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Review article

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Hip arthroscopy for lateral cam morphology: how important are the vessels?

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ABSTRACT

The purpose of this narrative review is to identify the anatomy and relevant blood supply to the femoral head as it pertains to hip arthroscopy and lateral cam morphology. The primary blood supply to the femoral head is the lateral ascending superior retinacular vessels, which are terminal branches of the medial femoral circumflex artery. These vessels penetrate the femoral head at the posterolateral head–neck junction. Surgeons performing posterolateral femoral osteoplasty must respect this vasculature to avoid iatrogenic avascular necrosis (AVN). Avoidance of excessive traction, avoidance of distal posterolateral capsulotomy and avoidance of disruption of the superior retinacular vessels should keep the risk for AVN low. Hip extension, internal rotation and distraction are useful in hip arthroscopy to better visualize lateral/posterolateral cam morphology to facilitate an accurate comprehensive cam correction and avoid vascular disruption.

BACKGROUND

The utilization of arthroscopy for the treatment of non-arthritic hip disorders, including femoroacetabular impingement (FAI) syndrome due to cam morphology, continues to rapidly increase. The natural history of patients with cam morphology indicates they may develop early hip osteoarthritis [1]. Patients undergoing arthroscopic hip preservation have demonstrated statistically significant and clinically relevant improvements in validated short- and mid-term patient-reported outcomes [2]. These outcomes are related to the correction of the cam and likely due to improved hip flexion and internal rotation [3]. There is evidence, albeit limited, that correction of cam morphology reduces the risk of hip arthritis [4–7]. Further, it has been repeatedly established that a residual cam is the most common reason for residual symptoms following arthroscopy and the most common reason for reoperation [8]. Cam correction may be performed using either open or arthroscopic techniques. Cam-type pathomorphology is a complex, three-dimensional (3D) issue, encompassing an aspherical head–neck junction, offset, neck–shaft angle, head tilt, neck version and femoral torsion [9]. The lateral and posterior extent of the cam may come in close proximity to the primary vascular supply to the femoral head (Table I), near the lateral synovial fold, where terminal lateral ascending superior retinacular vessels from the medial femoral circumflex artery (MFCA) penetrate the head–neck junction. Surgeons treating patients with FAI syndrome secondary to cam morphology must be able to comprehensively address these issues, avoid inadequate resection (and over-correction) and avoid complications related to iatrogenic vascular injury.

The most common location of the apex of the cam is at 1:15 (right hip) on the femoral clockface (11:45–2:45) and may be appropriately localized and resected with six intra-operative flexion and extension views [10]. However, in some situations, the cam extends posterolaterally, near the lateral synovial fold [11, 12]. The radial extent of the cam morphology can be quantified using the omega angle, measured on radial imaging acquired with magnetic

Table I. Relevant investigations evaluating proximal femoral vascular supply

Study	*Year*	*Study design*	*Primary outcome*
Gautier *et al.* [15]	2000	Cadaveric; femoral or internal iliac artery neoprene–latex injection	• Primary blood supply to head of femur—deep branch MFCA superior retinacular arteries • Main division of deep branch crosses posterior to OE tendon (along inferior border), anterior to SG/OI/IG • Deep branch pierces capsule, superior to SG, inferior to piriformis—branches into 2–4 subsynovial terminal branches • OE tendon never surgically divided due to proximity to deep branch MFCA • Trochanteric branch of MFCA along superior margin QF—anterior to this, marks OE tendon • Largest, most consistent MFCA anastomosis from IGA, along inferior border of piriformis
Zlotorowicz *et al.* [29]	2011	Cadaveric; microsurgical dissection	• Crucial role in blood supply to femoral head—deep branch MFCA • Deep branch easily identifiable in adipose tissue posterior to OE, anterior to QF • Then crosses SG/OI/IG anterior surface, enters capsule • Anastomosis between MFCA and IGA along with inferior margin piriformis, posterior to SG/OI/IG
Grose *et al.* [30]	2008	Cadaveric; MFCA or IGA latex injection	• Clear anastomosis between IGA and MFCA adjacent to OE—always extra-capsular • The anastomosis is able to perfuse femoral head from IGA even in the presence of MFCA injury • Deep branch passes deep to posterior zona orbicularis, never found in interval between SG/OI/IG and capsule

(continued)

Table I. (continued)

