Are the anatomy textbooks wrong? A clinical patho-anatomic study of foveal vessels in the round ligament of the hip

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Background: The foveal vessels of the ligamentum teres are an anterior branch of the posterior division of the obturator artery, providing blood to the capitis of the femoral head. However, the basic anatomic description of foveal vasculature in the ligamentum teres of the hip is widely variable, with some studies reporting that the vessels are not patent in roughly one third of all adults. Therefore, the purpose of this study was to evaluate the status of foveal vessels in primary total hip arthroplasty (THA) patients. Specifically, we evaluated: (I) if the foveal vessels were intact; and we (II) correlated foveal vessel status with (i) patient demographics, including gender and age; as well as (ii) perioperative data, such as operative time and blood loss.

Methods: The macroscopic status of the foveal vessels in the ligamentum teres femoris was documented in 266 patients at the time of primary unilateral THA performed between August 2015 and April 2017. The vessels were considered to be intact if active bleeding was directly visible from the acetabular stump of the severed ligamentum teres femoris. Demographics including age, gender, and preoperative diagnosis were collected. The perioperative outcome variables included estimated blood loss (EBL) and operative time. Foveal vessel status defined as intact or not intact, was also correlated with patient demographics and perioperative data. A student's *t*-test was used to compare the continuous variables and a chi square test was used for categorical variables.

Results: The foveal vessels were intact in 161 patients (61%) and not intact in 105 patients (39%). The mean age for patients with intact foveal vessels was found to be 64 years (range, 18 to 94 years) *vs.* 65 years (range, 29 to 94 years) (P>0.05) for not intact. No correlation was found between preoperative diagnosis, gender, operative time, and EBL and foveal vessel status.

Conclusions: The results of this clinical patho-anatomic study of the foveal vessels in the ligamentum teres femoris of the hip refutes the polarized claims of prior anatomy texts that document the vessels as either "absent in adults" or "always intact." Rather, the results of this study reveal an alternate option: that foveal vessels can be present and either be intact (61%) or not intact (39%). No correlation was found between age, gender, operative time, and EBL and foveal vessel status.

Keywords: Foveal vessels; round ligament of hip; anatomy

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Introduction

The ligamentum teres of the hip is thought to be an embryonic remnant that does not play an important vascular role in adult hips. The foveal vessels of the ligamentum teres are an anterior branch of the posterior division of the obturator artery, providing blood to the fovea capitis into the femoral head (1,2). However, this artery is not patent in all adults. In fact, one study reported that the vessel is not patent in roughly one third or more of all adults, thus highlighting potential variations in femoral head blood supply (3). Thus, the basic anatomic description of foveal vasculature in the ligamentum teres of the hip is widely variable, and studies have demonstrated conflicting results regarding whether foveal vessels remain intact in adult hips.

Tucker *et al.* (4) performed a study on 24 children and 20 adults by injecting a radio-opaque in order to visualize the blood supply to the femoral head. The found that the foveal artery of the ligamentum teres helps to supply the more proximal end of the femur. Furthermore, they found that foveal artery supplies, albeit to a small amount, the femoral epiphysis. The group also noted that the artery penetrated the cartilaginous or osseous head in 33% of children and 70% of adults and that vessel size was proportional to age. In contrast, Kalhor *et al.* (5) performed a cadaver study on 35 hips by injecting colored silicone in order to identify blood supply of the femoral head, and found that the foveal artery provided no important vascular contribution in any patient.

Because the basic anatomic description regarding foveal vessels is debated, and the few studies addressing foveal vessels are dated, some over 60 years old (4,6), further, more up-to-date evaluation is needed to better describe these vessels. Therefore, the purpose of this study was to evaluate the status of foveal vessels in primary total hip arthroplasty (THA) patients. Specifically, we evaluated: (I) if the foveal vessels were intact; and we (II) correlated foveal vessel status with (i) preoperative diagnoses; (ii) patient demographics, including gender and age; and (iii) perioperative data, such as operative time and blood loss.

Methods

Patient selection

A consecutive group of 266 hips from 247 adult patients who underwent primary THA between August 01, 2015 and April 30, 2017 were identified for this study. Patients had the following preoperative diagnoses for inclusion: osteoarthritis (OA), secondary OA, osteonecrosis (ON), and/or rheumatoid arthritis (RA). Demographic data, such as age, gender, and preoperative diagnosis, were collected and analyzed as well. There were total of 131 right THAs (49%), and a total of 135 left THAs (51%).

Intraoperative evaluations

Intraoperatively, patients were assessed for foveal vessel status. This included determining if the foveal vessels were present or not and if they were present, whether they remained intact. Assessment was made based on macroscopic evaluation. Specifically, the vessels were considered to be intact if active bleeding was directly visible from the acetabular stump of the severed ligamentum teres femoris. A single board certified orthopaedic surgeon at a high volume institution performed all of the surgeries using an anterior supine intramuscular approach.

Perioperative outcomes

Perioperative factors such as estimated blood loss (EBL) and operative times were recorded. These factors were analyzed to determine if patients with present foveal vessels had greater EBL and/or greater operative times than patient who did not have foveal vessels present.

Data analysis

All pre-, intra-, and postoperative data was collected in the patient's electronic medical record. From these records, foveal status, preoperative diagnosis, age, gender, EBL, operative times, and intraoperative report data was extracted and exported to a Microsoft Excel spreadsheet (Microsoft Office 2013, Microsoft Corporation, Redmond, WA, USA). Foveal vessel status was defined as intact or not intact. Vessel status was compared to preoperative diagnosis, age, gender, operative times, and EBL in order to identify any potential correlations. Statistical analyses were performed SPSS Version 23 (International Business Machine Corporation, Armonk, NY, USA). A student's test was used to compare the continuous variables and a chi square test was used for categorical variables. A cutoff P value of <0.05 was set to determine any statistical significances between the results.

