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# Arterial endofibrosis in endurance athletes: prospective comparison of the diagnostic accuracy of intra-arterial digital subtraction angiography and computed tomography angiography

Short title :

## Diagnosis of arterial endofibrosis using computed tomography

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## Abstract

**Purpose:** To prospectively compare the diagnostic capabilities of computed tomography angiography (CTA) and digital subtraction angiography (DSA) findings in endurance athletes with suspicion of arterial endofibrosis

**Materials and methods:** Forty-five athletes (39 men, 6 women; median age: 30 years, interquartile range: 23-42 years) prospectively underwent DSA and CTA without (n=5) or with (n=40) electrocardiogram gating. DSA was interpreted by a single expert (experience of 15 years). CTA was independently interpreted by three other readers (experience of 5-8 years). Readers assessed the presence and degree of stenoses on iliac and femoral arteries and the overall diagnosis (negative, uncertain, positive) of endofibrosis at the limb level. Sensitivities and specificities of DSA and CTA were estimated at the limb level using histological findings and long-term follow-up as reference, and compared using the McNemar test.

**Results:** For diagnosing and quantifying stenoses, concordance between DSA and CTA was moderate-to-good for common and external iliac arteries, moderate for lateral circumflex arteries and poor-to-moderate for the other branches of the deep femoral artery. It was good for all readers for the overall diagnosis of endofibrosis. After long-term follow-up (median, 95 months; interquartile range: 7-109), DSA sensitivity and specificity were respectively 88.6% (39/44; 95% confidence interval [95%CI]: 76-95%) and 75% (24/32; 95%CI: 57.9-86.7%); CTA sensitivity and specificity were respectively 88.6% (39/44; 95%CI: 76-95%;  $P > 0.99$ ) and 84.4% (27/32; 95%CI: 68.2-93.1%;  $P = 0.51$ ), 86.3% (38/44; 95%CI: 73.3-93.6%;  $P > 0.99$ ) and 75% (24/32; 95%CI: 57.9-86.7%;  $P > 0.99$ ), and 84.1% (37/44; 95%CI: 70.6-92.1%;  $P = 0.68$ ) and 75% (24/32; 95%CI: 57.9-86.7%;  $P > 0.99$ ) for the three readers.

**Conclusion:** CTA showed similar performances than DSA in predicting the long-term diagnosis of endofibrosis in endurance athletes with suggestive symptoms.

**Keywords:** Computed tomography angiography; Digital subtraction angiography; Iliac arteries; Athletes; Athletic injuries.

## List of Abbreviations

ABPI: ankle-brachial pressure index

CCC: coefficient of correlation concordance

CI: confidence interval

CIA: common iliac artery

CTA: computed tomography angiography

DAP: dose area product

DSA: digital subtraction angiography

DLP: dose length product

ECG: electrocardiogram

EIA: external iliac artery

IQR: interquartile ranges

LCA: lateral circumflex artery

SD: standard deviation

## **Introduction**

Arterial endofibrosis affects endurance athletes, mostly cyclists and long-distance runners. It is characterized by arterial stenoses due to intimal thickening made of loose connective tissue usually occurring in the first centimeters of the external iliac artery (EIA) [1-8]. However, the common iliac artery (CIA), the lateral circumflex artery (LCA) or the other branches of the deep femoral artery can also be affected [4, 7]. Typically, symptoms include claudication at maximum effort with thigh pain and sensation of leg weakness that spontaneously resolve within minutes of cessation of exercise. In iliac arteries, the main pathogenic factor seems vascular shear stress due to repeated arterial kinking that may be aggravated by the excessive length of iliac arteries in endurance athletes [9] and by the fixation of the iliac artery by muscular branches to the psoas [4, 6]. However, other factors such as increased cardiac output may play a role, since stenoses can also affect non-mobile arterial segments such as the deep femoral artery.

The measure of the ankle-brachial pressure index (ABPI) at rest and within one minute after ceasing maximal exercise remains the first diagnostic examination in patients with suspicion of endofibrosis [8]. An ABPI <0.4-0.6 at cessation of exercise is highly suggestive of endofibrosis of the iliac artery, but does not rule out a lesion of the deep femoral artery [8, 10-13]. Doppler ultrasound can show elevated peak systolic and end-diastolic velocities after

exercise in the affected arteries [14-16]. However, it is user-dependent and its sensitivity decreases in patients with less marked symptoms [6, 10, 14]. Arterial endofibrosis can affect several arteries at the same time, as shown by the recent so-called Common-External-Femoral (CEF) classification that describes patterns of lesion associations [7]. As a result, intra-arterial digital subtraction angiography (DSA) remains the reference test for diagnosing endofibrosis [4]. Indeed, it can altogether confirm the diagnosis and assess the location and length of all lesions, thereby allowing optimal surgical planning. However, DSA remains an invasive and expensive procedure. Detection of endofibrosis by computed tomography angiography (CTA) has been reported [17], but CTA performance in diagnosing arterial endofibrosis has never been assessed.