Study	*Year*	*Study design*	*Primary outcome*
Kalhor *et al.* [33]	2012	Cadaveric; common iliac silicone injection	• Primary femoral head blood supply MFCA (81% of specimens) or IGA (19% of specimens) • To reduce risk of iatrogenic AVN, branches of IGA and MFCA in interval between piriformis and QF must be protected • Piriformis tenotomy carries minimal AVN risk; tenotomy OE, SG/OI/IG carries significant AVN risk • Since all intra-capsular vessels penetrate near femoral insertion, avoid distal capsulotomy posterolateral, inferomedial • MFCA consistently provided one inferior retinacular artery on top of medial ligament of Weitbrecht—but small
Lazaro *et al.* [28]	2015	Cadaveric; polyurethane MFCA injection	• Intra-capsular deep branch MFCA divides into mean 6 (4–9) terminal subsynovial branches • 80% of superior retinacular vessels are posterior to lateral synovial fold • Transverse MFCA branch forms inferior retinacular artery, on Weitbrecht ligament with mean 5 (3–9) terminal branches
DeWar *et al.* [27]	2016	Cadaveric; MRI contrast, polyurethane injection	• Femoral head vascular supply (82% MFCA; 18% LFCA); femoral neck (67% MFCA; 33% LFCA) • LFCA supplied 48% of anteroinferior femoral neck
Sussmann *et al.* [49]	2007	Cadaveric; deep femoral artery latex injection	• Posterolateral portal did not injure deep branch MFCA or its terminal branches • MFCA protected by overhang of posterior aspect of greater trochanter
Sussmann *et al.* [48]	2007	Cadaveric; deep femoral artery latex injection	• Arthroscopic femoral osteoplasty 150° arc (6–1 o'clock); mean 3 superior retinacular branches • All specimens with superior retinacular branches, near-to-complete filling superior, inferior retinacular vessels observed

(continued)

Table I. (continued)

Study	*Year*	*Study design*	*Primary outcome*
McCormick *et al.* [16]	2011	dGEMRIC 76 patients with FAI	• MFCA inserted on posterosuperior neck from 10:30 to 12:00, just posterior to lateral synovial fold • MFCA progressed up neck via mean 4 (range 2–6) superior retinacular vessels • 97% of vessels were posterior to 12 o'clock position
Rego *et al.* [34]	2016	Radial MRI pre-, post-hip arthroscopy for FAI	• Alpha angle, omega angle measured (no relation of values of alpha and omega angles found) • Mean radial extension of cam (omega angle) was 138° (90–180°); wider omega associated with posterior cam • 76% of patients presented posterior extension cam overlapping retinacula; 3 vascular foramina per patient • Cam resection complete in 88% (22/25) cases ($n = 14$ SHD; $n = 11$ arthroscopy); 12% (3/25) of cases missed posterior cam • Even in pure anterior cam (12–1:30 o'clock), bone needed to be removed over vascular foramina in 44% of cases

MFCA, medial femoral circumflex artery; IGA, inferior gluteal artery; SG, superior gemellus; OI, obturator internus; IG, inferior gemellus; OE, obturator externus; QF, quadratus femoris; AVN, avascular necrosis; dGEMRIC, delayed gadolinium-enhanced MRI of cartilage; FAI, femoroacetabular impingement; SHD, surgical hip dislocation.

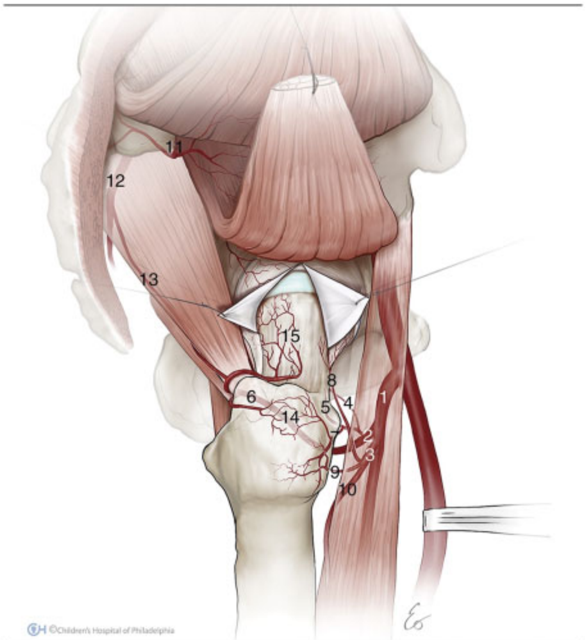

Fig. 1. Illustration depicting a sagittal view of the hemipelvis with corresponding vasculature to the hip joint. The profunda femoris artery (1) and its medial femoral circumflex artery (MFCA; 2) and lateral femoral circumflex artery (LFCA; 3) branches are shown. After bypassing the obturator externus, the ascending branch of the MFCA becomes the deep branch and enters the trochanteric fossa, where it joins with the piriformis branch of the inferior gluteal artery and the LFCA. Other structures depicted are the acetabular (4), posterior inferior nutrient (5), ascending (6) and transverse (7) branches of the MFCA; the ascending (8), transverse (9) and deep (10) branches of the LFCA; the superior gluteal artery (11); the inferior gluteal artery (12); the piriformis branch of the inferior gluteal artery (13); the cruciate anastomosis (14) and lateral ascending superior retinacular vessels (15). Reproduced, with permission from Seeley *et al.* —[32].

