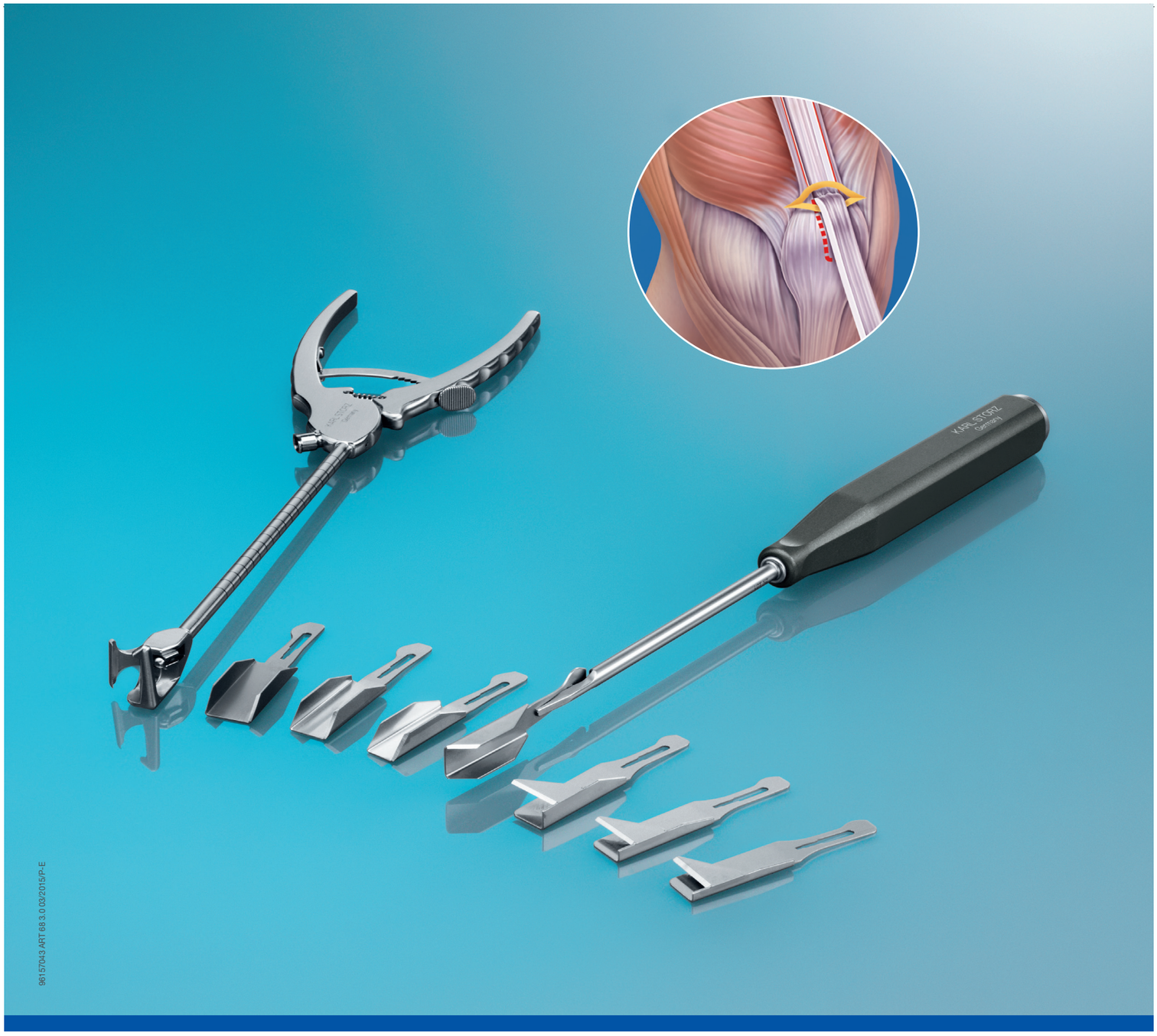

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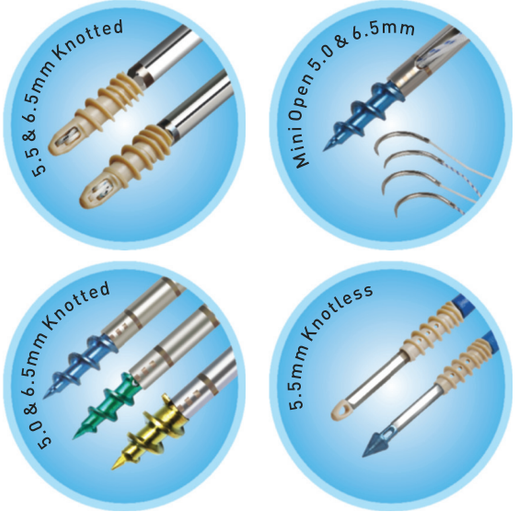

