Deep and superficial circumflex iliac arteries and their relationship to the ultrasound-guided femoral nerve block procedure - a cadaver study

Abstract

Background

The in-plane lateral to medial approach is a standard technique used for ultrasound-guided femoral nerve block (USG-FNB). The first bifurcation of the femoral artery, which consists of the deep artery of thigh (DAT), or occasionally the lateral circumflex femoral artery (LCFA), is considered as the distal border for this procedure. We sometimes detect arteries along the estimated needle trajectory for USG-FNB. The superficial circumflex iliac artery (SCIA) and deep circumflex iliac artery (DCIA) are known to run laterally parallel to the inguinal ligament from the femoral artery or external iliac artery.

Materials and Methods

Gross anatomical examination of 100 formalin-fixed adult cadavers around the femoral triangle region was performed to examine the relationship between the SCIA and DCIA and the other anatomical structures related to USG-FNB.

Results

At least one SCIA and one DCIA were identified around each femoral triangle. 81.8% of SCIA and 58% of DCIA originated from the femoral artery. All DCIA coursed between the fascia lata and fascia iliaca and 80% of SCIA penetrated the fascia lata. At least one arterial branch heading towards the lateral part of the thigh originated from the femoral artery from the level of inguinal ligament to the first bifurcation of the femoral artery in 94% of femoral triangles.

Conclusions

The presence of SCIA and DCIA should be considered during USG-FNB using the in-plane lateral to medial approach to avoid their inadvertent injury, as they are occasionally located along the presumed needle trajectory superficial to the fascia iliaca.

Key words

superficial circumflex iliac artery; deep circumflex iliac artery; femoral nerve block

Introduction

The needle in-plane, nerve in short-axis approach (Ilfeld et al., 2010) is one of the standard techniques employed for a single-injection (Kim et al., 2016; Taha and Abd-Elmaksoud, 2013) or continuous ultrasound-guided femoral nerve block (USG-FNB) (Mariano et al., 2013). The ultrasound probe is placed parallel to the inguinal ligament or inguinal crease (Gupta et al., 2013; Kim et al., 2015; Mariano et al., 2013; Moura et al., 2016; Taha and Abd-Elmaksoud, 2013) to visualize the short-axis views of the femoral nerve located underneath the fascia iliaca, and the femoral artery and vein located between the fascia iliaca and fascia lata (2012; Peng and Narouze, 2009). The first bifurcation of the femoral artery is considered as a sonoanatomical landmark of the distal border of the probe position during USG-FNB using the in-plane lateral to medial approach (Szucs et al., 2014).

Inadvertent vascular puncture and its related complications such as local anesthetic toxicity (Klein et al., 2003) or hematoma formation (Rodriguez et al., 2011; Wiegel et al., 2007) can occur during FNB. We occasionally identify arteries on the estimated needle trajectory in the groin region during the USG-FNB procedure (Fig. 1). The superficial circumflex iliac artery (SCIA) and deep circumflex iliac artery (DCIA) are considered to originate from the lateral aspect of the femoral artery and external iliac artery, respectively, and are known to run laterally to the ipsilateral anterior superior iliac spine (ASIS) along with the inguinal ligament (He et al., 2016; Neil and Jeremiah, 2008; Tremblay et al., 2016). Therefore, the SCIA or DCIA can be visualized and be inadvertently punctured during USG-FNB using the in-plane lateral to medial approach. However, the anatomical relevance of the SCIA and DCIA to USG-FNB has not been rigorously investigated. The goal of the present study was to examine the relationship of the SCIA and DCIA to the anatomical structures related to the USG-FNB procedure of the in-plane lateral to medial approach in the groin region employing formalin-fixed cadavers.

Materials and Methods

The present study was performed following approval from the Institutional Review Board and with written informed consent from the family of each cadaver donor. Gross anatomical examination of adult cadavers around the bilateral femoral triangle region, bounded superiorly by the inguinal ligament, medially by the lateral border of the adductor longus muscle, and laterally by the medial border of the sartorius muscle, was performed between April 2013 and December 2014. Femoral triangle regions subject to previous surgical procedures or extreme contracture of the hip joint were excluded from the present study.

Gross anatomical examination

Before removing the skin, the inguinal crease was identified and marked (Fig. 2). Careful dissection proceeded from the proximal portion of the inguinal ligament to the middle of the thigh. After the dissection, we identified the inguinal ligament, femoral nerve, femoral artery, femoral vein, deep artery of thigh (DAT), lateral circumflex femoral artery (LCFA), SCIA, DCIA, fascia lata, and fascia iliaca (Fig. 3). The SCIA and DCIA were followed to a point close to the ASIS and their relationship with the fascia iliaca and fascia lata was evaluated. Subsequently, the branching pattern of the femoral artery was examined by detecting the origin of the DAT, LCFA, SCIA, and DCIA. Dichotomous assessment of the configurations of the SCIA and DCIA (straight or winding) was undertaken (Fig. 3, 4). We measured the following: external diameters of the SCIA and DCIA at their origin; the distance from the point where the middle of the femoral artery crossed with the inguinal ligament to the origins of the DAT, LCFA, SCIA and DCIA; the distance from the middle of the femoral nerve crossed with the inguinal ligament to its first branch; the distance from the inguinal ligament to inguinal crease along with the femoral artery; the distance from the origin of the SCIA or DCIA to the point where they penetrated through the fascia lata when applicable (Fig. 3, 6). For all measurements, the inguinal ligament was defined as the line between centers of the ASIS and the ipsilateral pubic tubercle, because the inguinal ligament is not linear and has an inferior and an anterior convexity (Neil and Jeremiah, 2008). Each value was measured using a Mitutoyo Caliper with values accurate to 0.1 mm (Vernier Caliper; Mitutoyo, Kanagawa, Japan), by defining the direction from the inguinal ligament to the foot as positive.

