

Classification and Localization of the Adductor Hiatus: A Cadaver Study

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ABSTRACT

Objective: To determine not only the vertical but also horizontal localization of the adductor hiatus (AH) and classify its shape and structure macroscopically.

Material and Methods: Forty lower extremities were dissected to expose the AH. Its shape and structure were macroscopically noted, and the AH was classified into four types. For determining the localization, measurements were made with digital calipers.

Results: Twenty-four oval fibrous types, 12 oval muscular types, 2 bridging fibrous types and 2 bridging muscular types of AH were determined. For the horizontal localization of AH, the apex of the AH was determined to be located medial to the vertical line between the midpoint of the interepicondylar distance and the line which was drawn transversely from the apex of the AH, in all of the cadavers. For the vertical one, the apex of the AH was located in the middle third of the femur length in 14 thighs, and in the remaining 26 ones, the apex of the AH was located in the distal third of the femur length.

Conclusion: Adductor hiatus was classified according to its shape and structure for the first time. Moreover, the localization of the AH was practically defined, in order not to harm the popliteal artery and vein.

Key Words: Adductor hiatus, adductor canal outlet syndrome, femoropopliteal occlusion, adductor magnus muscle

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Introduction

The adductor hiatus (AH) can be described as an opening in the aponeurotic distal attachment of adductor magnus muscle, which transmits the femoral artery and vein from the adductor canal in the thigh to the popliteal fossa (1). The adductor magnus muscle is also interrupted by a series of osseo-aponeurotic openings, and these openings transmit the perforating branches and the termination of the profunda femoris artery (2).

The majority of femoropopliteal occlusions are located distally in the thigh (3-7). More specifically, occlusions of the femoropopliteal region have a high incidence in the adductor hiatus region (6, 7). Evaluating the previous studies, Watt (7) reported that 60-70% of all femoropopliteal occlusions were located in the adductor region. Using Duplex ultrasound, Scholten et al. (6) found that 72% of occlusions of the femoropopliteal region were localized at the level of the adductor canal hiatus.

The exact mechanism for causing occlusions at the adductor canal hiatus has not been well established yet. Besides general atherogenic causes, the high incidence of occlusions is considered to be due to local anatomic factors (5, 6, 8, 9). Several theories for these factors may include direct mechanical damage to the vessel wall due to traction or compression (4-6, 10), unfavourable haemodynamic circumstances such as

frequent branching or an S-shaped configuration of the femoral and popliteal arteries (7), repeated trauma created by the pulsatile movements of the arterial wall where it lies in intimate contact with the aponeurosis of the adductor magnus muscle (10, 11), and the influence of knee flexion on atherogenesis in the adductor and popliteal region as the femoral and popliteal arteries become tortuous during knee flexion (4, 7, 8). Moreover, in the hiatal region there is a transition zone from a fixed position in the adductor canal to a freely movable position in the fatty tissue of the popliteal fossa and, during muscle action and leg movement, shear forces may stress the vessel wall in the transition zone (6, 11). Contrarily, Wensing et al. (9) asserted that a relationship between localization of atherosclerotic lesions and haemodynamics was more likely and they reported that early atherosclerotic lesions revealed no apparent relation with surrounding structures and added that a preferential helical distribution had been observed in the atherosclerotic lesions.

However, neither the exact localization nor the shape and structure of the AH have been studied in detail yet. Knowledge of these factors might explain why only particular people are exposed to thrombosis of the femoral artery at the level of the AH. Consequently, the purpose of this study was to determine not only the vertical but also the horizontal localization of the AH in the thigh and classify its shape and structure macroscopically.

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Material and Methods

Forty lower extremities of 20 embalmed cadavers were dissected to expose the AH and the shape and structure of each AH were macroscopically noted. The cadavers did not have malformations or surgical operations of hip and femur. According to its shape, the adductor hiatus was firstly classified into two groups: the *oval type* and the *bridging type*. The ones which were oval in shape were classified as the oval type and the ones which crossed over the popliteal artery and vein like a bridge were classified as the bridging type. Afterwards, the structure of the fibers which formed the borders of the adductor hiatus was noted, and subgroups (*fibrous and muscular*) were formed according to these. Finally, the AH was classified into four types: *oval fibrous, oval muscular, bridging fibrous and bridging muscular*.

