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ORIGINAL COMMUNICATION

CLINICAL ANATOMY WILEY

Anatomical study of the descending genicular artery and implications for image-guided interventions for knee pain

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Abstract

Introduction: The descending genicular artery (DGA) has recently been mentioned as accompanying some nerves in the medial aspect of the knee joint. This could be clinically relevant as the arteries could serve as landmarks for accurate nerve capture during ultrasound-guided nerve blockade or ablation. The aim of this cadaveric study was to investigate the anatomical distribution of the DGA, assess the nerves running alongside its branches, and discuss the implications for regional anesthesia and knee pain interventions.

Methods: We dissected the femoral artery (FA) all along its course to identify the origin of the DGA, from which we carefully dissected all branches, in 27 fresh-frozen human specimens. Simultaneously, we systematically dissected the nerves supplying the medial aspect of the knee from proximally to distally and identified those running alongside the branches of the DGA. The surrounding anatomical landmarks were identified and measurements were recorded.

Results: The DGA was found in all specimens, arising from the FA 130.5 ± 17.5 mm (mean ± *SD*) proximally to the knee joint line. Seven distribution patterns of the DGA were observed. We found three consistent branches from the DGA running alongside their corresponding nerves at the level of the medial aspect of the knee: the artery of the superior-medial genicular nerve, the artery of the infrapatellar branch of the saphenous nerve, and the saphenous branch of the DGA.

Conclusion: The consistent arteries and surrounding landmarks found in this study could help to improve the capture of the targeted nerves during ultrasound-guided interventions.

KEYWORDS

arteries, innervation, interventional, knee joint, ultrasonography

1 | INTRODUCTION

During the last decade, genicular nerve blockade (GNB) and radiofrequency ablation (RFA) have emerged as promising interventions for patients with chronic knee pain due to osteoarthritis or persisting after total knee replacement (Jamison & Cohen, 2018). These procedures are based on selective inhibition of the consistent sensory nerves supplying the joint capsule, the so-called genicular nerves (GNs). Given the small volume injected during nerve blockade and the very limited size of a radiofrequency lesion, the success of these techniques relies on the choice of accurate anatomical targets to capture the articular nerves supplying the knee. However, since the original description of these procedures (Choi et al., 2011), several research groups have concluded that their anatomical bases were inaccurate

(Bhatia, Peng, & Cohen, 2016; Fonkoue, Behets, Kouassi, et al., 2019; Orduna Valls et al., 2017; Roberts, Stout, & Dreyfuss, 2019), and current studies are focusing on optimizing GNB and RFA (Conger et al., 2019; Fonkoue, Behets, Steyaert, et al., 2019; Tran et al., 2018).

Because the GN are very small, it can be challenging to target them accurately in interventional pain medicine. The GN are difficult to visualize directly under ultrasound guidance, but blood flow in the genicular arteries traveling alongside the nerves can help to identify them more easily and make injection more successful (DemIr, Guzelkucuk, Tezel, AydemIr, & Taskaynatan, 2017; Sari et al., 2017). This principle has been applied to ultrasound-guided elective neural ablation (Kim et al., 2019; Sari et al., 2017). Therefore, the genicular artery of interest should be the one running alongside the targeted nerve. Reliance on wrong patterns of genicular arteries would lead to a poor outcome.

Recent studies have shown that the contribution of the superior-medial GN (SMGN) and the infrapatellar branch of the saphenous nerve (IPBSN) to the sensitivity of the medial region of the knee joint makes them primary targets for relieving medial knee pain (Burckett-St Laurant et al., 2016; Fonkoue, Behets, Kouassi, et al., 2019; Orduna Valls et al., 2017). However, there are some discrepancies about the arteries accompanying these nerves; contrary to the original description, the descending genicular artery (DGA) has recently been mentioned as accompanying the SMGN (Fonkoue, Behets, Kouassi, et al., 2019; Fonkoue, Behets, Steyaert, et al., 2019; Tran et al., 2018).

Anatomical studies of the DGA have sparked great interest in the recent years owing to the emergence and increasing indications of medial femoral condyle (MFC) flap (Dubois, Lopez, Puwanarajah, Noyelles, & Lauwers, 2010; Garcia-Pumarino & Franco, 2014; Huang et al., 2011; Hugon, Koninckx, & Barbier, 2010; Sananpanich, Atthakomol, Luevitoonvechkij, & Kraisarin, 2013; Weitgasser et al., 2016; Xu, Zheng, Li, Zhu, & Ding, 2019; Ziegler et al., 2018). So far, anatomical studies of the DGA have been related to plastic surgery. To our knowledge, no study has specifically investigated the anatomy of the DGA regarding its potential implications for regional anesthesia and knee pain interventions. Therefore, the aims of this cadaveric study were to (a) describe the anatomical distribution of the DGA, (b) investigate the articular nerves running alongside the branches of the DGA, and (c) discuss its potential implications for ultrasound-guided regional anesthesia and chronic pain interventions.

2 | MATERIALS AND METHODS

Twenty-seven fresh-frozen lower limbs (16 right, 11 left) from 21 adult cadavers (11 males, 10 females; average age at death 82.9 ± 9.4 years), without evidence of prior knee surgery or trauma, were observed macroscopically. All the bodies were donated to the institution for education and research purposes in accordance with national laws and regulations. Approval was obtained from the University Research Ethics Committee. All the dissections were performed by an experienced anatomist, who had conducted the dissections in several previous studies addressing knee joint innervation.