Statistical Analysis

All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

A total of 130 femoral triangles derived from 65 formalin-fixed cadavers were employed in the present study. Twenty-five femoral triangles with severe hip contracture and five with previous surgical scars were excluded. Therefore, 100 femoral triangle regions (left side:right side = 50:50, male:female = 60:40) derived from 52 cadavers (31 males, 21 females) were examined (Table 1). As we considered that laterality had an insignificant effect on the result, measurement of left and right femoral triangles was analyzed without distinction. Thus, the data from left and right femoral triangles were combined for the entire analysis.

At least one SCIA and one DCIA were identified in each femoral triangle. Double SCIA were identified in ten femoral triangles; however, no multiple DCIA were identified. Within the ten femoral triangles (six left sided, four right sided) exhibiting double SCIA, each SCIA in a particular femoral triangle originated from the same artery; eight femoral arteries, one DAT and one DCIA. Double SCIA in bilateral femoral triangles were observed in one cadaver. 81.8% (90/110) of SCIA were from the femoral artery (He et al., 2016). 42% (42/100) of DCIA were from the external iliac artery and 58% (58/100) were from the femoral artery, (Table 2-1). 96.7% (87/90) of SCIA originating from the femoral artery were located between the origin of the femoral artery (at the level of the inguinal ligament) and its first bifurcation with the DAT or LCFA (Table 2-2). All DCIA originating from the femoral artery were located proximal to the first bifurcation of the femoral artery (Table 2-2). Thus, at least one arterial branch originated from the femoral artery and headed towards the lateral part of the thigh between the level of the inguinal ligament and the first bifurcation of the femoral artery in 94/100 (94%) femoral triangles. Overall, the DCIA located around the inguinal ligament and the SCIA were usually identified about 2 cm distal to the inguinal ligament (Table 3, Fig. 3, 4) (Tremblay et al., 2016). The external diameters of the SCIA and DCIA at their origin were approximately 2 and 3 mm, respectively (Table 2-3). All DCIA coursed between the fascia lata and fascia iliaca towards the ipsilateral ASIS in a straight configuration. On the other hand, 80% (88/110) of SCIA emerged through the fascia lata to its superficial part (Fig. 6) and 63.6% (70/110) of SCIA showed a winding configuration (Table 2-4, Fig. 3, 4). The distance from the origin of the SCIA to the point where it penetrated the fascia lata (median [range]) was 17.35 [3.4-53.3] mm (Fig. 6).

One DAT and one LCFA were identified in each femoral triangle. All DAT originated from the femoral artery at around 4 cm from the inguinal ligament (Table 3, Fig. 3, 5). The LCFA originated from the DAT (73%, 73/100) or the femoral artery (23%, 23/100) at around 5 cm from the inguinal ligament (Table 3, Fig. 3, 5). The origin of all DAT and LCFA originating from the femoral artery headed for the distal part of the leg and took the form of an acute angle with the femoral artery (Fig. 3, 5). The first bifurcation of the femoral artery was identified about 4 cm distal to the inguinal ligament (Table 3).

The inguinal crease was definitively identified in 95 of 100 femoral triangles approximately 5-6 cm distal to the inguinal ligament (Fig. 2, Table 3). In femoral triangles with an apparent inguinal crease, 78% (74/95) of first bifurcations were located proximal to the inguinal crease. The first branch of the femoral nerve was located about 3 cm distal to the inguinal ligament.

Discussion

The present study has revealed that more than 90% of the femoral artery, from its origin to its first bifurcation, comprised at least one branch (SCIA or DCIA) heading towards the ipsilateral ASIS or lateral part of the thigh and that this can interfere with needle advancement during USG-FNB. The DCIA with an external diameter of about 3 mm at its origin (Fredrickson et al., 1985; Shimizu et al., 2002; Taylor et al., 1979; Yaginuma et al., 2000) that locates around the inguinal ligament heading towards the ipsilateral ASIS in a straight configuration (Fig. 3), can be visualized during USG-FNB as a linear hypoechoic structure between the fascia iliaca and fascia lata using the in-plane lateral to medial approach. Because the space between the fascia lata and fascia iliaca is very small and is sometimes visualized as a homogenous hypoechoic structure, even without any vascular structure, color Doppler identification of blood flow may be necessary to detect any arterial structure (Fig. 1) and to avoid its inadvertent injury (Reid et al., 1999; Satija et al., 2012). Confirmation of continuity with the femoral artery can help identify the arterial structure (Fig. 1).

Likewise, the SCIA can also be visualized during USG-FNB using the in-plane lateral to medial approach because more than 90% of SCIA heading towards the lateral part of the thigh arose cephalad to the first bifurcation of the femoral artery. However, ultrasonographic identification of the SCIA may be difficult because of its smaller external diameter (about 2 mm) (Sinna et al., 2010) than that of the DCIA and its tendency to exhibit a winding configuration (Tremblay et al., 2016). When we find multiple discontinuous hypoechoic structures between the fascia iliaca and fascia lata, or superficial to the fascia lata (Fig. 6), these can represent the SCIA exhibiting a winding configuration (Fig. 4). On this occasion, continuous needle tip visualization throughout needle advancement may have increasing importance (Sites et al., 2007) in avoiding inadvertent injury of the SCIA outside the ultrasound beam that can cause hematoma formation (Hagiwara et al., 2005) during the USG-FNB procedure. As the DCIA and SCIA did not run deep into the fascia iliaca, the risk of inadvertent vascular puncture may have become lower during USG-FNB once the needle tip reached below the fascia iliaca.