resonance imaging (MRI) or computed tomography (CT) [13, 14]. The primary blood supply to the femoral head is from two to six intra-capsular and subsynovial superior retinacular branches from the deep branch of the MFCA, coursing along with the posterosuperolateral proximal femoral head–neck junction [15, 16]. Thus, surgeons performing posterolateral femoral osteoplasty to completely correct cam morphology must respect the vascular supply to the femoral head to avoid iatrogenic femoral head avascular necrosis (AVN).

The impetus for this review is a recent retrospective case series of 14 patients (8 females and 6 males; mean age 44) who underwent femoroplasty that deliberately extended into the posterolateral vascular region of the femoral head for cam FAI syndrome. These authors only state that the femoroplasty extended to the posterolateral femoral head, but do not provide more details on the extent of bone resected. They confirmed visualization of the lateral synovial fold and stated the procedure 'necessitated removal of the penetrating vascularity in this region', but did not quantify how many vessels were sacrificed. There was no MRI evidence of AVN in any of the 14 patients at a mean 25 months after femoroplasty. This study concluded that cam morphology near (or in) the posterolateral vascular zone of the femoral head can be treated completely with femoroplasty without causing AVN [12]. The purpose of this narrative review is to summarize relevant literature regarding lateral cam morphology and how it relates to the vasculature of the femoral head to hypothesize why AVN did not result from femoroplasty that extends into or behind the lateral synovial fold.

LATERAL CAM MORPHOLOGY

Cam impingement is caused by an aspherical femoral head and characterized by abnormal contact between the acetabulum and the proximal femur. Although preoperative assessment of patients being treated for FAI has been underreported in the literature [17], several imaging modalities can be used to characterize an aspherical femoral head. Cam morphology can be quantified two dimensionally by the alpha angle, which measures the extent that the femoral head deviates from being spherical. There are several different plain radiographs that can accurately characterize the location of asphericity [18, 19]. As a single radiograph, the Dunn 45 likely most closely approximates the 3D nature of the cam, while the Meyer lateral and Dunn 90 radiographs together best provide the most effective prediction of the 3D shape of the proximal femur [18, 20]. Similarly, the radial extent of the cam shape can be quantified by the omega angle [13, 14]. The best defining characteristic of cam morphology is recognition and localization of the aspherical location(s) on 3D imaging, which can be static (CT or MRI) or dynamic (collision detection motion analysis software). Anterosuperior cam morphology, in particular the area between 11:45 and 2:15 on the right hip femoral clockface, is where maximum alpha angles are most commonly seen [21]. To achieve complete resection of cam lesion, posterolateral cam morphology must also be addressed, which occurs behind the lateral synovial fold at ∼12:00 on the femoral clockface. This deformity has a radiographic appearance of the 'pistol-grip deformity' on the anteroposterior (AP) radiograph, which provides visualization of 12:01 on the femoral clockface [19, 22].

Table II. Periarticular vascular anastomoses relevant to arthroscopic and open hip surgeons

Anastomosis	*Corona mortis*	*Cruciate anastomosis*	*Trochanteric anastomosis*
Contributing vessels	• Obturator and inferior epigastric • Obturator and external iliac • Connection that runs posterosuperiorly over the pubic ramus, >30 mm from symphysis	• Inferior gluteal artery (descending branch) • Medial femoral circumflex artery (transverse) • Lateral femoral circumflex artery (transverse) • First perforator of profunda femoris artery (ascending branch)	• Superior gluteal artery (descending branch) • Inferior gluteal artery • Medial femoral circumflex artery (ascending) • Lateral femoral circumflex artery (ascending)
Variants	• Aberrant obturator artery	• No common variants	• Posterior branch obturator artery
Significance	• Usually regarded as arterial. However, venous is slightly more common than arterial • Prevalence ranges from 10% to 80% • Can be damaged during surgery around the superior pubic ramus (e.g. trauma, PAO, THA, herniorrhaphy)	Allows blood to reach the popliteal artery indirectly from the internal iliac and inferior gluteal artery if there is an interruption between external iliac and femoral arteries	• Ensures femoral head circulation if one or more contributions are injured

PAO, periacetabular osteotomy; THA, total hip arthroplasty.