In order to determine the localization of the AH, we made some measurements with digital calipers. Firstly, some landmarks were defined and several lines were drawn between these landmarks for the measurements (Figure 1). The distance between the medial and lateral epicondyles of the femur was measured and the midpoint of this distance was marked. Then

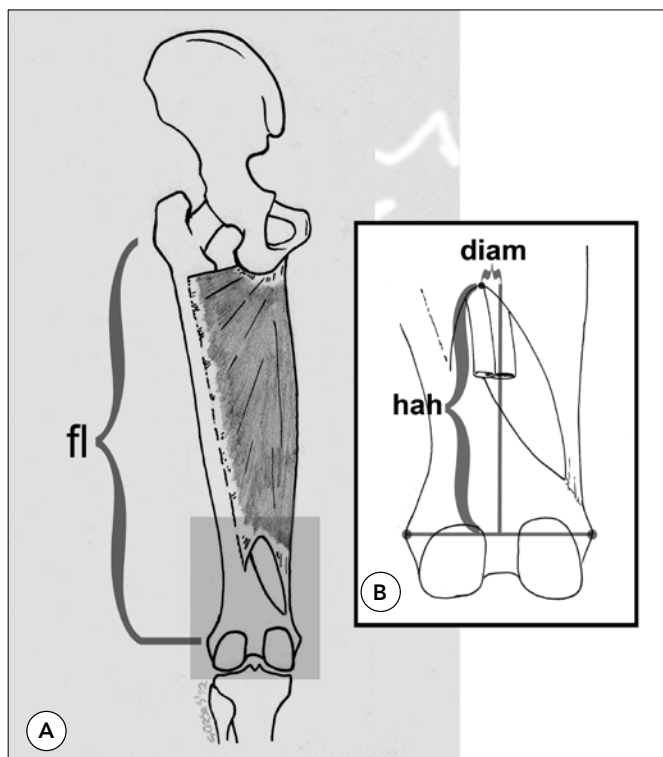


Figure 1. The illustration showing the measurements taken related with the localization of the adductor hiatus. A) left thigh from behind, B) inset showing close up view of the AH and the measurements performed to find the localization of the apex of the AH. fl: femur length (the distance between the highest palpable point of the greater trochanter and the horizontal continuation of the interepicondylar distance), hah: height of the adductor hiatus, diam: distance between the apex and the vertical line beginning from the midpoint of the interepicondylar line

the distance between the midpoint of the interepicondylar distance and the line which was drawn transversely from the apex of the AH (height of the AH) was measured. To define a proportional relation of the vertical localization of the AH according to the length of the femur, the distance between the line drawn transversely from the highest palpable point of the greater trochanter and the horizontal continuation of the interepicondylar distance was measured as the femur length. Afterwards, the height of the AH was proportioned to the femur length and the localization of the apex of the AH was noted to be found either at the proximal third, middle third or distal third of the femur length. To define the horizontal localization of the AH, the distance between the line which was drawn vertically upwards from the midpoint of the interepicondylar distance and apex of the AH was measured. The position of the apex of the AH, being either medial or lateral to the vertical line between midpoint of interepicondylar distance, and the line which was drawn transversely from apex of AH, were noted.

The popliteal artery and vein leaving through the adductor hiatus were examined in each thigh and their relationship to each other were noted. Moreover, the adductor magnus muscle was examined for the presence of perforating arteries. Furthermore, the insertion of the medial part and lateral part of the adductor magnus muscle were examined.

Results

In 36 thighs, the AH was oval in shape. Of these 36 thighs, 24 thighs had oval fibrous type AH (Figure 2). The remaining 12 had oval muscular type AH (Figure 3). In 4 thighs, the AH had a bridging shape. Two of these 4 thighs had bridging fibrous AH (Figure 4) and the other two thighs had bridging muscular AH (Figure 5). Of a total of 20 cadavers, the AH did not have the same type in both sides except in 2 cadavers.

The mean distance between medial and lateral epicondyles of the femur was measured as 88.5 mm (range from 76.3 to 94.7 mm). In relation to the vertical localization, the mean distance between the midpoint of the interepicondylar distance and the line which was drawn transversely from the apex of the AH (height of the AH) was found as 119.6 mm (range from 72 to 170.4 mm). The femur length was found as a mean of 369.2 mm (range from 334 to 445 mm). In 14 thighs, the apex of the AH was located in the middle third of the femur length and in the remaining 26, the apex of the AH was located in the distal third of the femur length.