A previous study reported that the presence of the LCFA originating from the DAT or femoral artery (Neil and Jeremiah, 2008) should be considered to avoid its inadvertent puncture during nerve stimulator-guided FNB (Orebaugh, 2006). The DAT or LCFA forming the first bifurcation with the femoral artery coursed inferiorly and almost parallel to the femoral artery at their initial points (Fig. 3, 5). The bifurcation is then depicted on the ultrasound image as dual round structures medial to the femoral nerve. When the appropriate probe position for USG-FNB is determined around the inguinal ligament or inguinal crease by finding the femoral artery visualized as a “sole round pulsating structure” on the ultrasound image, the DAT or LFCA can be regarded as a structure allowing determination of the proper probe positon for USG-FNB, but not be a candidate for inadvertent puncture during USG-FNB (Szucs et al., 2014). If USG-FNB is performed using the longitudinal in-plane approach at the femoral triangle where the LCFA or DAT can be visualized (Ilfeld et al., 2010; Koscielniak-Nielsen et al., 2008; Mariano et al., 2013; Wang et al., 2010), the courses of the DAT or LCFA may need to be monitored to avoid their inadvertent puncture.

A limitation of the present study is that the data presented here were derived from formalin-fixed cadavers only. Each measurement may have been affected by the preservation status of each cadaver. However, the relative position of each structure was maintained. For example, more than half of DCIA clearly originated distal to the inguinal ligament in the present study and their presence should be considered during the USG-FNB performed around the inguinal ligament. The accurate identification, detection rate, and visualization pattern of the arterial branch from the femoral artery superficial to the femoral nerve around the inguinal ligament on the ultrasound image needs to be warranted by future study using Thiel's embalmed; these are appropriate for ultrasound examination (Benkhadra et al., 2012; Desroches et al., 2013; Munirama et al., 2016).

In conclusion, the presence of DCIA and SCIA should be considered during USG-FNB using the in-plane lateral to medial approach to avoid their inadvertent injury, as they are occasionally located along the presumed needle trajectory superficial to the fascia iliaca.

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Legends

Figure 1.

(A) Transverse ultrasound image in the groin area for ultrasound-guided femoral nerve block using the in-plane lateral to medial approach. The femoral nerve (FN) is visualized lateral to a hypoechoic round femoral artery (FA). A hypoechoic linear structure (*) is located between the fascia lata (FL) and fascia iliaca (FI). (B) Colour Doppler can help identify the hypoechoic linear structure (*) between the FL and FI as a branch from FA.

Figure 2

Pictorial depiction of the skin surface of right groin region of one of the cadavers studied. Arrowheads indicate the inguinal crease. ASIS = anterior superior iliac spine; PT = pubic tubercle.

Figure 3

Right (A) and left (B) femoral triangle of cadavers studied. The blue string between the right anterior superior iliac spine (ASIS) and the ipsilateral pubic tubercle (PT) indicates the inguinal ligament. Branches from the femoral artery tied with a green and a red string represent the deep circumflex iliac artery (DCIA) and the superficial circumflex iliac artery (SCIA), respectively. The configurations of all DCIA and SCIA were judged as straight. Pins with pink pinheads indicate bifurcation of the femoral artery (FA) and deep artery of thigh (DAT) or bifurcation of the DAT and the lateral circumflex femoral artery (LCFA). A pin with a yellow pinhead indicates the first branch from the femoral nerve (FN). A pin with a white pinhead (*) placed on SCIA indicates the point where SCIA emerged through the fascia lata in the direction from deep to superficial layer. FV indicates the femoral vein. Fascia lata and fascia iliaca have been removed.

Figure 4

Superficial circumflex iliac artery (SCIA) with winding configuration. Two branches with red strings indicate the SCIA originating from the deep circumflex iliac artery. FA = femoral artery; FN = femoral nerve.

Figure 5

The lateral circumflex femoral artery (LCFA) originating from the femoral artery (FA). The deep artery of thigh (DAT) originating peripheral to the LCFA-FA bifurcation (pink pinheads with asterisk), which is hidden behind the FA in this photograph.

Figure 6

The superficial circumflex iliac artery (black arrows) emerging through the fascia lata (indicated by the asterisk) between the inguinal crease (white arrowheads) and the inguinal ligament, estimated as a line between the anterior superior iliac spine (ASIS) and the pubic tubercle (PT) in the right femoral triangle.

Tables

Table 1

Demographic characteristics of femoral triangles investigated in the present study.

Laterality/Gender	Male	Female	Total
Left	30	20	50
Right	30	20	50
Total	60	40	100

Data are n

Table 2-1

Characteristics of the superficial circumflex iliac artery (SCIA) and deep circumflex iliac artery (DCIA). DAT, Deep artery of thigh; LCFA, lateral circumflex femoral artery

Origin	SCIA	DCIA
External iliac artery	0 [0%] (0)	42 [42%]
Femoral artery	90 [81.8%] (8)	58 [58%]
DAT	5 [4.5%] (1)	0
LCFA	4 [3.6%] (0)	0
DCIA	11 [10.0%] (1)	-
Total	110 (10)	100

Data are n [%] (number of femoral triangles with double SCIA)

Table 2-2

Relationship between the origins of superficial circumflex iliac artery (SCIA) and deep circumflex iliac artery (DCIA) originating from the femoral artery and the first bifurcation of the femoral artery