In the symptomatic CHECK (the Netherlands) and the asymptomatic female Chingford (United Kingdom) cohorts, AP pelvis radiographs (weight-bearing in CHECK; supine in Chingford) were exclusively used to assess cam morphology [23]. In CHECK, 11.1% (156/1411) of hips had an alpha angle >60° [24]. In Chingford, 9.3% (25/268) of hips that progressed to hip replacement had a mean alpha angle of 62.4° [25]. In CHECK, the odds ratio (OR) of development of end-stage osteoarthritis was 9.7 with an alpha angle >83°. In Chingford, an OR of 1.05 for every single degree of alpha angle increase at baseline and receiving hip replacement within 19-year follow-up. In the Bergen Birth Cohort, mean AP pelvis alpha angle values ($n = 2005$ individuals) were 62° (40–105°) and 52° (36–103°) for men and women, respectively [26]. Thus, correction of posterolateral cam pathomorphology is important because there is evidence that patients with posterolateral cam FAI syndrome are at significant risk for hip pain and arthritis [4–7].

FEMORAL HEAD CIRCULATION

The periarticular vascular supply around the hip is highly complex and prone to significant variability (Fig. 1). Hip surgeons need complete knowledge of common and uncommon variants of blood supply to avoid iatrogenic injury. Anastomoses around the hip permit distal flow and/or femoral head flow in the presence of occlusion. There are at least three common eponymic vascular anastomoses (Table II) around the hip that necessitate protection during intra- and extra-articular hip surgery. The MFCA is the primary blood supply (∼82%) to the weight-bearing portion of the femoral head [27]. This artery typically arises from the posteromedial aspect of the profunda femoris and its transverse segment traverses posteriorly between the iliopsoas tendon and pectineus. Its ascending segment ascends posteriorly toward the inter-trochanteric crest between the obturator externus and quadratus femoris. Finally, the deep segment of the MFCA penetrates the hip capsule at the level of the superior gemellus and gives off