The dissection started with a skin incision and superficial cutaneous removal at the medial aspect of the thigh, from the groin to the middle of the leg. In supine position, we exposed the femoral artery (FA) and femoral nerve with its branches in the femoral triangle. We dissected the FA all along its course to identify the origin of the DGA, from which we carefully dissected all the branches from proximally to distally. The DGA was studied with particular emphasis on the knee nerves in close proximity. So, simultaneously with the arterial dissection, we performed a systematic proximal-to-distal dissection of the nerves supplying the medial part of the knee joint. Then we identified the nerves supplying the medial aspect of the knee running alongside branches of the DGA in each specimen. Surrounding anatomical structures that could serve as complementary landmarks were also identified.

We collected the following data:

- the pattern of origin and distribution of the DGA according to the Dubois et al. (2010) classification;
- the distance between the origin of the DGA and the medial femoro-tibial joint line;
- the length of the DGA from its origin to its division;
- the distance from the origin of the DGA to the periosteum of the MFC;
- the lengths of the branches of the DGA;
- the branches of the DGA running alongside the nerves supplying the knee joint;
- the longitudinal distance between the point where a branch of the DGA joins the corresponding nerve and the femoro-tibial joint line.

Dissections were performed under magnification with a ×3.5 surgical loupe. The measurements were taken with a sliding digital caliper in a full-extension position. The findings were recorded with photographs. In two specimens, the FA was injected with red latex before dissection.

3 | RESULTS

3.1 | Branching pattern of the DGA

The DGA was found in all the specimens. It branched off the medial side of the FA just before the passage through the adductor hiatus. It was the last medial branch of the FA. We identified seven branching patterns of the DGA from the Dubois et al. classification (Table 1). The type I pattern (Figure 1) was observed in 16 (59.3%) cases, Type II (Figure 2) in 9 (33.3%) and Type III (Figure 3) in 1 (3.7%). In one case, the three branches emerged from a common trunk as in Type I, but the osteo-articular branch (AB) occurred first, leaving behind a sapheno-muscular trunk (Figure 1d). This subtype of the Type I branching pattern is not included in the Dubois et al. classification.

The DGA originated on average 130.5 ± 17.5 mm (mean ± *SD*) proximally to the medial femoro-tibial joint line (Table 2). In most cases, it divided into its terminal branches after a short descending

TABLE 1 Origin and distribution pattern of the descending genicular artery in our series according to the Dubois et al. classification

Branching pattern	Description	Frequency in our series
Type I	The three branches emerge from a common trunk: The DGA	16/27 (59.3%)
Ia	The DGA divides into the three terminal branches	5/27 (18.5%)
Ib	The MB occurs first, leaving behind a sapheno-articular trunk	7/27 (26.0%)
Ic	The SB occurs first, and leaving behind a musculo-articular trunk	4/27 (14.8%)
Type II	One of the three branches arises directly from the FA	9/27 (33.3%)
IIa	The AB arises directly from the FA	0/27 (0%)
IIb	The SB originates directly from the FA	4/27 (14.8%)
IIc	The MB originates directly from the FA	5/27 (18.5%)
Type III	The three branches (SB, AB, and MB) arise separately from the FA	1/27 (3.7%)
Nonapplicable	The three branches emerge from a common trunk, the AB occurring first, leaving behind a sapheno-muscular trunk	1/27 (3.7%)

Abbreviations: AB, articular branch; DGA, descending genicular artery; FA, femoral artery; MB, muscular branch; SB, saphenous branch.

course of 11.2 ± 8.0 mm: the muscular, osteo-articular, and saphenous branches (SBs; Figure 4).

3.2 | Anatomical description of terminal arterial branches and identification of knee nerves running along them

The muscular branch (MB) was the first to emerge in half of the specimens, either from the short initial course of the DGA or directly from the FA. It was a strong branch with a short transverse course toward the vastus medialis muscle, where it divided to supply the posterior-medial aspect of the muscle (Figure 4). No nerve was found along this branch. The main trunk of the DGA then divided into two branches (Figure 4): a descending longitudinal (osteo-articular) branch and a posterior oblique (saphenous) branch.

The osteo-AB of the DGA was longitudinal, descending almost vertically toward the MFC, with a course lateral to the adductor magnus tendon (AMT), close to the bone (Figure 4). Its average length was 79.6 ± 10.2 mm. The AB was observed in the sub-vastus region, between the posterior aspect of the vastus medialis muscle and the AMT, anterior to the medial intermuscular septum of the thigh. During its course, it detached 0–3 thin transverse MBs to the vastus medialis and one inconstant posterior branch that anastomosed with the popliteal artery (Figure 4). The AB divided above the adductor tubercle into two terminal branches, almost perpendicular (Figure 4):

- A transverse branch, running forward on the periosteum at the junction of medial epicondyle and femoral diaphysis, 61.5 ± 5.8 mm from the joint line: the upper transverse artery of the medial condyle. This branch was not accompanied by a nerve.
- A longitudinal branch, running distally to the MFC: the central longitudinal artery of the MFC. It was an extension of the AB, passing beneath a transverse retinaculum stretched between the distal end of the AMT and the periosteum of the medial aspect of the femoral metaphysis, and supplying the MFC.

Before its bifurcation, the AB gave rise to an artery that ran obliquely distally and medially to join the trunk of the SMGN, which ran on the anterior surface of the AMT above the adductor tubercle (Figure 5). In three cases, the artery of the SMGN arose from the distal MB of the AB or the central longitudinal artery of the MFC; in one case, it arose from the SB. We dissected and distinctly identified this consistent small artery accompanying the SMGN in 23 out of 27 (85%) specimens (Figures 5 and 6). The SMGN and its artery joined on average 64.2 ± 9.7 mm above the knee joint line, traveled together in the same sheath on the AMT, passed just in front of the adductor tubercle and divided into three terminal branches to supply the superior-medial aspect of the knee capsule (Figure 6). The point of bony contact of the SMGN before its division (corresponding to the target point for image-guided GNB or RFA) was located at 44.3 ± 6.2 mm from the femoro-tibial joint line, in comparison to 61.5 ± 5.8 mm for the upper transverse artery ($p < .001$). The superior medial genicular artery (SMGA) emerged from the popliteal artery, ran forward passing between the end of the AMT and metaphysis and joined the transverse terminal branch of the SMGN (running at the level of the medial epicondyle), but not its trunk. Therefore, the SMGA and the artery of the SMGN were two different arteries.