Origin	SCIA	DCIA
Proximal to the first bifurcation	87 [96.7] (79)	58 [100]
Distal to the first bifurcation	3 [3.3] (3)	0 [0]
Total	90	58

Data are n [%] (number of femoral triangles)

Table 2-3

Diameters of superficial circumflex iliac artery (SCIA) and deep circumflex iliac artery (DCIA) at their origin

Artery	Male	Female	Total
SCIA (n = 110)	2.18 ± 0.45 (65)	1.96 ± 0.47 (45)	2.06 ± 0.50
DCIA (n = 100)	3.30 ± 0.70 (60)	3.0 ± 0.66 (40)	3.18 ± 0.69

Data are mm, mean ± SD, and (n)

Table 2-4

Pathway and configuration of superficial circumflex iliac artery (SCIA) and deep circumflex iliac artery (DCIA)

Pathway and configuration	SCIA	DCIA
Between the fascia lata and fascia iliaca throughout the pathway		
Straight	7 (6.3)	100 (100)
Winding	15 (13.6)	0 (0)
Between the fascia lata and fascia iliaca, and then emerging through the fascia lata		
Straight	33 (30)	0 (0)
Winding	55 (50)	0 (0)

Data are n (%)

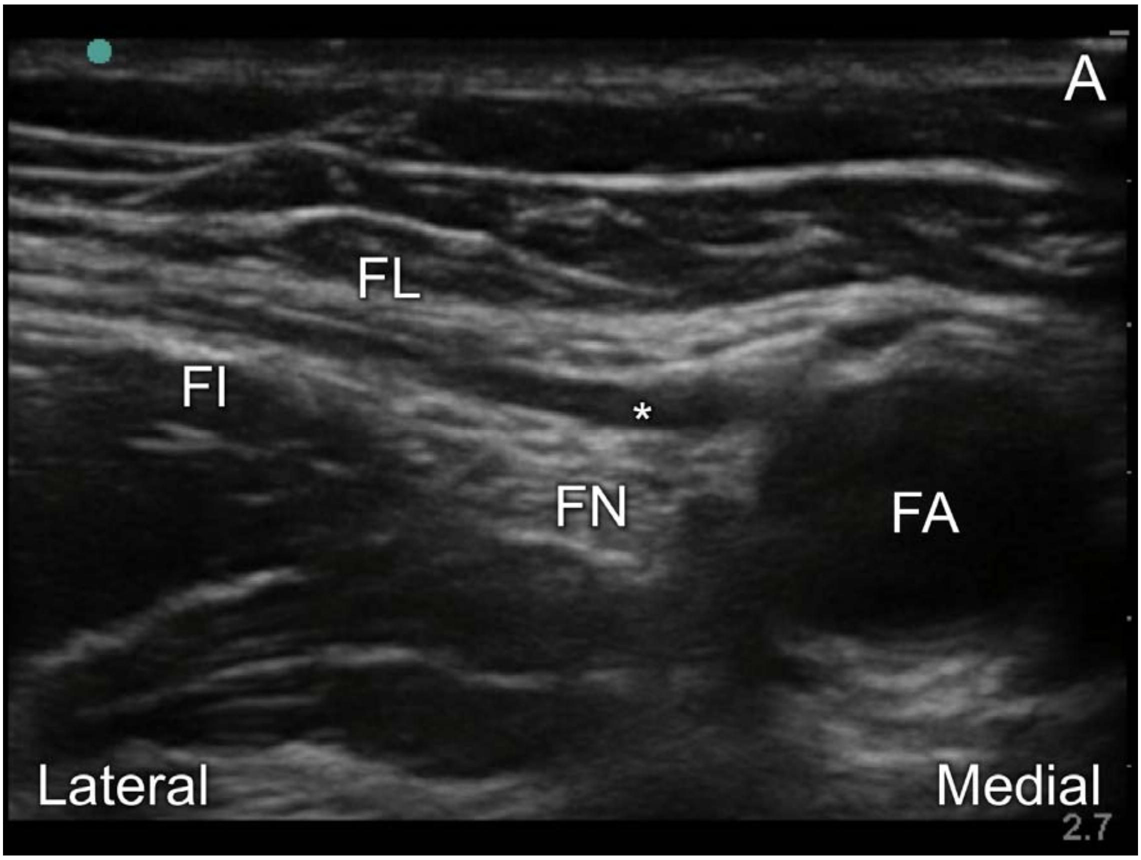
Table 3

Distance from the inguinal ligament to each structure within the femoral triangle. The direction from the inguinal ligament to the foot is positive. DCIA, deep circumflex iliac artery; SCIA, superficial circumflex iliac artery; DAT, deep artery of thigh; LCFA, lateral circumflex femoral artery

Structure	Male	Female	Total
DCIA	0.31 ± 7.50	-1.06 ± 7.97	-0.24 ± 7.68
SCIA	20.22 ± 10.71	19.22 ± 13.44	19.81 ± 11.85
First branch of the femoral nerve	32.73 ± 6.47	30.92 ± 9.42	32.00 ± 7.79
DAT	47.32 ± 11.12	37.07 ± 14.02	43.22 ± 13.29
First bifurcation of the femoral artery	45.99 ± 11.78	35.95 ± 13.82	41.98 ± 13.51
LCFA	58.60 ± 12.86	50.19 ± 14.30	55.24 ± 14.01
Inguinal crease	55.77 ± 10.49	51.48 ± 10.31	53.96 ± 10.35

Data are mean ± SD [mm]

Figure 1. (A)