The purpose of this pilot study was to prospectively compare the diagnostic capabilities of CTA and DSA findings in endurance athletes with suspicion of arterial endofibrosis.

## **Patients and methods**

### *Study population*

All consecutive endurance athletes referred to the department of vascular surgery of our institution between April 30, 2008 and June 12, 2012 for suspicion of arterial endofibrosis were asked to participate to this prospective study. Exclusion criteria were age <18 years, pregnancy and contraindications to intravenous administration of iodinated contrast material. The study protocol was approved by our Ethics Committee and all patients provided written informed consent. Because there was no preliminary data on the accuracy of CTA in diagnosing endofibrosis, no reliable calculation of the optimum sample size could be made for this pilot study. Forty-five patients were planned to be included. This number was pragmatic and based on an estimated period of inclusion of three years.

### *CTA protocols*

CTA was performed on a 32-section Lightspeed-Pro<sup>®</sup> multidetector scanner (GE Healthcare), from two centimeters above the aortic bifurcation to mid-thigh, after intravenous administration of 100 mL of iodixanol (Visipaque<sup>®</sup> 320; GE Healthcare) at a rate of 3 mL/sec.

## **Initial evaluation**

The first five patients underwent CTA without electrocardiogram (ECG) gating using  $32 \times 1.25$  mm detector configuration, 100 kV energy setting, tube current modulated between 190 and 609 mAs (noise index: 21.45), 1.38 pitch, 0.35 sec gantry rotation time, 1.25 mm slice thickness and 0.8 mm reconstruction increment.

An evaluation of motion artifacts of the iliac arteries was planned after inclusion of five patients. If substantial blurring was found in at least two patients, a switch to an ECG-gated acquisition was to be used in the rest of the patients. Image analysis was performed by a radiologist with more than 15 years of experience in endofibrosis imaging (O.R.). Substantial blurring of EIAs due to motion artifacts was found in two patients (Figs 1-2). This prompted the use of ECG gating in the 40 subsequent patients, as per protocol.

## **ECG-gated CTA**

A prospective step-and-shoot ECG-gated acquisition was performed only in diastole (70-80% of the RR interval) using  $32 \times 1.25$  mm detector configuration, 100 kV energy setting, 597-609 mAs tube current, 0.16 - 0.22 pitch, 0.4 sec gantry rotation time, 1.25 mm slice thickness and 0.8 mm reconstruction increment.

## ***DSA procedure***

A femoral Seldinger approach contralateral to the symptoms was performed under local anesthesia. Angiograms of iliac arteries were obtained in anteroposterior and right and left anterior oblique projections through a 5-F catheter positioned above the aortic bifurcation. The CIA of the symptomatic limb was catheterized and selective angiograms of the iliac artery were obtained using contralateral anterior oblique projection with a straight hip and with maximal hip flexion. Then, selective angiograms of the deep femoral artery of the symptomatic and asymptomatic limb were performed [7]. Two to three frames were obtained per second, using 80.1 Kv energy setting and 47.9 mAs tube current for pelvic acquisitions, and 70.7 kV energy setting and 65.5 mAs tube current for femoral acquisitions.

## ***Image analysis***

DSA was interpreted by a radiologist with more than 15 years of experience in endofibrosis imaging (O.R.). CTA was interpreted by three readers with six (reader 1, R.B.), eight (reader 2, N.G.) and five years (reader 3, M.P.) of experience in endofibrosis imaging.

CTA readers could perform reformations whenever needed, using an Advantage Windows workstation (GE Healthcare). DSA and CTA readers knew that patients had clinical suspicion of endofibrosis, but they were blinded to the type and severity of symptoms and to the ABPI results. CTA readers were also blinded to the laterality of symptoms while the DSA reader could not (Seldinger approach contralateral to the symptoms). CTA readers analyzed CT images independently and were blinded to each other's interpretation. No attempt at reaching a consensus was made in case of discrepant findings.