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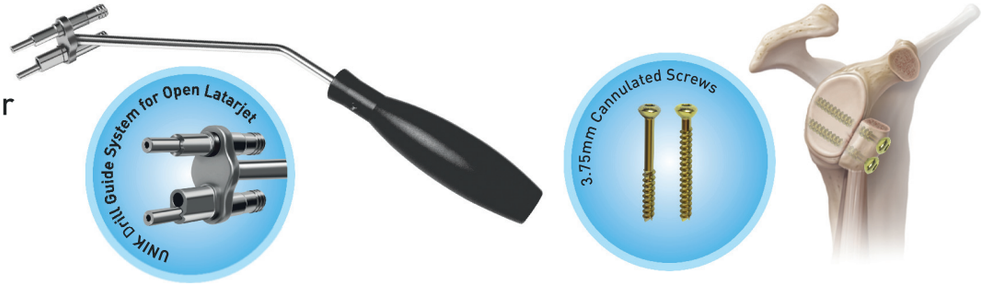

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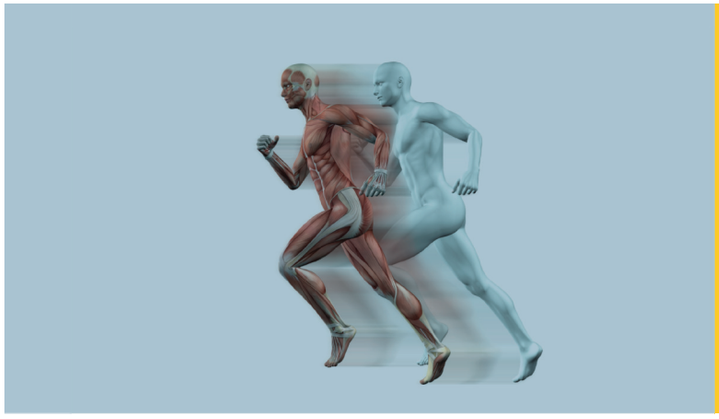

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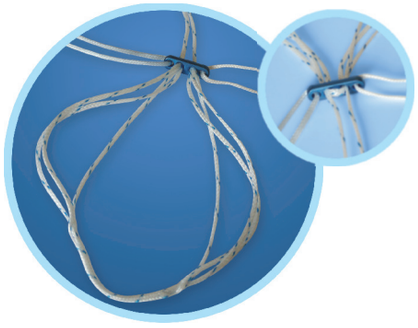

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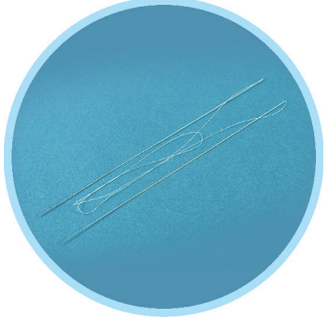

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Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2542-6001)

Volume 5, Number 3, September–December 2018

Aims and Scope

Journal of Arthroscopy and Joint Surgery (JAJS) is committed to bring forth scientific manuscripts in the form of original research articles, current concept reviews, meta-analyses, case reports and letters to the editor. The focus of the Journal is to present wide-ranging, multi-disciplinary perspectives on the problems of the joints that are amenable with Arthroscopy and Arthroplasty. Though Arthroscopy and Arthroplasty entail surgical procedures, the Journal shall not restrict itself to these purely surgical procedures and will also encompass pharmacological, rehabilitative and physical measures that can prevent or postpone the execution of a surgical procedure. The Journal will also publish scientific research related to tissues other than joints that would ultimately have an effect on the joint function.