In relation to the horizontal localization, the mean distance between the line which was drawn vertically upwards from the midpoint of the interepicondylar distance and the apex of the AH was measured as 7.94 mm (range from 2.2 to 17.4 mm). In all of the cadavers, the apex of the AH was determined to exist medial to the vertical line between the midpoint of the interepicondylar distance and the line which was drawn transversely from apex of the AH.

The numerical and characteristic data of all cadavers are summarized in Table 1.

The popliteal artery and popliteal vein, leaving through the adductor hiatus, were present in all thighs. In all of the

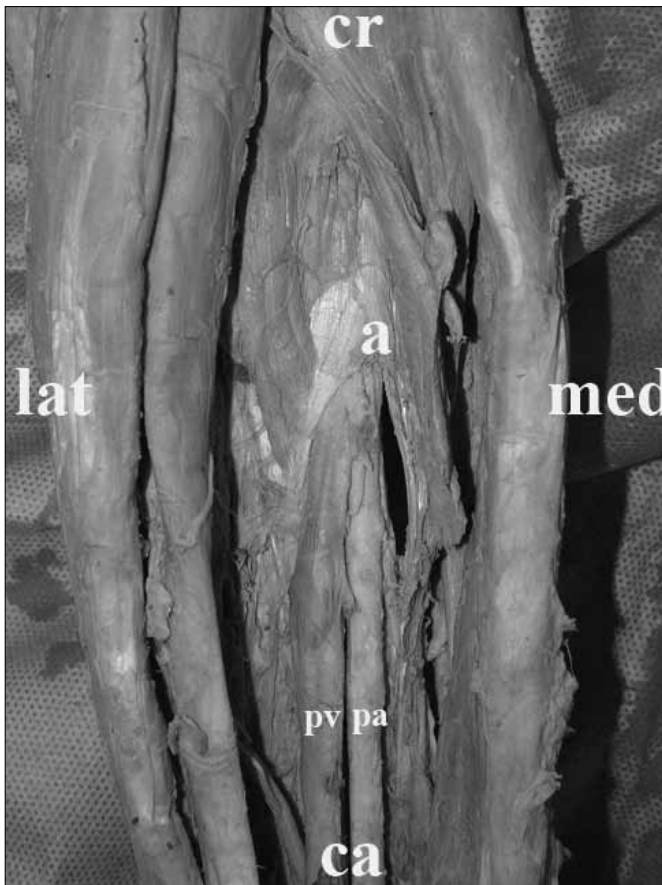


Figure 2. Oval fibrous type adductor hiatus. a: apex of the adductor hiatus, cr: cranial, ca:caudal, med: medial, lat: lateral, pa: popliteal artery, pv: popliteal vein

cadavers, the popliteal vein was lateral to the popliteal artery. The adductor magnus muscle was always perforated by several perforating arteries above the adductor hiatus regardless of the type of the adductor hiatus (Figure 3). The medial part of the adductor magnus muscle was always attached to the adductor tubercle of the femur, and its lateral part was always attached to the proximal part of the medial supracondylar line, regardless of the type of adductor hiatus, either fibrous or muscular.

Discussion

The compression of the femoral artery at the AH is a well-recognized entity and the majority of lower limb arterial occlusions have been located in the distal third of the thigh (4-9, 12-14). Related to this localization, a rare entity, the adductor canal outlet syndrome has also been described (12, 15, 16). This syndrome involves thrombosis of the femoral artery at the level of the AH. It occurs as a result of microtrauma to the intima of the vessel due to a scissor-like compression from the vastus medialis or adductor magnus tendons. A hypertrophied band or portion of the tendon is usually responsible for the compression. Calf claudication, numbness, paresthesias and coolness of the foot, lack or diminishing of the popliteal and pedal pulses due to the exist-