The SB, just after its origin from the DGA, crossed the AMT and descended posteriorly and medially to join the saphenous nerve after its exit from the adductor canal (Figures 2 and 4), at about 102.3 ± 13.7 mm from the knee joint line. Both traveled together in the subsartorial space, from which they exited between the sartorius and the gracilis tendon below the femoral condyle and descended toward the medial aspect of the leg. During its course, the SB detached muscular perforators for the vastus medialis and sartorius muscles, and cutaneous perforators (Figure 4). In addition, we observed that the SB detached a small artery that accompanied the IPBSN in the inferior-medial quadrant of the knee (Figure 7). The artery of the IPBSN joined its nerve on average 36.6 ± 29.6 mm from the joint line.

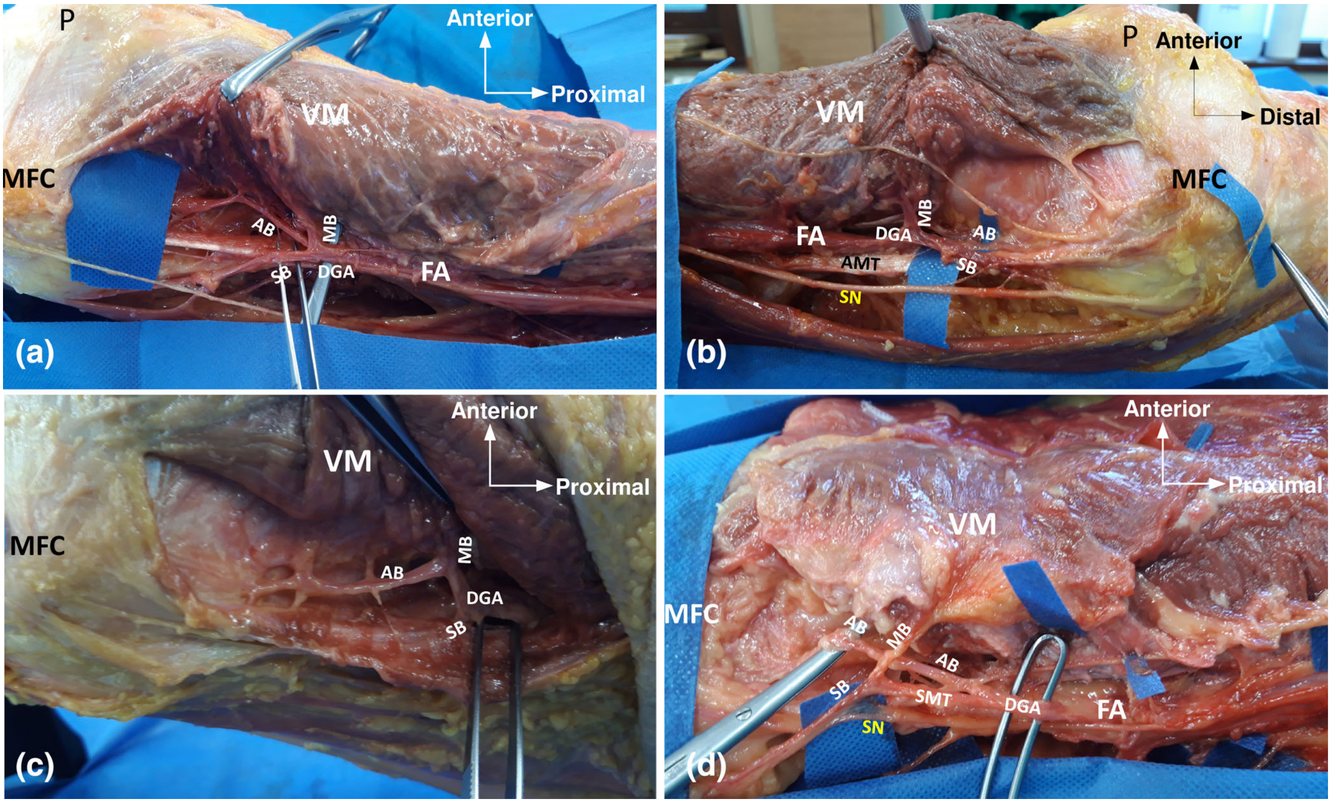

FIGURE 1 Type I branching patterns of descending genicular artery (DGA). (a) Type Ia. The DGA divides at its origin into its three terminal branches: the muscular branch (MB), the saphenous branch (SB), and the osteo-articular branch (AB). (b) Type Ib. The DGA originates from femoral artery (FA) and first gives the MB, leaving a sapheno-articular trunk, which divides into the SB and AB. (c) Type Ic. The DGA originates from the FA and first gives the SB, leaving a musculo-articular trunk that divides into MB and AB. (d) The DGA originates from the FA and first gives the AB, leaving a sapheno-muscular trunk (SMT) that divides into the MB and SB. AMT adductor magnus tendon; MFC, medial femoral condyle; P, patella, SN, saphenous nerve; VM: vastus medialis muscle [Color figure can be viewed at wileyonlinelibrary.com]

3.3 | Potential branches from the DGA that could serve as landmarks for the targeting and capture of nerves during ultrasound-guided interventions

In total, we found DGA branches accompanying the nerves at the medial aspect of the knee that could serve as complementary landmarks for precise and specific targeting of those nerves during ultrasound-guided interventions. They included:

- The artery of the SMGN: on the AMT and the adductor tubercle (Figures 5 and 6).
- The SB of the DGA: in the subsartorial space (Figures 1 and 2).
- The artery of the IPBSN: at the inferior-medial aspect of the knee joint (Figure 7).