Table 1 Patient demographic analysis of foveal vessel status

Parameter	Intact vessels	Not intact vessels	P value
Age, mean (range) years	64 (18 to 94)	65 (29 to 94)	>0.05
Gender, n [%]			>0.05
Women	85 [53]	67 [64]	
Men	76 [47]	38 [36]	

Results

Intraoperative evaluation

The foveal vessels were considered intact in 161 patients (61%) and not intact in 105 patients (39%). A visual correlation was noted between the severity of femoral-sided disease and vessels that were not intact.

Preoperative diagnoses

Of the 217 patients with a preoperative diagnosis of OA (82%), 130 patients (60%) had intact foveal vessels, while 87 patients (40%) did not. Of the 22 patients with a preoperative diagnosis of secondary OA (8%), 12 patients (55%) had intact foveal vessels while 10 patients (45%) did not. Of the 21 patients who had a preoperative diagnosis of ON (8%), 13 patients (62%) had intact foveal vessels, while 8 patients (38%) did not. Of the 6 patients with RA (2%), all 6 patients had intact foveal vessels. No statistical correlation was found preoperative diagnosis and foveal vessel status.

Patient demographics—age

The mean age for patients with intact foveal vessels was found to be 64 years (range, 18 to 94 years). The mean age for patients in the non-intact foveal vessels cohort was 65 years (range, 29 to 94 years). No significant correlation existed between age and foveal vessel status (P>0.05) (*Table 1*).

Preoperative demographics—gender

A total of 38 men (36%) were found to have non-intact foveal vessels, while a total of 67 women (64%) were found to have non-intact foveal vessels. A total of 76 men (47%) were found to have intact foveal vessels, while a total of 85 women (53%) were found to have intact foveal vessels. No correlation was found between gender and intact or not intact foveal vessels (P>0.05) (*Table 1*).

Perioperative outcomes

Operative times

The overall mean operative time for all cases was 64 minutes (range, 42 to 96 minutes). The mean operative time for patients who had intact foveal vessels was 64 minutes (range, 42 to 89 minutes). The mean operative time for patients who did not have intact foveal vessels was 63 minutes (range, 46 to 96 minutes). No correlation between operative time and foveal vessel status was found (P>0.05).

EBL

The overall mean EBL for all 266 cases was 118 mL. The mean EBL for patients who had intact foveal vessels was 124 mL (range, 25 to 400 mL). The mean EBL for patients who did not have intact foveal vessels was 110 mL (range, 25 to 500 mL). No correlation existed between EBL and foveal vessel status (P>0.05).

Discussion

The femoral head is covered by articular cartilage, except for a small ovoid depression situated slightly inferior and posterior to the center of the head called fovea capitis, which serves as a site of attachment of ligamentum teres. A number of studies have been previously performed in order to determine the functionality and importance of the vessels of the ligamentum teres and have had variable results. Therefore, the purpose of this study was to better classify foveal vessel status as in tact or not intact in an adult population of patients undergoing primary THA. Overall, our results yield a non-statistical difference between the presences of intact or not intact foveal vessels. Furthermore we did not identify any correlations between age, gender, operative time, EBL, or preoperative diagnosis and foveal vessel status.

This study was not without limitations. One of the primary modalities in assessing foveal vessel status was by surgeon macroscopic evaluation of presence and bleeding of vessels. Specifically, the vessels were considered to be intact

if active bleeding was directly visible from the acetabular stump of the severed ligamentum teres femoris. Therefore, there is a level of subjectivity in determining the status of the foveal vessels. However, while a potential bias could be present; all surgeries were performed by the same surgeon, allowing for more consistent evaluation. Furthermore, the sample size used in this study was relatively small at 266 primary THA patients. Additionally, these study findings were focused on a middle-aged population with a mean age of 64 years. Therefore, more in depth analysis characterizing foveal vessels should be done in large, more diverse patient cohorts and with other modalities such as MRI or arthroscopy.

Conclusions

The results of this clinical patho-anatomic study of the foveal vessels in the ligamentum teres femoris of the hip refutes the polarized claims of prior anatomy texts that document the vessels as either "absent in adults" or "always intact." Rather, in this adult cohort with present foveal vessels, the vessels were intact in 61%, and not intact in 39%. Patients with more advanced disease at the time of THA, are more likely to have vessels that are no longer intact, although non-significantly. These findings might have implications for hip dislocations or hip arthroscopy, particularly if intact foveal vessels contribute to the femoral head blood supply.

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Footnote

Conflicts of Interest: Dr. Barrington is a consultant for or has received institutional or research support from the following: Biomet, DJ Orthopaedics, Iconacy, Mallinckrodt, Pacira, Professional Communications, Inc., Smith & Nephew, Tier 1 Healthcare and Education Research, and Zimmer. Dr. Mont is a consultant for or has received institutional or research support from the following: Stryker, Cymedica, DJO Global, Johnson & Johnson, Microport, National Institutes of Health, Ongoing Care Solutions, Orthosensor, Pacira Pharmaceuticals, Peerwell, Performance Dynamics Inc., Sage, TissueGene. The other authors have no conflicts of interest to declare.

Ethical Statement: The study was deemed exempt from the hospital's institutional review board since no identifiable patient information was obtained.

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