First, readers scored image quality (0: marked artifacts hindering the diagnosis; 1: moderate artifacts with diagnosis still possible; and 2: good image quality) in four arterial segments (CIA, EIA, LCA and other branches of the deep femoral artery). They assessed, for each arterial segment, the presence of a stenosis and its degree (< 10%, 11 - 50%, > 50%), and, for each limb, the CEF categories [7] and the overall assessment of endofibrosis (positive, uncertain, negative).

### *Assessment of the radiation dose*

For CTA, the volume computed tomography dose index and the dose length product (DLP) were recorded. The effective dose was calculated using CTE<sub>expo</sub> v2.3 (SASCRAD, Buchholz, Germany) and a conversion coefficient of 0.015 mSv/mGy.cm [18]. For DSA studies, the fluoroscopy time and the dose area product (DAP) were recorded. The effective dose was evaluated using a conversion coefficient of 0.11 mSv/Gy.cm<sup>2</sup> [19].

### *Final long-term diagnosis*

Long-term follow-up was used to assess the final diagnosis at the limb level. The diagnosis of endofibrosis was considered certain in case of surgery with histological confirmation. It was considered likely in symptomatic limbs that were not operated but kept typical symptoms during the follow-up period with no other disease diagnosed as the cause of symptoms, or in asymptomatic limbs that became symptomatic during follow-up, with onset of typical pain, but were not operated. The diagnosis was considered unlikely in cases of apparition of atypical symptoms during the follow-up period. Endofibrosis was ruled out if symptoms disappeared spontaneously or after treatment of another condition (*e.g.*, spine intervention or change of cycling position) or in limbs that remained asymptomatic throughout the follow-up period. Limbs that were not operated and that were followed-up for less than a year were excluded from long-term analysis.

## *Statistical analysis*

Quantitative variables were expressed as medians and interquartile ranges (IQR). Qualitative variables were expressed as raw numbers, proportions and percentages for each category. Agreement between CTA and DSA findings was estimated with coefficient of correlation concordance (CCC; Agreement package of the R statistical software, version 0.8-1; <https://CRAN.R-project.org/package=Agreement>). The 95% confidence intervals (95% CIs) of CCCs were built using a bootstrap method. Concordance was classified as poor, weak, moderate, good and excellent for CCC values of 0.20 or less, 0.21-0.40, 0.41-0.60, 0.61-0.80 and more than 0.80, respectively. DSA and CTA sensitivity and specificity were estimated at the limb level using the final long-term diagnosis as reference. For this, uncertain and positive findings at imaging were considered positive. When the final diagnosis was certain or likely, the limb was considered as having the disease. When the final diagnosis was unlikely or ruled out, the limb was considered as free of the disease.

The presence and degree of stenosis were not assessed in arterial segments with image quality score of 0 and these segments were excluded from concordance analysis. However, readers had to assess the presence of endofibrosis (positive, uncertain, negative) in all limbs, whatever the image quality. Therefore, arterial segments or limbs with inadequate image quality were not excluded from the calculation of CTA and DSA sensitivities and specificities.

Differences in sensitivities and specificities were assessed using the McNemar test. 95% CIs for sensitivity and specificity were built using the Wilson method. A *P* value < 0.05 was considered to indicate statistical significance.

## **Results**

### *Study population*

Forty-five athletes were included. There were 39 men and 6 women with a median age of 30 years (IQR: 23-42 years; Table 1). Symptoms involved the left limb in 30/45 patients (67%; 28 men, 2 women), the right limb in 12/45 patients (27%; 9 men, 3 women) and were bilateral in 3/45 patients (6%; 2 men, 1 woman). The exercise test results were missing in 6 limbs. In the others, it was positive (ABPI < 0.5) in 32 limbs, unclear (ABPI between 0.5 and 0.7) in 4 limbs and negative (ABPI > 0.7) in 48 limbs. All patients underwent CTA and DSA within one week. No adverse event occurred during these examinations.



### *Image quality*

In total, 360 arterial segments were studied. On DSA images, 10 (2.8%) arterial segments had a quality score of 1 due to motion artifacts. None had a quality score of 0. CTA readers reported quality scores of 0 and 1 in 0 - 8 (0-2.2%) and 34-81 (9.4 - 22.5%) arterial segments respectively (Supplemental table 1). No motion artifacts were seen on ECG-gated examinations. The main reasons for decreased quality of ECG-gated images were increased noise level, improper arterial phase imaging due to long acquisition times, and slight misregistration on reformations between the stacks of slices acquired during two different diastoles.