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Publishing Office: Elsevier, A division of Reed Elsevier India Pvt. Ltd., 14th Floor, Building No.10B, DLF Cyber City, Phase-II, Gurgaon-122002, Haryana, India. Email: journals.india@elsevier.com

Journal of Arthroscopy and Joint Surgery

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Volume 5, Number 3, September–December 2018

Printed at EIH Limited-Unit Printing Press, IMT Manesar, Gurgaon

Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2542-6001)

Volume 5, Number 3, September–December 2018

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Journal of Arthroscopy and Joint Surgery

journal homepage: www.elsevier.com/locate/jajs

Research paper

Potential damage to the femoral neurovasculature during approach to the hip

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ARTICLE INFO

Article history:
Received 16 February 2018
Accepted 2 September 2018
Available online 4 September 2018

ABSTRACT

Introduction: Femoral neurovascular injury is an uncommon, but potentially devastating complication following surgical approaches to the hip. The intraoperative misplacement of the anterior acetabular retractor is the most commonly cited mechanism for this injury yet there is no gold standard for a proper insertion location in the literature We examined the course of the femoral neurovasculature about the hip to identify safest location for retractor insertion and furthermore demographic populations who are at-risk for injury due to a decreased distance between the hip joint and the femoral neurovasculature.
Methods: A total of 100 non-pathologic hip magnetic resonance imaging (MRI) studies from adult patients were included. Patients were chosen at random from our medical center's digital radiographic archive and their demographic data recorded. Mean distances between the anterior acetabular wall and the femoral artery were measured at three axial levels (acetabular dome, superior iliopectineal ridge, and inferior iliopectineal ridge).
Results: Our data showed the femoral neurovascular structures pass closer in proximity to the acetabular wall as they progress distally about the hip. An average direct separation distance of 40.1 mm was seen at the acetabular dome while measurements at the inferior iliopectineal ridge demonstrated an average distance of 20.5 mm. Additionally, statistically significant ($p < 0.05$) decreases in distances between acetabulum and femoral neurovasculature were found in patients that were female, >45 years-old, <1.7 m, and <75 kg.
Discussion: By undertaking a large-scale MRI evaluation of the femoral neurovasculature about the hip, not only were we able to approximate the location of the femoral neurovascular bundle as it passes the hip joint, but also the safest location for insertion of anterior acetabular retractors at the level of the acetabular dome or above in close proximity to the bony cortex. Additional care should be taken placing retractors in patients when demographic risk factors including female gender, age >45 years old, stature <1.7 m, and body mass <75 kg are present.

1. Introduction

An estimated 400,000 + total hip arthroplasties (THA) will be performed yearly throughout the United States by the year 2026.[1] And while THA has repeatedly been shown to be a highly successful procedure,[2,3] it is not completely free from risk. Neural and vascular injuries occur in 0.09%–3.7% and 0.1%–0.2% of primary THAs respectively.[4] Femoral neurovascular injury is an uncommon, but potentially devastating complication of THA. These injuries can cause lower extremity weakness, chronic pain or parenthesis, paralysis, amputation, and in rare cases even death.[4–6] A variety of possible mechanisms have been identified as sources for these injuries including hematoma formation, cement extrusion and nerve lengthening.[4,7] However, the misplacement of anterior acetabular retractor around the acetabulum is the most commonly cited

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https://doi.org/10.1016/j.jajs.2018.09.002
2214-9635/

source of injury in the literature.[7–10]

Despite this known and established risk, literature has sparse examinations concerning the course of the femoral neurovascular structures about the acetabulum or the proper location for retractor placement. Additionally, most of the research in this area has been performed on cadaveric specimens.[9] In an effort to improve anatomic understanding and surgical technique, the present study sought to define the location of the neurovascular bundle as it relates to the acetabulum in living human subjects without altering tissue tension, tissue fluid content or structure displacement that would all occur from cadaveric dissection studies. Our secondary goal was to investigate the impact of patient demographic factors on the course of the femoral neurovascular bundle in relation to the acetabulum.

2. Methods

After obtaining Institutional Review Board approval, we retrospectively reviewed our medical center's Picture Archiving and Communication Software (PACS) (General Electric Medical Systems, Milwaukee, WI) for all magnetic resonance imaging studies of the hip performed from February 2001 to February 2015. In an attempt to include natural variation of hip anatomy a total of 100 patients were randomly selected for inclusion. Patients were required to be 18-years or older for inclusion into this study. Patients with hip pathologies that altered anatomic relationships, such as a history of tumor, fracture, or any evidence of prior hip surgery were excluded. Patients were de-identified and compiled in a database with demographic information including gender, age, height, weight, and ethnicity.