4 | DISCUSSION

The aim of this study was to investigate the anatomy of the DGA and its branches. It highlights another potentially relevant clinical application of the anatomical study of the DGA, identifying complementary landmarks to improve the capture of the targeted nerves during ultrasound-guided regional anesthesia and pain relief interventions. We found three constant arteries running on the medial side of the knee in close proximity to the nerves that are the primary targets for the above-mentioned clinical interventions: the artery of the SMGN, the SB of the DGA, and the artery of the IPBSN.

The distribution pattern of the DGA and the various distances were consistent with the literature, summarized in a recent exhaustive systematic review and meta-analysis (Ziegler et al., 2018), although we did not observe the Type IIa pattern. We also observed an additional subtype of the Type I pattern in which the AB arises first from the common trunk, leaving behind a sapheno-muscular trunk. The classification by Dubois et al. (2010) is the most frequently used because it provides a logical and clinically relevant tool for analyzing the varieties of DGA branching patterns in relation to their application in MFC flaps. However, while the three main groups follow this logic, from the best branching pattern (Type I, which allows bone, muscle, and skin flaps with a long pedicle to be obtained) to the most challenging (Type III), and from the most to the least frequent (I–III), this is

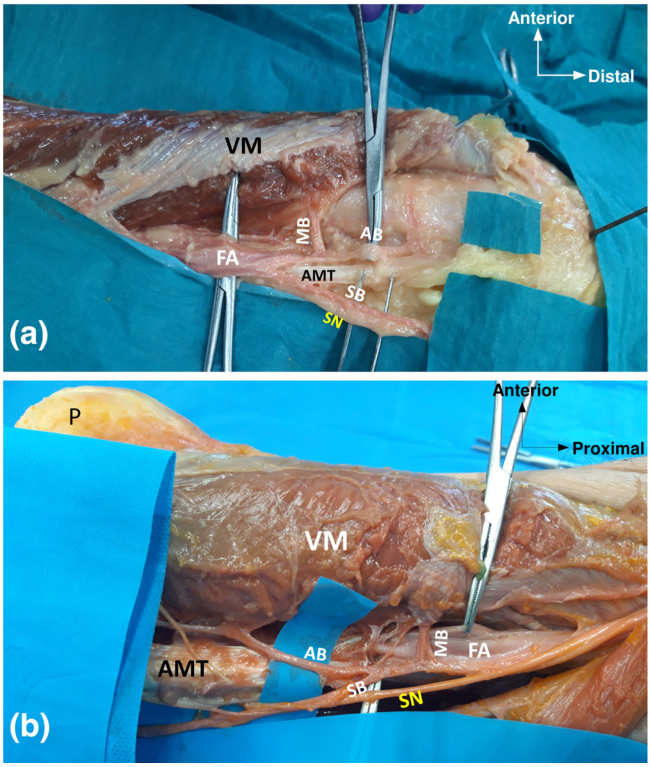

FIGURE 2 Type II branching patterns of descending genicular artery (DGA). (a) Type IIb. The saphenous branch (SB) originates directly from the femoral artery (FA). (b) Type IIc. The muscular branch (MB) originates directly from the FA. AB, the osteo-articular branch; AMT, adductor magnus tendon; P, patella; SN, saphenous nerve; VM, vastus medialis muscle [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Morphometric results

Distance measured (in mm)	Mean (*SD*)	Range
From the origin of the DGA to the medial femoro-tibial joint line	130.5 (17.5)	85–154
From the origin of the DGA to the periosteum of the MFC (maximum length of the pedicle)	96.7 (12.7)	62–120
From the origin of the DGA to its division	11.2 (8.0)	0–40
DGA external diameter	2.7 (1.1)	1.7–4.0
From the origin of the MB to the VM	14.5 (3.4)	10–21
From the origin of the SB to the medial femoro-tibial joint line	114.8 (13.8)	86–150
From the origin of the AB to the periosteum of the MFC	79.6 (10.2)	59–103
From the origin of the AB to its bifurcation	56.4 (11.6)	32–80
From the upper transverse artery to the femoro-tibial joint line	61.5 (5.8)	53–71
Distance from the connexion of the SMGN and its artery to the medial femoro-tibial joint line	64.2 (9.7)	44–79
Distance from the connexion of the IPBSN and its artery to the medial femoro-tibial joint line	36.6 (29.6)	17–97
Distance from the connexion of the SN and the SB branch of the DGA to the medial femoro-tibial joint line	102.3 (13.7)	69–125

Note: Data are presented as mean ± *SD* and range.
Abbreviations: AB, articular branch; DGA, descending genicular artery; IPBSN, infrapatellar branch of the saphenous nerve; MFC, medial femoral condyle; SB, saphenous branch; SMGN, superior-medial genicular nerve; SN, saphenous nerve; VM, vastus medialis muscle.