### *Concordance analysis*

At CTA, the arterial wall at the site of stenosis was thin in all cases and no wall thickening could be measured (Fig 3). For detecting and quantifying stenosis, concordance between DSA and CTA findings were moderate-to-good for CIAs and EIAs, moderate for LCAs and poor-to-moderate for the other branches of the deep femoral artery (Tables 2-3). Concordance between DSA and CTA findings was moderate-to-good for assessing the C and E categories of the CEF classification, and highly variable depending on readers for the F category. At per limb analysis, it was good for all readers for the overall diagnosis of endofibrosis (Tables 3-5, Figs. 4-5). Concordance between CTA readers was good for CIAs, EIAs and LCAs and weak-to-moderate for the other branches of the deep femoral artery (Table 6).

### *Long-term final diagnosis*

After a median follow-up of 95 months (IQR, 7 – 109 months), 33 limbs were operated in 32 patients. Endofibrosis was histologically confirmed in all cases and the diagnosis was considered certain in these 33 limbs. Endofibrosis was considered likely in 11 limbs that were not operated despite typical symptoms. Patients usually reduced their sport practice intensity but kept persistent pain at maximal effort. Endofibrosis was considered unlikely in one limb due to the apparition of atypical pain during follow-up. Endofibrosis was ruled out in 31 limbs. Fourteen limbs were excluded from long-term diagnosis because of a follow-up of less than 12 months (Supplemental Table 2).

Using this long-term diagnosis as reference, DSA sensitivity and specificity at the limb level were respectively 88.6% (39/44; 95% CI: 76 - 95%) and 75% (24/32; 95% CI: 57.9 - 86.7%); CTA sensitivity and specificity were respectively 88.6% (39/44; 95% CI: 76 - 95%) ( $P > 0.99$ )

and 84.4% (27/32; 95% CI: 68.2 - 93.1%) ( $P = 0.51$ ) for reader 1, 86.3% (38/44; 95% CI: 73.3 - 93.6%) ( $P > 0.99$ ) and 75% (24/32; 95% CI: 57.9 - 86.7%) ( $P > 0.99$ ) for reader 2 and 84.1% (37/44; 95% CI: 70.6 - 92.1%) ( $P = 0.68$ ) and 75% (24/32; 95% CI: 57.9 - 86.7%) ( $P > 0.99$ ) for reader 3 (Table 7, Supplemental Table 3).

Eleven symptomatic limbs had negative exercise test. Five had surgery for an endofibrosis lesion of the deep femoral artery that was correctly showed either at DSA ( $n = 3$ ) or by at least one of the CTA readers ( $n = 5$ ). Endofibrosis was ruled out in only two of these symptomatic limbs with negative exercise test; DSA and CTA, that showed either positive or unclear findings, failed to identify these two limbs as negative (Supplemental Table 3).

### ***Radiation dose***

For DSA, the median DAP and fluoroscopy time were respectively 190 Gy.cm<sup>2</sup> (IQR, 144.7-236.5) and 2.6 minutes (IQR, 1.7-3.5). The corresponding median effective dose was 20.7 mSv (IQR, 15.8-25.6). For CTA, the median DLP without and with ECG gating were respectively 367 mGy.cm (IQR, 332-369 mGy.cm) and 1569 mGy.cm (IQR, 1404 - 11,858 mGy.cm). The corresponding median effective doses were 5.5 mSv (IQR, 5.0 - 5.5 mSv) and 23.5 mSv (IQR, 21.1 - 27.9 mSv) respectively.

### **Discussion**

We prospectively compared DSA and CTA findings in 45 athletes with suspicion of arterial endofibrosis. Concordance between both tests was moderate-to-good for CIAs and EIAs, and moderate for LCAs. However, both tests showed similar diagnosis performance for predicting long-term final diagnosis.

DSA was interpreted by a single expert in order not to complexify the concordance analysis and because we were interested in the reproducibility of CTA reading and not in that of DSA reading. Alternatively, the three readers could have interpreted both DSA and CTA. We did not choose this study design because the small number of patients and some potential striking features (e.g. stenoses of the branches of the deep femoral artery other than LCA) might have favored recall between DSA and CTA interpretation.

At CTA, endofibrosis lesions were not associated with any measurable thickening of the arterial wall. Instead, they appeared as areas of stenosis with the artery seeming smaller than its contralateral counterpart. This is in line with a recent study of 16 endurance athletes

assessed by MRI that found similar wall thickness in iliac arteries of symptomatic and asymptomatic legs [20]. This suggests that intimal fibrosis may not limit the arterial flow by obstructing the lumen but rather by inducing a constrictive effect that reduces the diameter of the whole artery. Thus, CTA could not show added value to DSA by providing direct visualization of the endofibrosis lesions. As DSA, it only assessed the consequences of the disease on the arterial lumen.