Utilizing our PACS system, side-by-side mid-coronal and axial MRI images were generated. To localize the femoral bundle we elected to measure the distance from the acetabular ridge to the femoral artery, the nearest portion of the femoral neurovascular bundle.[11] The location of the femoral artery was examined at three cross-sections about the acetabulum: at the level of the acetabular dome, superior iliopectineal ridge, and inferior iliopectineal ridge [Fig. 1]. For each axial level, the distances between the femoral artery and the lateral-most aspect of the anterior acetabular wall were recorded in anteroposterior (AP), mediolateral (ML), and vector (V) directions. In the ML direction, if the femoral artery appeared lateral to the anterior acetabular wall it was defined as a negative distance [Fig. 2].

Demographic information for each patient in the study was gathered from our medical center's electronic medical record (Powerchart, Cerner Corporation, Kansas City, MO). Recorded data included patient gender, ethnicity, age, height, and weight nearest to the time of the MRI scans. In an attempt to identify demographic groups where the femoral neurovasculature courses closer to the acetabulum, we utilized the average age, height and weight, of our patient cohort, and compared the mean distances for patients above and below the mean. Genders differences were also included. Thus the demographic risk factors we examined were male v female gender, age greater than vs. less than 45 years old, stature greater than vs. less than 1.7 m, and body mass greater than vs. less than 75 kg.

Two physician reviewers, an orthopaedic surgeon and a radiologist, evaluated all MRIs. Inter-rater reliability was determined for a random sample of 20 patients between the reviewer and a second author. A kappa value was calculated for this value. Statistical analysis for demographic comparison was performed using Student's independent *t*-test. All statistics were calculated using SPSS software version 22 (IBM corporation, Chicago, IL).

3. Results

The study population included 31 males and 69 females. The mean patient age was 44.7 years old (range 18–83). The mean patient height and weight were 1.69 m (range 1.31–1.98) and 74.7 kg (range 47.8–136.1), respectively. The breakdown in ethnicities was 3 Asian, 14 Hispanic, 16 Caucasian, and 67 African-American patients [Table 1].

After AP, ML, and V measurements were collected at each axial level and mean distances calculated, we observed the location of the femoral neurovascular bundle coursed nearer to the anterior acetabular wall, as it passed inferiorly. Examining our distances at the acetabular dome and moving inferiorly to the superior and inferior iliopectineal ridge, we see the AP distances were 22.1 mm, 14.9 mm, and 17.0 mm; ML distances were 33.2 mm, 7.3 mm, and 0.3 mm; V distances were 40.1 mm, 21.6 mm, and 20.5 mm respectively [Table 2].

Additionally, we were able to identify statistically significant ($p < 0.05$) reductions in a collection of mean AP, ML, and V distances

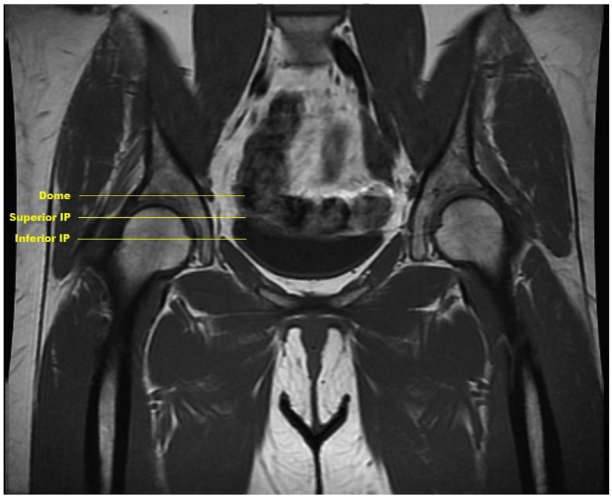

Fig. 1. Coronal MRI of the hip demonstrating the locations of the three axial cuts utilized for the examination of the femoral neurovascular bundle; these levels included the acetabular dome, superior iliopectineal ridge and the inferior iliopectineal ridge.

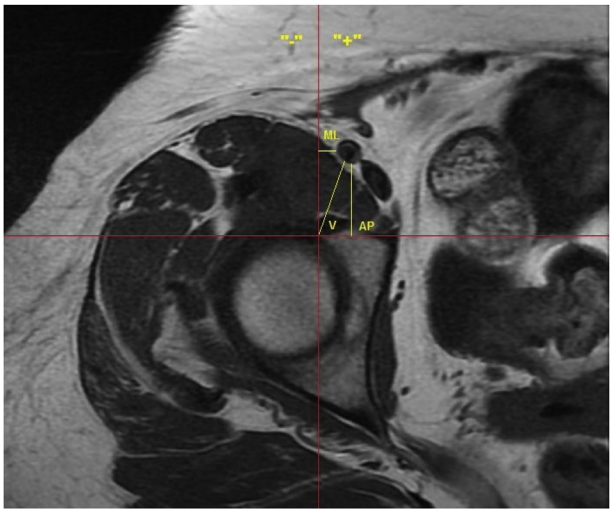

Fig. 2. Axial MRI of the hip with lines drawn to demonstrate methodologies for the measurement of the AP, ML, and V distances from the anterior acetabular wall to the femoral artery.