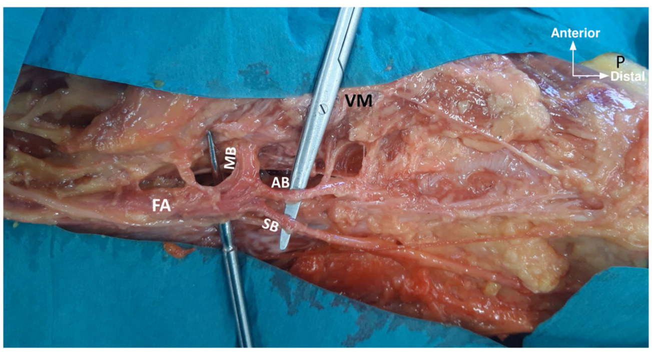

FIGURE 3 Type III branching patterns of descending genicular artery (DGA). The muscular branch (MB), saphenous branch (SB), and the osteo-articular branch (AB) originate separately from the femoral artery (FA). P, patella; VM, vastus medialis muscle [Color figure can be viewed at wileyonlinelibrary.com]

not reflected in the subgroups (a, b, c). For instance, Subtype IIc appears more frequently and has a clinically better branching pattern than Subtype IIa. Logically, Subtype IIc should have been the most challenging in Group II, but this was not actually the case. On the basis of our study and literature review, we propose a slight modification of the delineation of subgroups to improve consistency and gradation in this sound classification, thus improving its clinical relevance (Table 3, Figure 8).

For 10 years now, the SMGN has been one of the targeted nerves in GNB and RFA. However, controversies about the anatomical landmarks for accurate capture of this nerve persist, since a radiofrequency lesion has a very limited volume. As illustrations, two recent anatomical studies on the accuracy of ultrasound-guided RFA described two different landmarks for the SMGN (Vanneste, Tomlinson, Desmet, & Krol, 2019; Yasar et al., 2015), which sustains the confusion among pain physicians. Earlier authors described the SMGN running alongside the SMGA (a branch of the popliteal artery) at the junction between the MFC and the diaphysis (Choi et al., 2011; Gardner, 1948). This anatomical basis for the RFA technique has been used to date. A few recent anatomical studies suggested that the SMGN runs rather with the DGA, but were not more precise (Fonkoue, Behets, Kouassi, et al., 2019; Tran et al., 2018). To our knowledge, ours is the first anatomical description and illustration of this specific artery accompanying the SMGN.

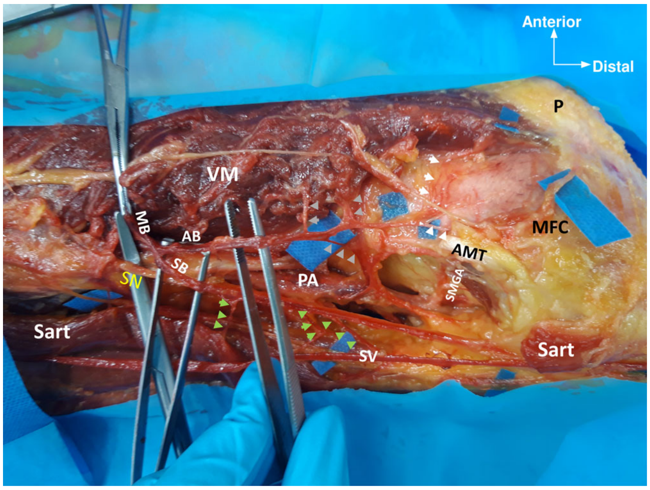

FIGURE 4 Distribution of the descending genicular artery (DGA) branches. The osteo-articular branch (AB) gives small anterior (muscular) and posterior (anastomosis with popliteal artery) collateral branches (gray arrowheads) and divides into its two terminal branches (white arrowheads). The saphenous branch (SB) joins the saphenous nerve (SN) and gives several (muscular and cutaneous) perforators (green arrowheads). The muscular branch (MB), strong and short, supplies the vastus medialis muscle (VM). AMT, adductor magnus tendon; MFC, medial femoral condyle; P, patella; PA, popliteal artery; Sart, sartorius muscle; SMGA, superior-medial genicular artery; SV, great saphenous vein [Color figure can be viewed at wileyonlinelibrary.com]

Moreover, the present study demonstrates that the vessels running on "the medial junction between epiphysis and diaphysis" correspond to the upper transverse artery of the medial condyle (transverse branch of the AB from the DGA), instead of the SMGA. Neither the trunk nor a branch of the SMGN was found alongside that upper transverse artery. The SMGA emerged from the popliteal artery and was found distally, at the level of the femoral epicondyle, running alongside the transverse terminal branch of the SMGN (Figure 9). Thus, during ultrasound-guided RFA, a lesion performed at "the midpoint of the medial junction between epiphysis and diaphysis" (Vanneste et al., 2019), therefore corresponding to the upper transverse arterial flow (and not the SMGA flow), would be likely to capture the upper transverse artery of the medial condyle but no nerve. A lesion performed distally at the level of the medial epicondyle, following the flow of the SMGA, would capture only the transverse branch of the SMGN. A lesion performed just in front or above the AT, targeting the flow of the artery of the SMGN, which descends on the anterior side of the AMT, would capture the trunk of the SMGN leading to inhibition of all its terminal branches. This seems to be the best target for capturing the trunk of the SMGN, thus ablating all its terminal branches. Although the anatomical description of the origin and course of the SMGN and its artery by Yasar et al. (2015) was not consistent with our findings, their proposed landmark for the SMGN during ultrasound-guided procedure appears relevant.