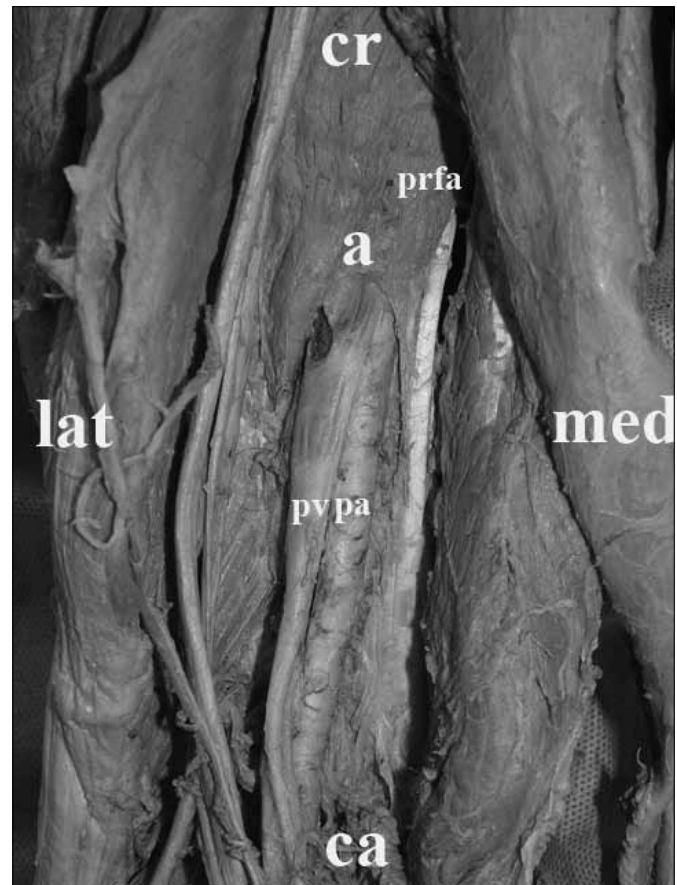


Figure 3. Oval muscular type adductor hiatus. a: apex of the adductor hiatus, cr: cranial, ca:caudal, med:medial, lat:lateral, pa: popliteal artery, pv: popliteal vein, prfa: perforating artery

ing occluding thrombus can be observed in patients having adductor canal outlet syndrome. In these cases, angiography shows segmental occlusion of the femoral artery at the level of the AH. The symptoms may begin suddenly or in a gradual way. Mostly, initiation of a running program or a twisting injury while cross-country skiing have been held responsible for the onset of symptoms (16, 17). An awareness of the relationship of these activities to acute intimal injury and thrombosis is key to providing effective treatment and saving limbs that would otherwise be lost (12, 15). Treatment consists of surgical excision of the compressing tendinous band along with saphenous vein bypass grafting (16, 17).

Although thrombosis of the femoral artery at the level of the AH has been well defined, neither the exact localization nor shape of the AH has been clarified by any surgical, radiologic or postmortem observations.

A few cadaver studies report only the vertical localization of the AH (18, 19). Olson and Holt (19) measured the distance from the adductor tubercle to the AH in both lower extremities of 24 skeletally mature cadavers and they reported that this distance ranged from 80 to 135 mm (mean 100) and they stated that the area up to 80 mm proximal to the adductor tubercle, appeared to be a safe interval for avoiding vascular structures with percutaneous or limited open surgeries of the

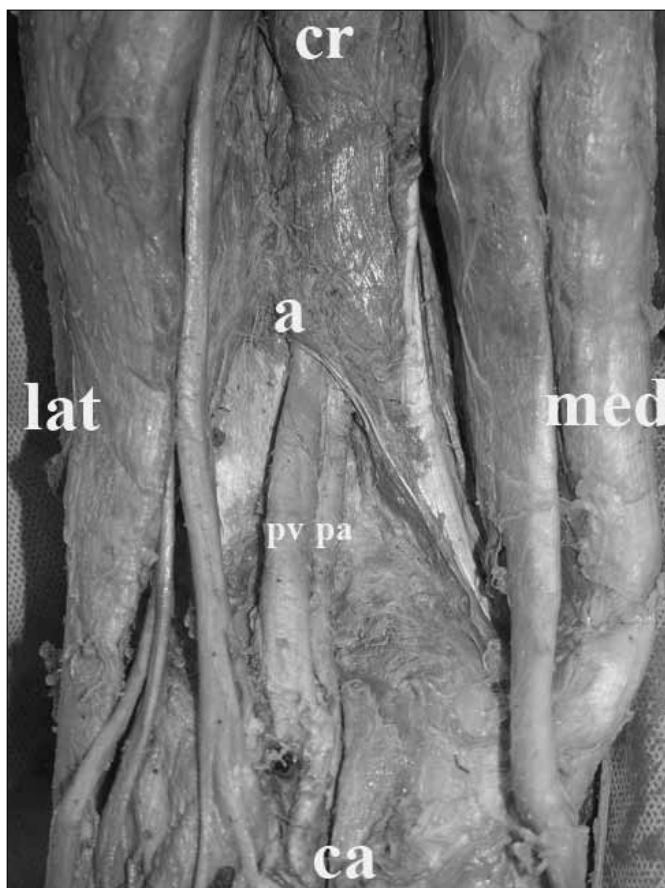


Figure 4. Bridging fibrous type adductor hiatus. a: apex of the adductor hiatus, cr: cranial, ca:caudal, med: medial, lat: lateral, pa: popliteal artery, pv: popliteal vein