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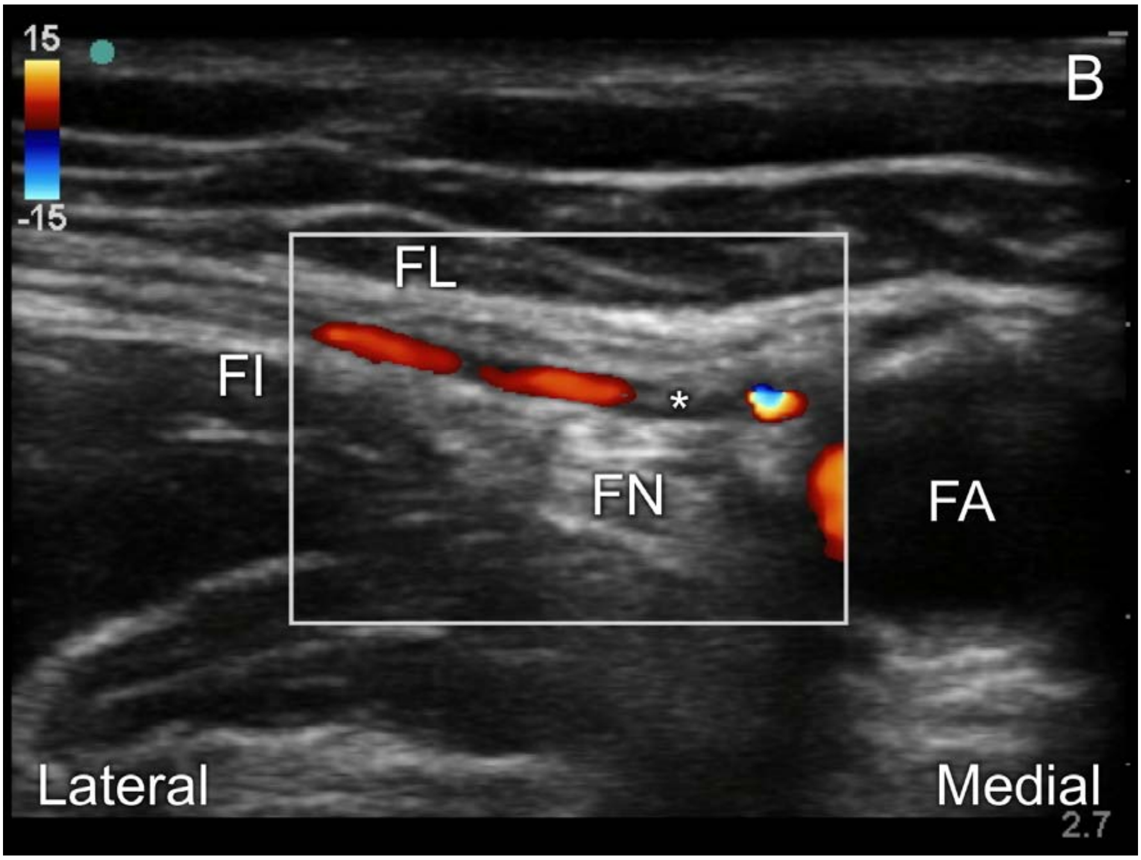

Figure 2

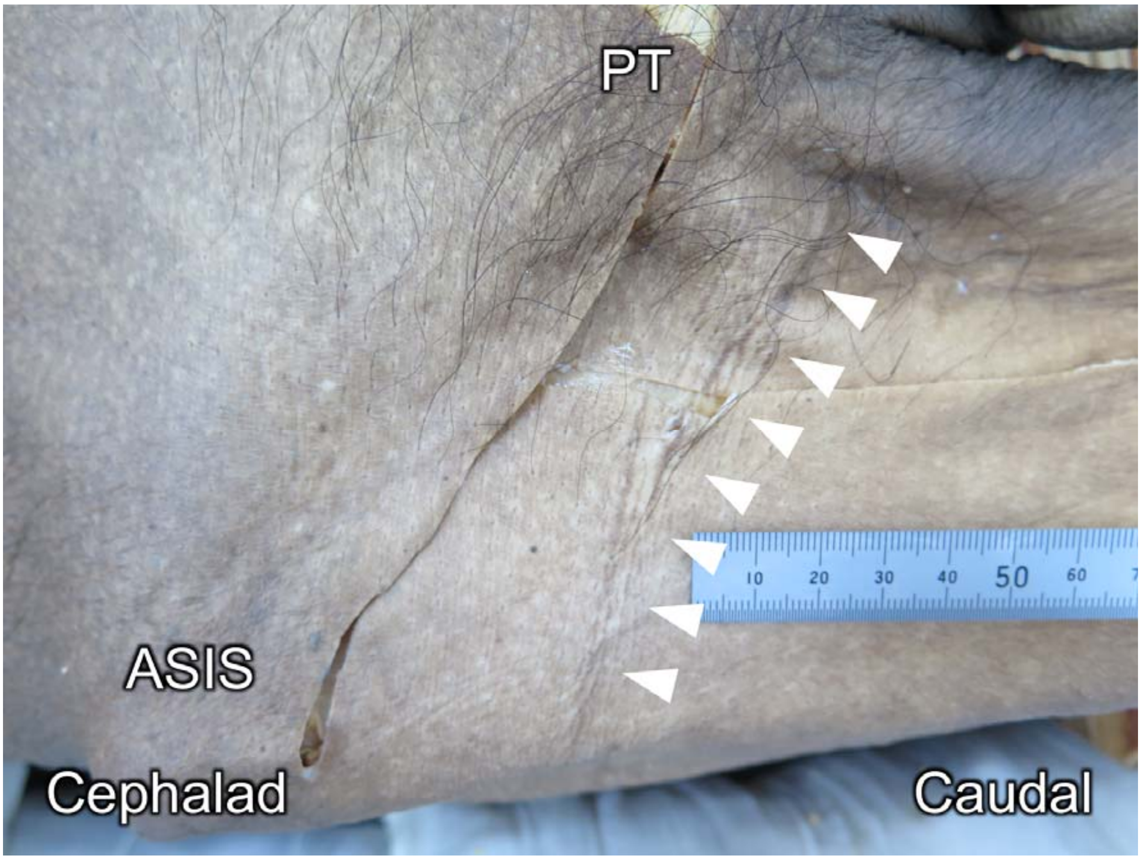

Figure 3. (A)