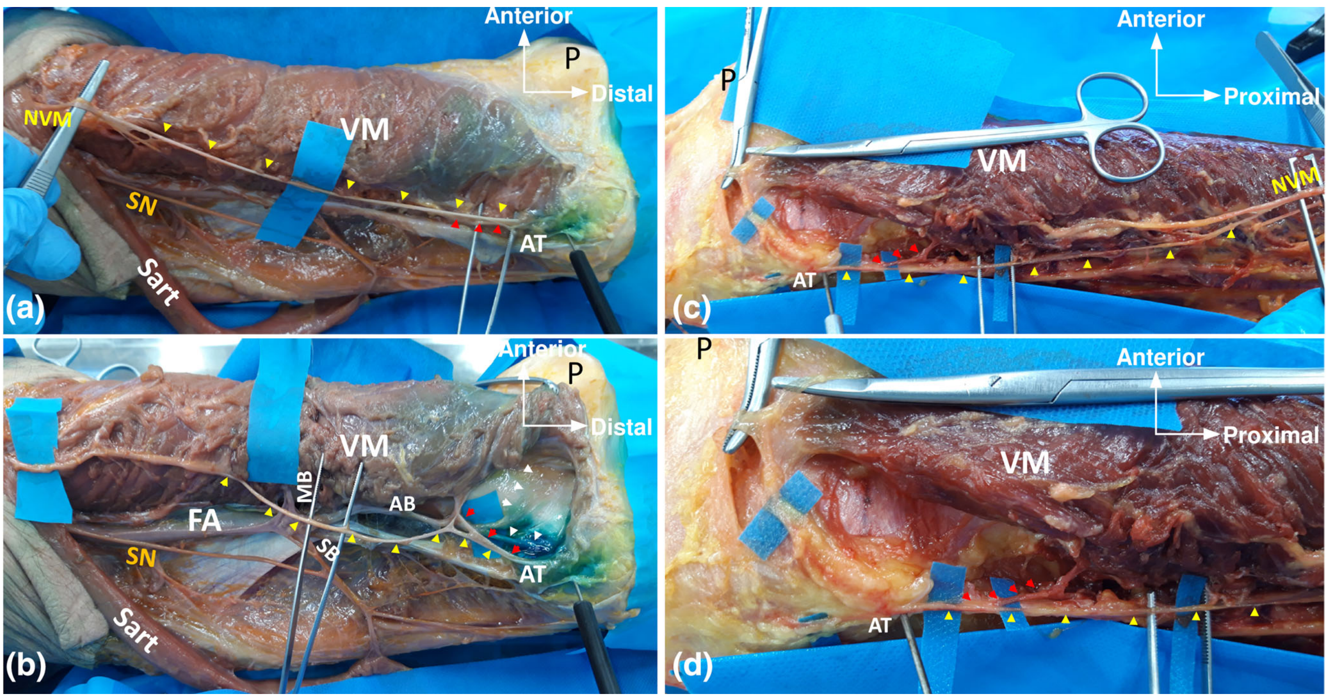

FIGURE 5 Descending genicular artery (DGA) and superior medial genicular nerve (SMGN) (a,b). The SMGN (yellow arrowheads), branching off the nerve to the vastus medialis (NVM), is joined on the adductor magnus tendon (AMT) by its artery (red arrowheads) from the osteo-articular branch (AB) of the DGA. Note the two terminal branches (white arrowheads) of the AB, which are not accompanied by nerves. (c,d) The SMGN (yellow arrowheads) and its artery (red arrowheads) from the AB of the DGA, running on the AMT and passing together in front of the adductor tubercle (AT). AT, adductor tubercle; FA, femoral artery; P, patella; Sa, sartorius; SB, saphenous branch; SN, saphenous nerve; VM, vastus medialis muscle [Color figure can be viewed at wileyonlinelibrary.com]

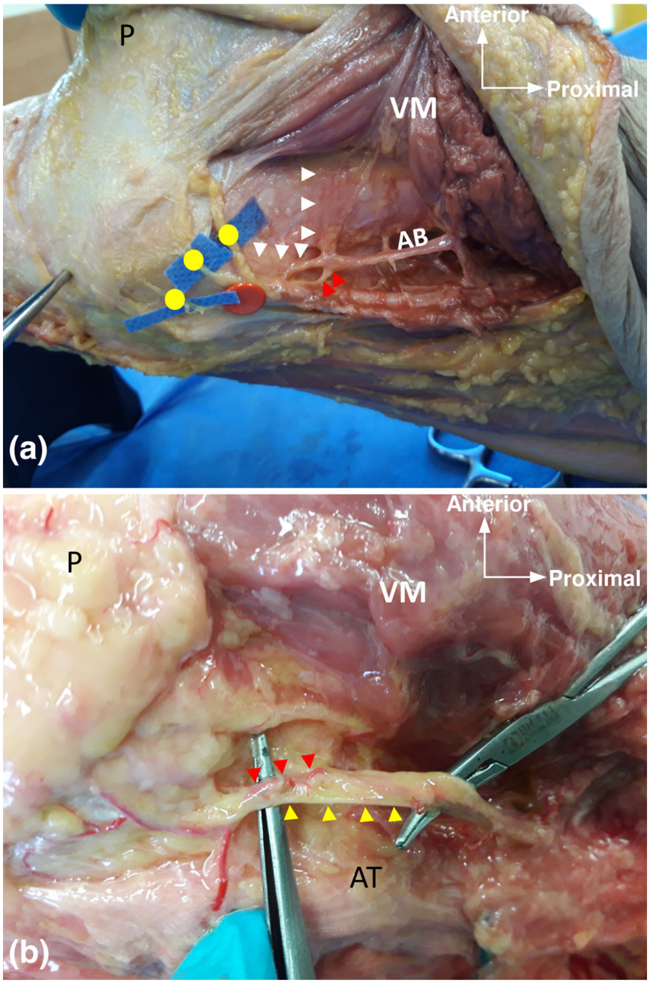

FIGURE 6 Artery of the superior medial genicular nerve (SMGN). (a) The artery of the SMGN (red arrowheads) originates from the osteo-articular branch (AB) of the descending genicular artery (DGA) just before its bifurcation (white arrowheads), and pierces the fascia to join the SMGN on the adductor magnus tendon. Only the distal branches (yellow points) of the SMGN are presented in this figure. (b) The SMGN (yellow arrowheads) and its artery (red arrowheads) descending together in the same sheath in front of the adductor tubercle (AT). AT, adductor tubercle; P, patella; VM, vastus medialis muscle [Color figure can be viewed at wileyonlinelibrary.com]