medial aspect of the distal femur. Checroun et al. (18) measured the distance from the adductor tubercle to the proximal most point of the AH and found that it ranged from 132 to 180 mm. In the present study, the mean distance between the midpoint of the interepicondylar distance and the line which was drawn transversely from the apex of the AH was found as 119.6 mm (range from 72 to 170.4 mm). Consequently, as in Olson and Holt's results (19), the region over the distance 72 mm proximal to the midpoint of the interepicondylar distance seems to be safe for the popliteal artery and vein during surgical procedures of the distal femur. The importance of this safe interval was also emphasized by Scheibel et al. (20). In their study related with total knee replacement via a subvastus approach, they reported that the proximal limitation for the mobilization was the AH, in order not to damage the femoral artery and vein (20).

Two ultrasonographic studies were also performed to localize the AH (5, 6). In 1989, Scholten et al. (5) used external sonography to localize the AH. According to them, the exact location of the adductor canal hiatus was defined as the site where the cross section of the femoral artery was at the level of the two echogenic lines that represented the continuation of the adductor fascia on either side of the defect. They also reported that the location of the AH varied from 80-130 mm (mean 100 mm) cranial to patella in 16 legs of eight healthy

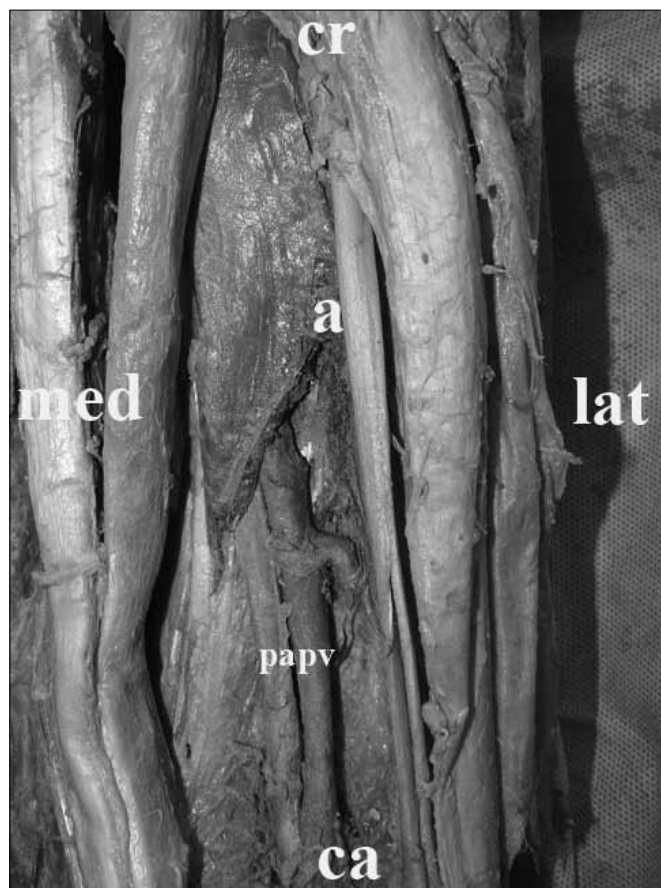


Figure 5. Bridging muscular type adductor hiatus. a: apex of the adductor hiatus, cr: cranial, ca: caudal, med: medial, lat: lateral, pa: popliteal artery, pv: popliteal vein

volunteers (5). In 1993, Scholten et al. (6) used Duplex ultrasound to locate the level of femoropopliteal occlusions with respect to the level of the AH in 50 patients. They reported that the location of the AH varied from 70-150 mm (mean 105 mm) cranial to the upper border of the patella. They added that 72% of occlusions showed a relation with the hiatus (6). The results of the present study indicating the vertical localization of the AH were compatible with the results of these two ultrasonographic studies. Related with ultrasonography of the AH, The et al. (13) used intravascular sonography to differentiate between residual stenosis due to residual plaque and that due to extrinsic compression of the wall of the femoral artery near the AH.