Table 1
Patient demographic distribution.

Demographic	N (%)	Mean
Gender		
Male	31	–
Female	69	
Ethnicity		
Asian	3	–
Hispanic	14	
Caucasian	16	
African-American	67	
Age (years)		
18-30	25	44.7
31-45	29	
46-60	24	
60+	22	
Height (meters)		
<1.6	12	1.69
1.6	28	
1.7	26	
1.8	26	
>1.8	8	
Weight (kg)		
<50	6	74.7
50-75	43	
75-100	35	
>100	16	

between the femoral neurovasculature and the acetabulum between each of our demographic groups of interest (female gender, age >45 years old, stature <1.7 m, and body mass <75 kg) when compared to their counterpart [Table 3].

The testing for the weighted Kappa coefficient yielded a strong inter-rater reliability (k = .919, 95% CI: 0.81–1.0).

4. Discussion

Although rare, neurovascular injury is a known risk of THAs. This injury can occur with any approach to the hip[7,8,12–17] with the highest incidence of femoral neurovascular injury seen with malpositioning of anterior acetabular retractors.[7–10] This may be appreciated more frequently in surgeons who transition to an unfamiliar approach. Observed in young residents and as many surgeons trained in the posterior or lateral approaches are seen transitioning to the direct anterior approach as it gains popularity.

Between neurologic and vascular injuries in THAs, neurologic impairment occurs more commonly, being reported in 0.09%–3.7% of cases for primary THAs and up to 7.6% for revisions.[4] When postoperative neuropathy does transpire, the peroneal nerve was shown to be the most commonly injured followed by the femoral and sciatic nerves.[13,15,18] One study showed 54.1% of nerve injuries post-THAs affected the peroneal nerve while the femoral and sciatic nerves were affected 24.6% and 21.3% of cases respectively (injuries to the obturator, superior gluteal and lateral femoral cutaneous nerves have been reported but are exceedingly rare).[4,19,20] The primary etiology for injury of the femoral nerve has been shown to be the insertion of an anterior acetabular retractor along the anterior acetabular rim at an incorrect plane or to an incorrect depth.[8–10]

In comparison, vascular damage during THAs occurs less frequently, in only 0.1%–0.2% of cases, but is more emergent in nature.[21,22] The vessels most frequently injured are the external iliac and femoral arteries and while arterial damage was similarly due most frequently to retractor placement, direct laceration, thermal injury from polymerization heat, and tearing due to prosthesis were all documented sources of vessel damage.[9,21]

To our knowledge, this is the first large cohort magnetic resonance imaging study with 100 patients assessing the relationship between the femoral neurovascular bundle and the osseous landmark of the acetabular ridge. Cadaver studies have demonstrated that the closer the neurovascular bundle is in proximity to the acetabulum, the greater the risk of encroachment by surgical instrumentation during hip arthroplasties.[8,9] Our study showed the course of the femoral bundle could dangerously approach the anterior wall of the acetabulum, particularly at the inferior IP ridge where the femoral artery had a mean distance of 20.5 mm from the acetabular ridge. Applying this data, anterior retractor placement should err superiorly and hug the wall of the acetabulum; moving inferiorly puts the femoral neurovasculature at risk.[23]

Table 2
Mean distances from the anterior acetabular wall to the femoral artery.

Location	Anteroposterior Distance (mm)	Mediolateral Distance (mm)	Vector Distance (mm)
Acetabular Dome	22.1 (range 10.7–36.9)	33.2 (range 21.6–48.3)	40.1 (range 27.3–59.0)
Superior Iliopectineal Ridge	14.9 (range 4.7–25.0)	7.3 (range −5.9 - 31.0)	21.6 (range 12.5–43.7)
Inferior Iliopectineal Ridge	17.0 (range 4.3–27.1)	0.3 (range −13.8 - 11.7)	20.5 (range 11.4–31.9)

Table 3
Statistically significant ($p < 0.05$) decreases in the mean AP, ML and/or V distances between the femoral neurovascular bundle and the anterior acetabular wall are shown where present by demographic groupings and axial level of measurement.