The IPBSN is important for innervating the inferior-medial aspect of the knee, including the joint capsule, skin, and subcutaneous tissue (Fonkoue, Behets, Kouassi, et al., 2019; Fonkoue, Behets, Steyaert, et al., 2019; le Corroller, Lagier, Pirro, & Champsaur, 2011). It is a very thin branch, the elective ablation of which is challenging and requires special skills. Despite the thinness of the nerve, some studies have shown that experienced radiologists could identify its course in the subsartorial canal with high resolution sonography and real-time imaging (Le Corroller et al., 2011; Orduna Valls et al., 2017). However, since it is assumed that GNB and RFA are performed by pain physicians in real-life practice, complementary landmarks such as the artery that accompanies the IPBSN could be relevant to improving the targeting of this nerve. In addition, the above-mentioned studies noted the difficulty of assessing the nerve in the inferior medial aspect of the knee owing to its small size and the hyperechoic subcutaneous fat (Le Corroller et al., 2011). However, in order to be safe, RFA of the IPBSN should not be performed in the subsartorial region but rather distally at the level of the knee. Tracing the blood flow that follows a trajectory similar to the subcutaneous arc-like theoretical course of the IPBSN at the inferior-medial aspect of the knee could improve its capture during ultrasound-guided RFA.

This study has some limitations. First, a larger sample size would have made it possible to identify more branching patterns and anatomical variations of the DGA. Second, since the small size of the arteries is an issue in clinical practice, our findings do not necessarily imply that these arteries running alongside the GN would be clearly differentiated during U.S.-guided interventions. However, this study shows that targeting the vessels running transversely at the junction of the epiphysis and the diaphysis, as is commonly done in clinical practice, would not capture the SMGN. This is a sure and relevant clinical implication of these findings, as it reinforces the need to revise the current targets. Moreover, the arteries described in this study could be clinically useful in improving the target for genicular artery embolization for medial knee pain (Bagla et al., 2020).

A proof-of-concept study is required to evaluate the feasibility and the ablation success rate for SMGN and IPBSN based on the anatomical course of their respective arteries described in this

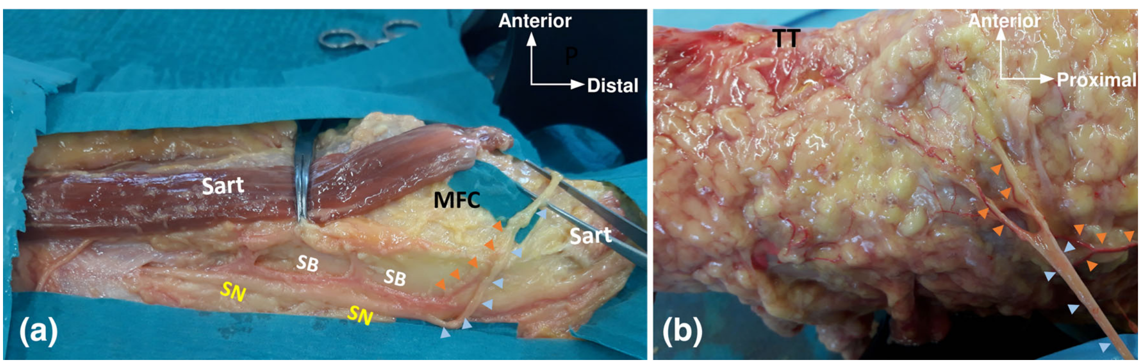

FIGURE 7 Saphenous branch of the descending genicular artery (DGA) and artery of the infrapatellar branch of the saphenous nerve (IPBSN). (a) (Medial view of a left knee): The saphenous branch (SB) of the DGA detaches a small artery (orange arrowheads) that joins the IPBSN (blue arrowheads). (b) (Anterior-medial view of a right knee): The IPBSN and its terminal branches (blue arrowheads) run together with the artery and its terminal branches (orange arrowheads) on the inferior-medial aspect of the knee joint. MFC, medial femoral condyle; Sart, sartorius muscle; SN, saphenous nerve; TT, tibial tuberosity [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Proposal for a slight modification of the Dubois et al. classification

Branching pattern	Description
Type I	The three branches emerge from a common trunk: The DGA
Ia	The DGA divides into the three terminal branches
Ib	The MB occurs first, leaving behind a sapheno-articular trunk
Ic	The SB occurs first, and leaving behind a musculo-articular trunk
Id	The AB occurs first, leaving behind a sapheno-muscular trunk
Type II	One of the three branches arises directly from the femoral artery
IIa	The MB originates directly from the FA
IIb	The SB originates directly from the FA
IIc	The AB arises directly from the FA
Type III	The three branches (SB, AB, and MB) arise separately from the FA

Abbreviations: AB, articular branch; DGA, descending genicular artery; FA, femoral artery; MB, muscular branch; SB, saphenous branch.

study. Further clinical studies are also expected to assess the effectiveness of these anatomical findings on the treatment of chronic knee pain.

5 | CONCLUSION

The DGA supplies three distal branches that run alongside the nerves at the medial side of the knee: the artery of the SMGN, the artery of the IPBSN and the SB of the DGA. According to this anatomical description, these arteries could serve as complementary landmarks for accurate capture of the corresponding nerves during ultrasound-guided interventions for regional anesthesia and pain control.