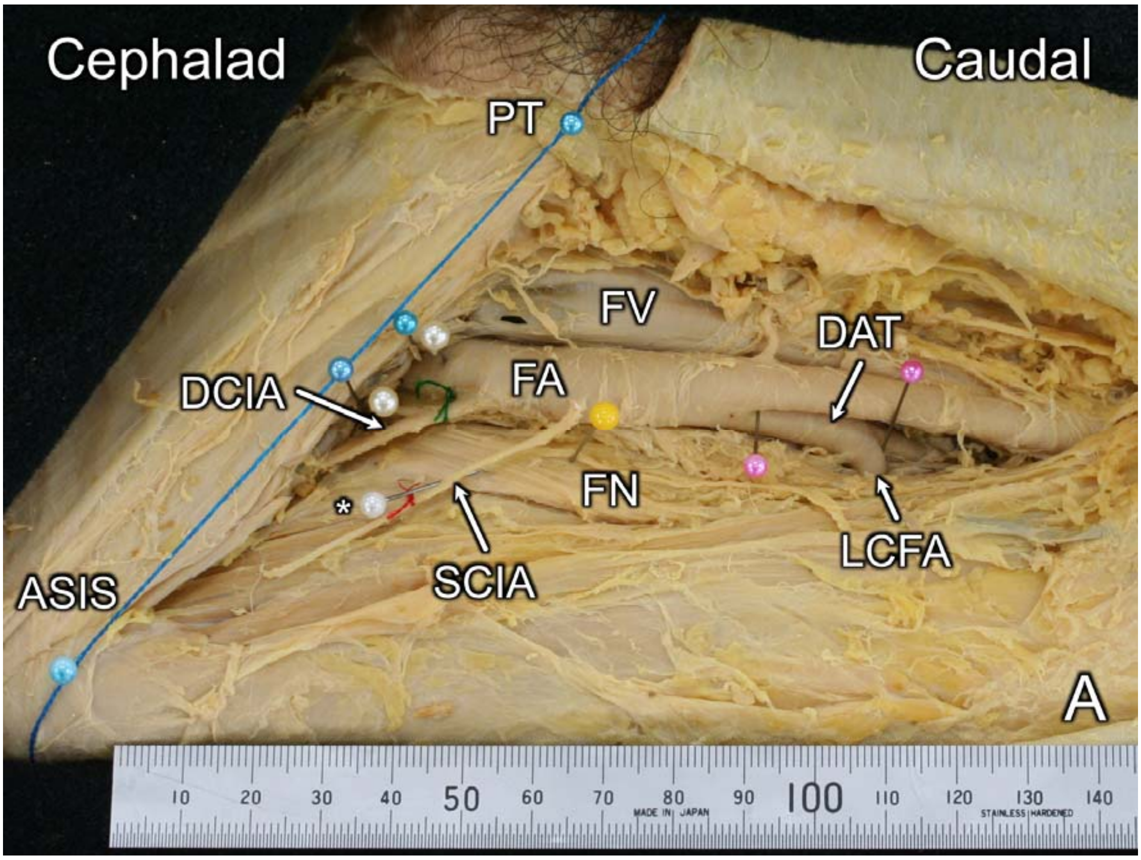
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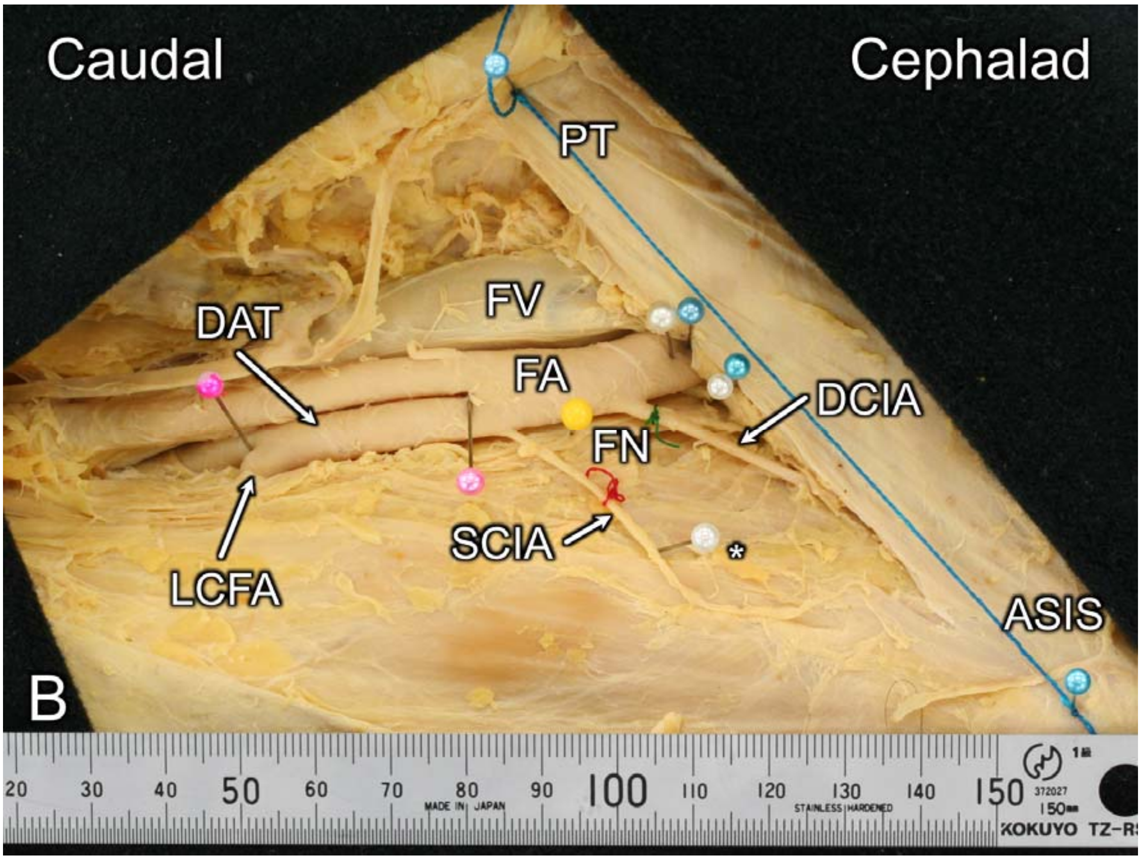
Figure 3. (B)