Location	Anteroposterior Distance (mm)	Mediolateral Distance (mm)	Vector Distance (mm)
Gender (Female vs. Male)			
Acetabular Dome	–	31.6 vs. 36.9 ($p < 0.001$)	38.0 vs. 44.9 ($p < 0.001$)
Superior Iliopectineal Ridge	14.2 vs. 16.2 ($p < 0.05$)	6.2 vs. 9.8 ($p < 0.01$)	20.1 vs. 25.0 ($p < 0.001$)
Inferior Iliopectineal Ridge	16.2 vs. 18.6 ($P < 0.05$)	–	19.6 vs. 22.6 ($p < 0.001$)
Weight (<75 kg vs. > 75 kg)			
Acetabular Dome	20.5 vs. 23.6 ($p < 0.01$)	31.7 vs. 34.7 ($p < 0.05$)	38.0 vs. 42.2 ($p < 0.001$)
Superior Iliopectineal Ridge	13.3 vs. 16.4 ($p < 0.001$)	–	19.9 vs. 23.3 ($p < 0.001$
Inferior Iliopectineal Ridge	–	–	–
Height (<1.7m vs. > 1.7m)			
Acetabular Dome	–	30.9 vs. 34.8 ($p < 0.001$)	36.9 vs. 42.3 ($p < 0.001$)
Superior Iliopectineal Ridge	–	–	19.6 vs. 23.0 ($p < 0.001$)
Inferior Iliopectineal Ridge	14.3 vs. 19.5 ($p < 0.001$)	–	18.3 vs. 22.7 ($p < 0.001$)
Age (<45yo vs. > 45yo)			
Acetabular Dome	–	–	–
Superior Iliopectineal Ridge	13.3 vs. 16.4 ($p < 0.001$)	–	19.9 vs. 23.3 ($p < 0.001$)
Inferior Iliopectineal Ridge	−1.3 vs. 1.9 ($p < 0.01$)	–	–

Our data also identified at-risk populations for femoral neurovascular damage during THAs. This study confirmed patients of the female gender to be at risk for decreased distances between the femoral artery and the acetabular wall, at each of the three cross-sectional levels. This known risk factor translates clinically as previous studies have cited greater than 7 out of 10 of cases of femoral neurovascular bundle injury during THAs occur in women.[9]

Our research found age >45, body mass <75 kg and shorter stature <1.5 m as three additional risk factors for neurovascular damage during THAs. To explain these trends, we examined the principle anatomic buffers between the femoral neurovascular bundle and the anterior acetabular wall, namely the muscle bodies/tendons of the iliocapsularis, iliopsoas and rectus femoris. It is reasonable to infer that a decrease in the muscle mass of these hip flexors may decrease the distance between the femoral bundle and the anterior wall of the acetabulum and thus places the neurovasculature at risk from injury. Heller and colleagues highlighted the importance of this notion when cautioning the use of anterior acetabular retractors in patients with diminished muscle mass due to their lack of psoas tendon protection.[7] As a direct relationship exists between increasing height and weight, and one's overall muscle mass, and an inverse relationship exists between muscle mass and increasing age. Anterior retractors placed in elderly patients should be placed with care as decreased muscle mass becomes more evident with age after the fourth decade of life.[24,25] Furthermore, using this information, the elevated incidence of femoral neurovascular damage seen in female patients when compared to men can be explained as the female population is traditionally shorter and of lower body mass. We can support this logic as we indeed see that women have been shown to have lower cross-sectional area of their iliacus muscle when compared to men.[11]

While this study was able to successfully calculate mean locations for the femoral neurovasculature along its anatomic course about the hip, and to identify various at-risk demographic groups, we must recognize that this study has limitations. First, the computed distance values are mean representations of a cohort of only 100 patients. Furthermore, while demographic trends were significant in this patient population with regards to femoral neurovascular anatomy, a larger cohort with a population more representative of a general patient body should be reviewed to ensure accuracy.

5. Conclusion

Understanding the correct plane for placement of anterior acetabular retractors is essential to prevent femoral neurovascular bundle damage regardless of surgical approach. Our study suggests that the safest insertion location for anterior retractors is at or above the level of the acetabular dome, in close proximity to the bony cortex. Furthermore, additional care should be taken placing retractors in smaller patients, particularly when demographic risk factors including female gender, age >45 years old, stature <1.7 m, and body mass <75 kg are present.

Conflicts of interest

There are no conflicts of interest related to this work.

Author's disclosures

SMM, RPM and MWM have none to declare.

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