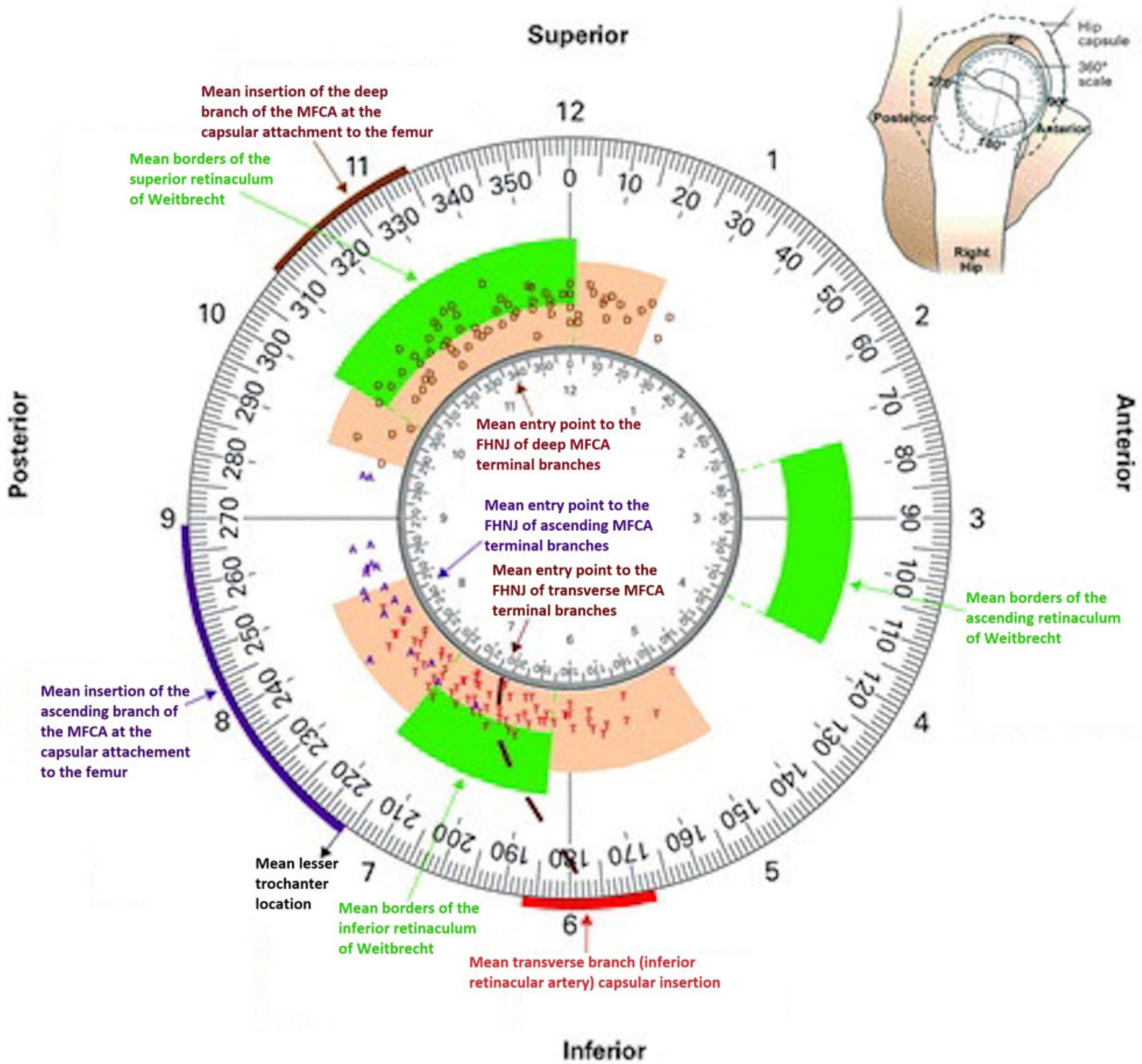

Fig. 2. Diagram showing the vascular supply to the proximal femur. The outer circle represents the femoral capsular attachment, the inner circle represents the articular rim of the femoral head and the millimeter scale represents the distance of the entry point of each terminal branch to the articular rim of the femoral head. The most common location for cam morphology is between 11:45 and 2:45 on the femoral clockface (∼350–80°). This arc illustrates the radial extent of cam morphology, which may be quantified on radial MRI as the omega angle. MFCA, medial femoral circumflex artery; FHNJ, femoral head–neck junction. Entry point for the terminal branches: T, transverse MFCA, A, ascending MFCA; D, deep MFCA. Reproduced and modified, with permission from Lazaro *et al.* —[28].

retinacular branches. The ascending superior retinacular vessels course from distal to proximal on the posterosuperior aspect of the femoral neck in the subsynovial layer before entering the femoral head and terminating as epiphyseal vessels [28].

During femoral osteoplasty, the principal arthroscopic landmark to identify the primary femoral head vascular supply is the lateral synovial fold at approximately the 12:00 femoral clockface position, which covers the superior retinacular vessels [16]. To review the role of the superior retinacular vessels during femoroplasty, we further investigated sources of femoral head vascular supply, including anatomical variants.

The deep branch of the MFCA becomes intra-capsular on the femoral neck from the 10:30–12:00 femoral

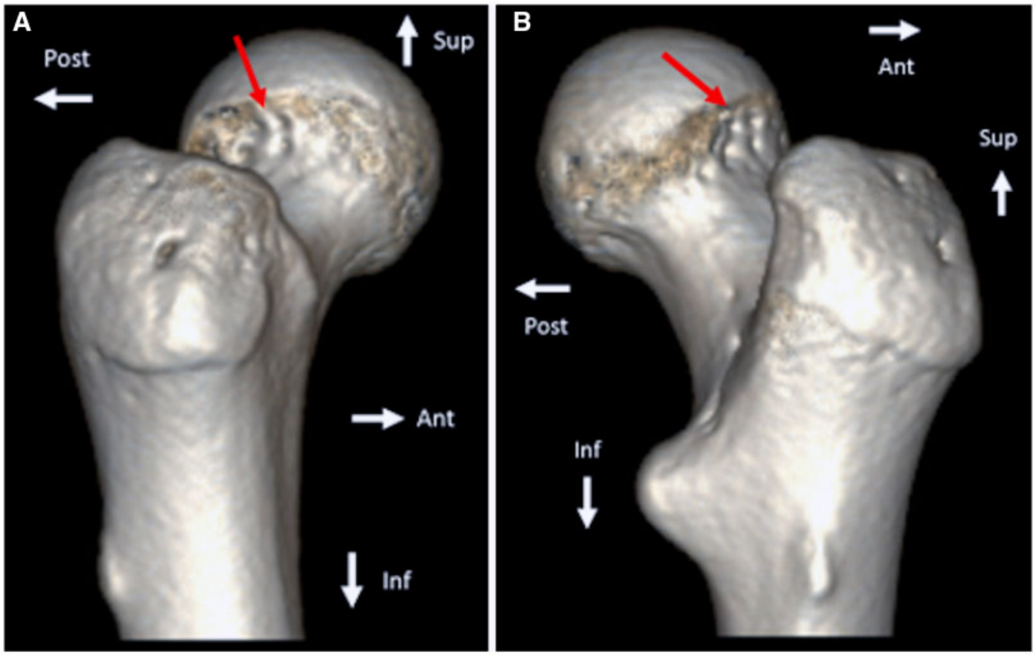

Fig. 3. Three-dimensional computed tomography (CT) scan of right proximal femur of 17-year-old female ballerina with cam morphology. Anterolateral view (**A**) and posterolateral view (**B**). Ant (anterior); post (posterior); sup (superior); inf (inferior). Red arrow indicates four foramina for the lateral ascending vessels, the terminal branches of the medial femoral circumflex artery, the primary blood supply to the femoral head.