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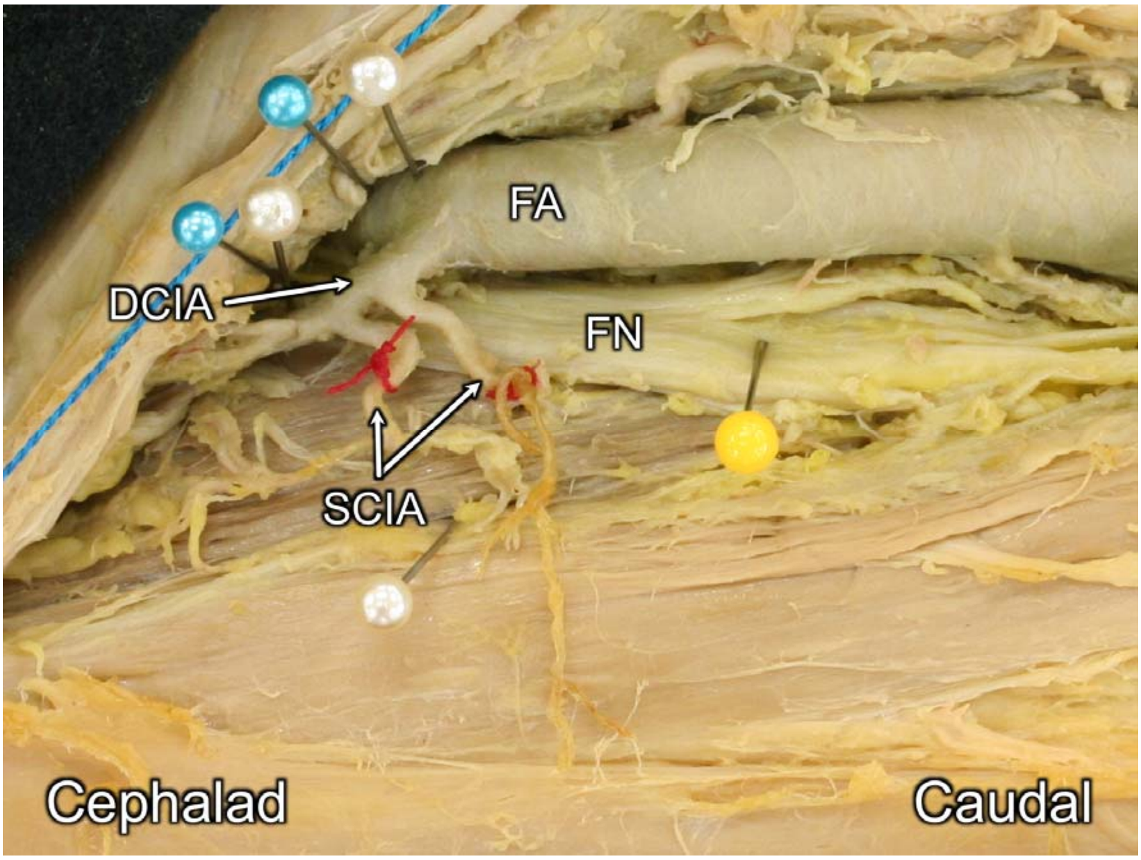