The most important finding of the present study was the classification of four different types of AH according to its shape for the first time and the structure and localization of the AH, not only vertically but also horizontally. The most frequent shape of the AH was found to be the oval fibrous one. For its horizontal localization, the apex of the AH was localized medial to the vertical line between the midpoint of interepicondylar distance and the line which was drawn transversely from the apex of the AH in all of the cadavers. For its vertical localization, the apex of the AH was most frequently localized in the distal third of the femur length.

Table 1. Shows the numerical and characteristic data of all cadavers

Cadaver no & side	Distance between medial and lateral epicondyles of femur	Distance between midpoint of interepicondylar distance and the line which was drawn transversely from apex of adductor hiatus	Distance between the line which was drawn vertically upwards from the midpoint of interepicondylar distance and apex of adductor hiatus	The femur length	Localization of apex of adductor hiatus; either existing in the middle or distal third of the femur length	Type of adductor hiatus
No: 1 right	89.4	156	14.8	348	Middle	Oval fibrous
No: 1 left	93.5	170.4	17.4	349	Middle	Oval fibrous
No: 2 right	85.4	135	9.6	354	Middle	Oval fibrous
No: 2 left	82.0	148	16.9	355	Middle	Oval fibrous
No: 3 right	76.3	105	12.2	344	Distal	Oval fibrous
No: 3 left	77.1	110	14.7	343	Distal	Oval fibrous
No: 4 right	91.5	115	15.3	372	Distal	Bridging muscular
No: 4 left	90.3	125	10.3	370	Distal	Oval fibrous
No: 5 right	94.0	110	8.8	383	Distal	Oval fibrous
No: 5 left	94.7	107	9.9	382	Distal	Oval fibrous
No: 6 right	90.9	130	7.9	400	Distal	Oval fibrous
No: 6 left	92.3	95	10.6	401	Distal	Oval fibrous
No: 7 right	83.3	131	5.8	388	Middle	Oval muscular
No: 7 left	83.1	125	5.7	386	Middle	Oval muscular
No: 8 right	85.4	128	6.7	363	Middle	Oval muscular
No: 8 left	84.4	129	7.9	365	Middle	Oval muscular
No: 9 right	87.9	123	2.2	371	Distal	Oval fibrous
No: 9 left	87.0	130	5.7	370	Middle	Oval fibrous
No: 10 right	91.7	102	5.8	335	Distal	Oval fibrous
No: 10 left	91.8	104	6	334	Distal	Oval fibrous
No: 11 right	90.9	106	5.4	443	Distal	Oval muscular
No: 11 left	94.7	108	8.2	445	Distal	Oval muscular
No: 12 right	91.9	88	3	336	Distal	Oval fibrous
No: 12left	88.7	72	6.9	334	Distal	Bridging muscular
No: 13 right	85.5	108	4.9	362	Distal	Bridging fibrous
No: 13 left	84.4	118	6.7	365	Middle	Bridging fibrous
No: 14 right	89.9	121	4.5	371	Distal	Oval fibrous
No: 14 left	90.8	111	5.6	372	Distal	Oval fibrous
No: 15 right	85.5	130	7.2	368	Middle	Oval fibrous
No: 15 left	86.6	125	6.4	366	Middle	Oval fibrous
No: 16 right	89.8	128	5.6	355	Middle	Oval muscular
No: 16 left	86.3	112	4.8	353	Distal	Oval muscular
No: 17 right	91.0	136	5.2	369	Middle	Oval fibrous
No: 17 left	90.4	131	6.2	370	Distal	Oval fibrous
No: 18 right	91.4	120	7.8	348	Distal	Oval muscular
No: 18 left	87.2	119.1	6.9	346	Distal	Oval muscular
No: 19 right	92.0	115	6.9	374	Distal	Oval muscular
No: 19 left	94.2	116	7.4	375	Distal	Oval muscular
No: 20 right	88.4	122	6.6	403	Distal	Oval fibrous
No: 20 left	86.6	120	6.8	401	Distal	Oval fibrous
Average results	88.5	119.6	7.94	369.2		

Conclusion

The AH was classified according to its shape and structure in the present study for the first time. Moreover, the localization of the AH was practically defined, in order not to cause harm to the popliteal artery and vein during the surgical procedures of the distal femur. Furthermore, as the AH is one of the two principal sites for femoropopliteal occlusions, the localization of the AH might be a guideline for the treatment of these occlusions for the vascular surgeons.

Conflict of Interest

No conflict of interest was declared by the authors.

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