clockface position (Fig. 2), just posterior to the lateral synovial fold and progresses medially and superiorly up the neck and becomes subchondral at the head–neck junction via a mean of four superior retinacular vessels (range two to six) [16]. These retinacular vessels are typically able to be observed on CT scans entering foramina on the lateral head–neck junction (Fig. 3A and B). High-resolution (minimum 1.5 T) radial MRI can visualize the lateral synovial fold and the MFCA well (Fig. 4). Ninety-seven percent of vessels are posterior to the 12:00 position [16]. The largest and most consistent anastomosis to the deep branch of the MFCA is from the inferior gluteal artery, running along the inferior margin of piriformis (piriformis branch; trochanteric anastomosis) [15, 29]. While this anastomosis can perfuse the femoral head in the presence of MFCA injury, the anastomosis is always extra-capsular [30]. Although 1976 study described a less distinct subsynovial intra-articular ring that is created by cervical vessels as they approach the femoral head, this conclusion was drawn from 147 autopsied fetuses and children (108 of the specimens coming from infants ranging in age from birth to 6 months) [31, 32]. A more recent cadaveric dissections identified zero intra-articular anastomotic connections between the LFCA and the MFCA, indicating that this intra-articular ring may disappear with increasing age [33].

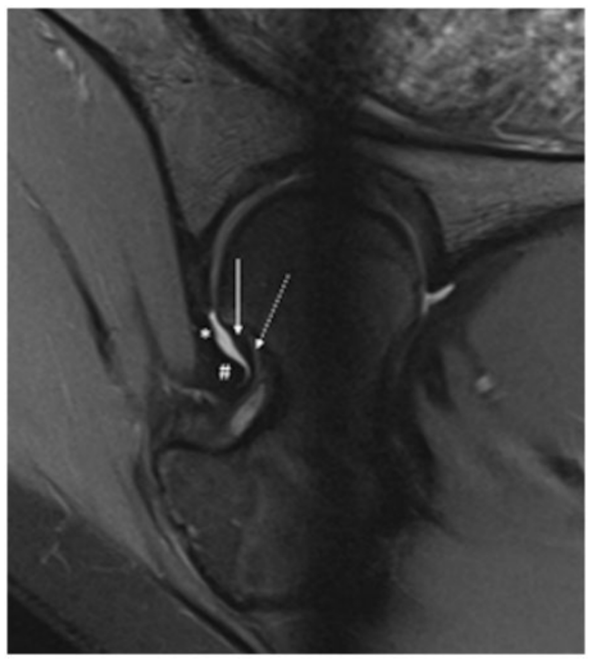

Fig. 4. Radial magnetic resonance imaging (MRI) demonstrating that the lateral ascending retinacular vessels (dotted arrow) largely travel in the lateral synovial fold (solid arrow) and run under the zona orbicularis (#). The zona orbicularis is the condensation of the iliofemoral ligament (*) that wraps circumferentially around the femoral neck.

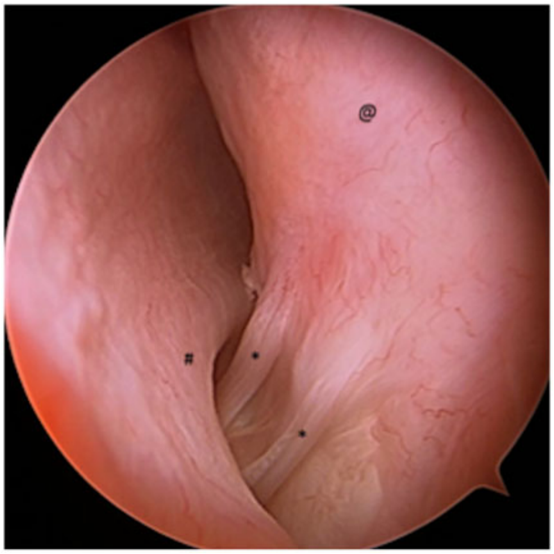

Fig. 5. Right hip arthroscopy in 25-year-old female soccer player, viewing from modified mid-anterior portal, in peripheral compartment, showing the lateral synovial fold (asterisks), the zona orbicularis in close proximity (#) and the proximal femur posterolateral extent of cam morphology (@).

Thus, intra-articular injury to the terminal branches of the deep branch of the MFCA, as would occur during arthroscopic posterolateral femoroplasty, potentially violates primary vascular supply of the femoral head, irrespective of any extra-capsular anastomoses.