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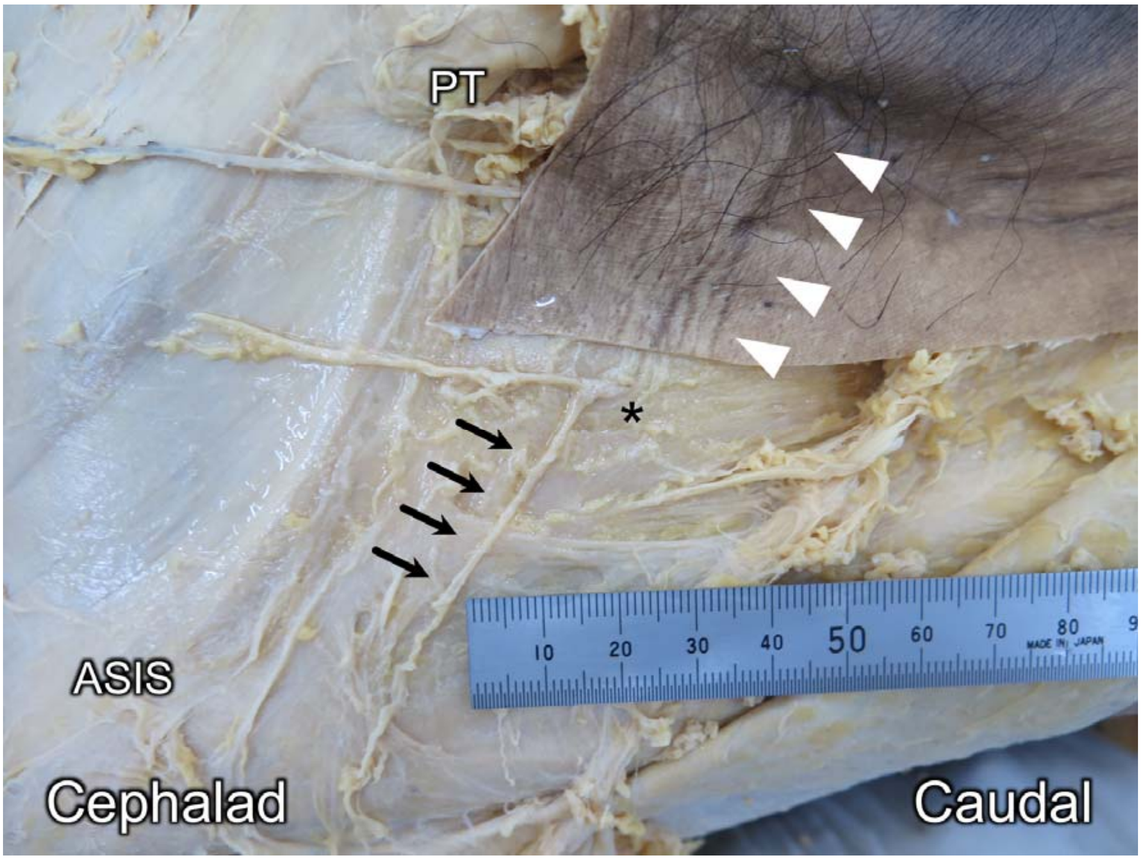
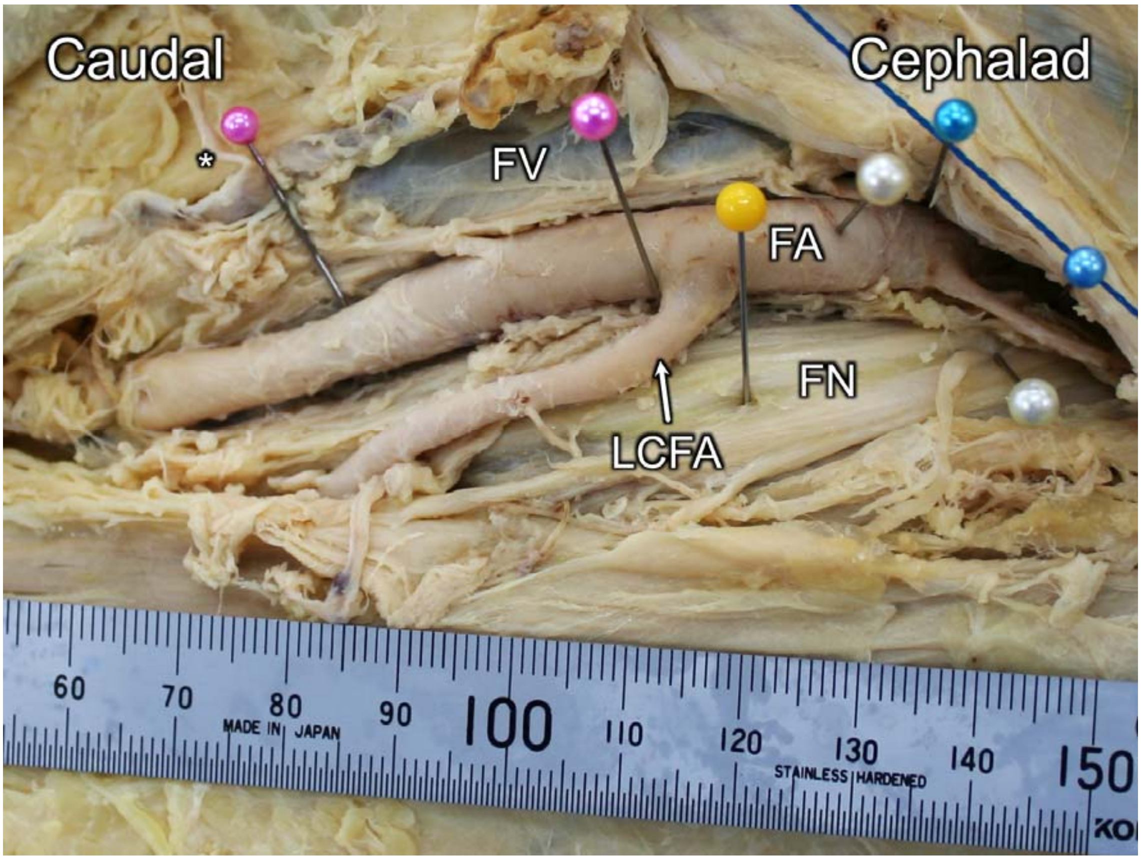


Figure 6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