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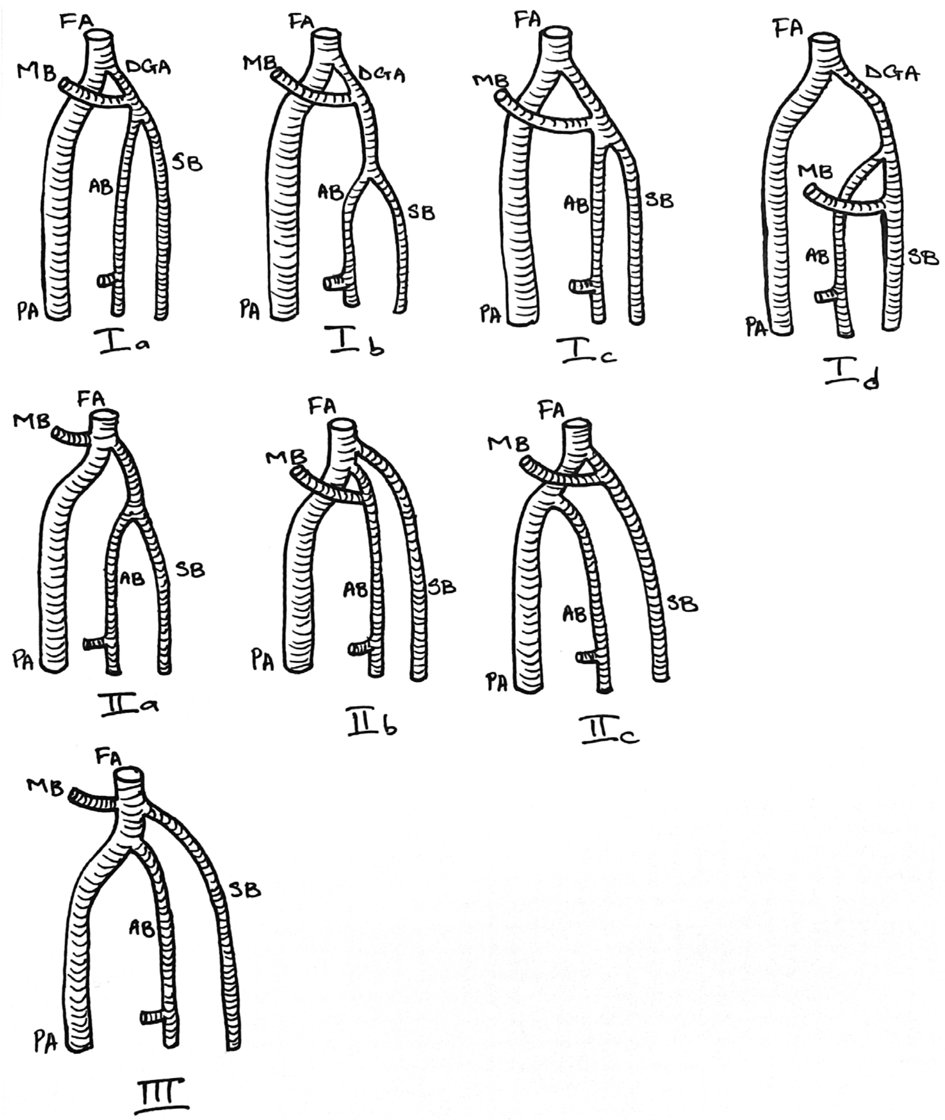

FIGURE 8 Diagram of distribution of the descending genicular artery (DGA) according to the proposed revision of the Dubois et al. classification. AB, osteo-articular branch; DGA, descending genicular artery; FA, femoral artery; MB, muscular branch; PA, popliteal artery; SB, saphenous branch

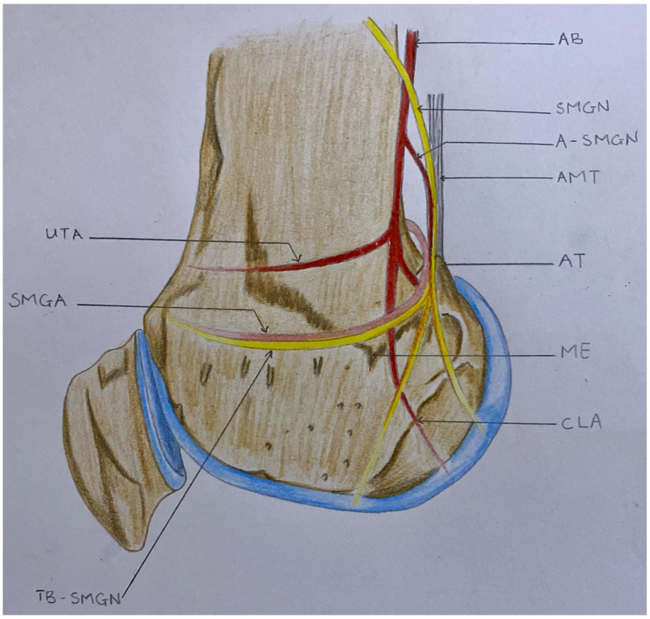

FIGURE 9 Diagram of the anatomical relationships of superior-medial genicular nerve (SMGN) and its terminal branches to the arteries in the superior medial aspect of the knee. The artery of the SMGN (A-SMGN) is detached from the trunk of the osteo-articular branch (AB) of the descending genicular artery (DGA), and descends with the SMGN on the adductor magnus tendon (AMT). The SMGA (from the popliteal artery) runs alongside the transverse terminal branch of the SMGN (TB-SMGN) at the level of the medial epicondyle. The upper transverse artery (UTA) runs on the junction of the medial femoral epiphysis and diaphysis, without a nerve branch. AT, adductor tubercle; CLA, central longitudinal artery; ME, medial femoral epicondyle; SMGN, superior-medial genicular nerve [Color figure can be viewed at wileyonlinelibrary.com]

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