The deep branch of the MFCA also gives off a consistent single branch to the inferior neck, the inferior retinacular artery, on top of the medial synovial fold ligament of Weitbrecht [33]. Nevertheless, this single branch (with mean 5 [range 3–9] terminal branches) is smaller in caliber relative to the superior retinacular vessels [28]. Although the MFCA provides the primary vascular supply (82%) to the femoral head, the lateral femoral circumflex artery (LFCA) provides a relevant contribution (18%), especially in the presence of terminal MFCA injury [27].

SAFE CONTOURING OF LATERAL CAM LESIONS

Pre-operative planning (radiographs, MRI and CT) is critical in determining cam resection location and the possibility of superior retinacular vessel involvement (Fig. 5). Using 3-T radial MRI, alpha angles may be calculated across the 360° circumference of the femoral head–neck junction. Moving either clockwise or counterclockwise around radial cuts, Rego and colleagues determined in degrees where the alpha angle exceeded the considered normal threshold value (45°) and begins to be abnormal and where it then returns to normal [34]. The difference between those two values was termed the omega angle. This radial extension (omega angle) of the cam morphology was an arc that ranged from 90 to 180° (mean 138°). Seventy-six percent of subjects had a cam that overlapped at least one superior retinacular vessel (mean three vessels per hip). A wider omega angle was significantly associated with posterior extension of the cam. Following surgical treatment, an incomplete correction and retention of an omega angle were observed in 12% of cases—all in a posterior extension location [34]. Nonetheless, the majority of the cam is on the epiphyseal side laterally, proximal to the vessels and may safely be corrected without vessel damage. There is a depression in the neck where the vessels terminate that is u-shaped and adequate decompression (restoration of lateral offset and reduction in alpha angle) can be obtained without violating the depression [11]. A distally sloping physeal scar is usually observed, especially during open surgical dislocation, that may contribute to the large lateral cam [35, 36].

While pre- and post-operative imaging has the potential to accurately localize posterolateral cam and associated vascular structure(s), intra-operatively, during arthroscopy, guides and landmarks are limited. Hip extension, internal rotation and distraction are useful in arthroscopically better visualizing posterolateral or posterosuperior cams and can facilitate a more accurate cam correction and avoidance of vascular disruption [11, 37]. Fluoroscopically, an AP internal rotation view is the best view to assess posterolateral cam [7]. Ross and colleagues showed that the AP internal rotation view, in combination with five other AP and flexion views, was able to detect the maximum CT-derived alpha angle (11:45–2:45) in 100% of 50 hips undergoing hip arthroscopy [11]. Bedi and colleagues demonstrated that posterosuperior femoroplasty can significantly improve alpha angle on the AP view (arthroscopy 12.6° and surgical dislocation 20.1°; $P < 0.05$) and concluded that the loss of offset that extends superiorly or posterosuperiorly behind the lateral retinacular vessels is better corrected with an open surgical dislocation [38].

A recent study evaluated if the vascular safe zone could be extended behind the 12:00 femoral clockface position to the 11:00 position during hip arthroscopy, which resulted in only an 11% reduction in femoral head perfusion [39]. Despite this finding, these results must be interpreted with caution and surgeons should avoid purposeful vascular disruption. During arthroscopic posterolateral cam correction, the surgeon should acknowledge the lateral synovial fold as a vascular danger zone and question if further, the further gain in cam decompression is worth the theoretical risk of femoral head AVN. Another reason to justify minimal intentional (or unintentional) vascular disruption

Table III. Summary of key reasons why aggressive posterolateral cam femoroplasty may not result in avascular necrosis

Why did avascular necrosis not result from disrupting the superior retinacular vessels within the lateral synovial fold during posterolateral cam femoroplasty?
(i) There are a mean 4 lateral ascending superior retinacular vessels (range 2–6) and this femoroplasty did not violate all of these vessels.
(ii) There is compensatory increased blood flow through the inferior retinacular artery on the ligament of Weitbrecht to the femoral head.
(iii) Although the inferior gluteal artery anastomosis to the deep branch of the MFCA is extra-capsular, a new neovascularization anastomosis may compensate.
(iv) The duration of time of the postoperative MRI following femoroplasty was insufficient to yet detect AVN (mean 25 months, low end of range was 7 months).
(v) There was compensatory increased blood flow via the artery of the ligamentum teres to the femoral head.
(vi) The actual damage to the superior retinacular vessels was incomplete.

posteriorly is the poor accuracy and inter-observer reliability of localizing around the femoral head–neck junction [40]. If a surgeon is unaware of exactly where they are, then vascular compromise is increasingly likely.

When adequate posterolateral femoroplasty cannot be performed using an arthroscope, then open surgery is indicated. Surgical hip dislocation reliably protects the MFCA via an intact obturator externus, as long as the short external rotators are not overstretched or avulsed during dislocation [41, 42].

CAPSULAR MANAGEMENT

Visualization of the proximal femur is necessary for comprehensive treatment of cam deformity and use of a T-capsulotomy results in significantly superior cross-sectional area of joint visualization of extended inter-portal capsulotomies [43]. Contemporary capsular management may involve a T-capsulotomy and capsule closure via plication, but vascular planes must be recognized to avoid disruption of the femoral head blood supply [44]. All intra-capsular vessels penetrate the capsule near its femoral insertion, so proximal capsulotomy should not place the vasculature at risk [33]. If an extensive capsulotomy is utilized, the vertical component of the capsular incision should be between the lateral and medial synovial folds and parallel to the femoral neck to avoid injury to retinacular perfusing vessels. The distal-most extent of the T-capsulotomy overlies the femoral head–neck junction approaches the intertrochanteric groove and risks injury to the terminal ascending branch of the LFCA, which can cause intra-operative bleeding [45]. Since all intra-capsular vessels penetrated the capsule near its distal attachment, distal capsulotomy carries a significantly higher risk of AVN than proximal capsulotomy, particularly posterolaterally and inferomedially.

INJURY TO THE FEMORAL HEAD VASCULAR SUPPLY

The idea of safe violation of extra-osseous posterolateral vasculature has been proposed as safe and effective in correcting cam morphology in/on the vascular supply to the femoral head [12]. This idea is erroneous, as a previous response to Rupp and Rupp suggested [46]. Violation of a single retinacular vessel would not cause AVN of the femoral head, but it should serve as a warning to surgeons to cease further violation of the posterolateral vascularity.

Rupp and Rupp arthroscopically identified the lateral synovial fold and intentionally violated penetrating vascularity to perform femoroplasty with complete contouring of the posterolateral region of the femoral head and neck [12]. The exact reason why this did not result in AVN is unable to be definitively determined, but the possibilities include: (i) this did not violate all of superior retinacular vessels; (ii) inferior retinacular artery on ligament of Weitbrecht responsively increases flow to the head; (iii) although the inferior gluteal artery anastomosis to the deep branch of the MFCA is extra-capsular, a new neovascularization anastomosis may compensate; (iv) the duration of time of postoperative MRI was insufficient to yet detect AVN (low end of range was 7 months); (v) compensatory increased flow via the artery of the ligamentum teres or (vii) the actual damage to the vessels was incomplete (Table III). In a systematic review of over 6000 hips (92 studies), there were only 10 cases of femoral head AVN [47]. Avoidance of excessive traction, avoidance of distal posterolateral capsulotomy and avoidance of intentional disruption of the superior retinacular vessels should keep this AVN rate low. Some authors have also advocated against watertight capsular closure following routine hip arthroscopy with cam morphology to avoid a contained hemarthrosis. The limited volume expansion, combined with increasing intra-articular pressure, may prohibit sufficient vascular inflow. Thus, near-complete closure may permit joint decompression but still retain the capsular closure stability benefits.

CONCLUSION

The primary blood supply to the femoral head is the lateral ascending superior retinacular vessels from the MFCA, which can safely be avoided during arthroscopic hip procedures. The vessels are at greatest risk during arthroscopic femoroplasty of lateral cam morphology and the surgeon should acknowledge the lateral synovial fold as a vascular danger zone. During hip arthroscopy, hip extension, internal rotation and distraction can facilitate a more accurate cam correction and avoidance of vascular disruption. Violation (intentional or unintentional) of a single retinacular vessel terminal branch is very unlikely to cause AVN of the femoral head, but it should serve as a warning to surgeons to cease lateral distal debridement and further violation of the posterolateral vascularity.

CONFLICT OF INTEREST STATEMENT

No COI for Wininger, Barter, Boutris, Pulido. For Ellis: Acute Innovations: IP royalties Medacta: Paid consultant; Research support. For Nho: Allosource: Research support American Orthopaedic Association: Board or committee member American Orthopaedic Society for Sports Medicine: Board or committee member Arthrex, Inc: Research support Arthroscopy Association of North America: Board or committee member Athletico: Research support DJ Orthopaedics: Research support Linvatec: Research support Miomed: Research support Ossur: IP royalties Smith & Nephew: Research support Springer: Publishing royalties, financial or material support Stryker: IP royalties; Paid consultant; Research support. For Harris: AAOS: Board or committee member American Orthopaedic Society for Sports Medicine: Board or committee member Arthroscopy: Editorial or governing board Arthroscopy Association of North America: Board or committee member DePuy, A Johnson & Johnson Company: Research support International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member SLACK Incorporated: Publishing royalties, financial or material support Smith & Nephew: Paid consultant; Paid presenter or speaker; Research support Xodus Medical: Paid presenter or speaker.

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