Most endofibrosis-induced iliac stenoses are very mild, as shown by a retrospective series of 180 patients in which the average degree of CIA and EIA stenoses was respectively  $19 \pm 7$  (SD) % and  $26 \pm 11$  (SD) % [7]. Nonetheless, DSA and CTA showed good concordance for assessing iliac stenoses for the three readers. On the contrary, concordance between DSA and CTA findings in assessing femoral lesions was only moderate for the LCA and highly variable among readers for the other branches of deep femoral artery. Detecting endofibrosis lesions of the deep femoral artery with imaging is of paramount importance, since these lesions are overlooked by the exercise test [4]. Several factors can explain the lack of concordance between DSA and CTA for the assessment of the deep femoral artery. First, at the beginning of the study, femoral lesions were thought to be rare outside the LCA and readers might have tended to overlook stenoses on the other branches of the deep femoral artery. Second, all femoral stenoses, including those of the LCA, are short and diaphragm-like [7]. They can be difficult to assess on small arteries using cross-sectional imaging and on DSA due to improper incidence and arterial superpositions. Doppler ultrasound may be an alternative to explore the deep femoral artery and its branches, but neither its accuracy nor its interobserver reproducibility have been prospectively assessed yet.

Despite the discordances between DSA and CTA findings, both tests showed similar sensitivities and specificities at per-limb analysis, for the three readers, when long-term diagnosis was used as standard of reference. This strongly suggests that CTA could replace DSA in the work-up of athletes with clinical suspicion of endofibrosis.

We used ECG-gated CTA in forty patients. Iliac arteries show some pulsatility even in atherosclerotic patients [21], but this pulsatility is usually not sufficient to induce motion artifacts at non-gated CTA. Because of the increased left ventricular stroke volume and increased arterial compliance associated with endurance training [22-25], we hypothesized that motion artifacts may occur in our patients' iliac arteries at non-gated CTA images. Therefore, we planned an analysis of motion artifacts after inclusion of the first five patients who were imaged without ECG gating. Of these, two showed substantial motion artifacts on

EIAs, which prompted the use of ECG gating, as per protocol. No motion artifacts were seen on iliac arteries with use of ECG gating. However, using ECG gating dramatically increased the amount of radiation exposure that reached the amount delivered by DSA.

Contrast-enhanced magnetic resonance angiography could be an interesting alternative to CTA to avoid irradiating these young patients. Magnetic resonance imaging could also assess the excessive length of iliac arteries and potential kinks by allowing repeated imaging with flexed hip [9, 26]. However, this would need an injection of a double dose of gadolinium-based contrast medium increasing the risk of deposition of gadolinium in the patients' brain [27]. In addition, whether the relatively limited spatial resolution of magnetic resonance angiography is sufficient to allow accurate detection of the mild stenoses of the iliac arteries and diaphragm-like stenoses of the deep femoral artery remains to be shown.

The present study has some limitations. First, because patients are symptomatic only at maximal effort, cessation of sport is an option for endofibrosis management [8]. As a result, not all patients underwent surgery and histological proof of endofibrosis could not be obtained in all patients with positive imaging. Therefore, we had to use a reference standard mixing histological findings and long-term follow-up to compare CTA and DSA performances. Although our long follow-up limited the risk of errors, our final diagnosis might have been erroneous in some cases. Second, patients were included between 2008 and 2012. This allowed long-term follow-up, but the CTA protocol evaluated herein is outdated. Continuous technological improvements could correct some of its limitations by both improving image quality and reducing the radiation dose, as exemplified by recent studies [28-33].

In conclusion, CTA showed similar performances than DSA in predicting the long-term diagnosis of endofibrosis in endurance athletes with suggestive symptoms. CTA can thus be used as an alternative to DSA for diagnosing arterial endofibrosis. Because of the marked pulsatility of the iliac arteries in this population, an ECG-gated acquisition is needed.

## **Conflicts of interest**

The authors have no conflicts of interest to disclose in relation with this article

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## **Ethical statement**

The study protocol was approved by our Ethics Committee and all patients provided written informed consent.

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## Figure Legends

**Figure 1.** Axial CT image obtained in a 41-year-old female triathlete without electrocardiogram gating showing marked motion artifact on the right external iliac artery (arrowhead).

**Figure 2.** Coronal reformation of CT images obtained in a 25-year-old male cyclist without electrocardiogram gating showing marked motion artifact on the left external iliac artery (arrowhead).

**Figure 3.** 25-year-old male cyclist with claudication of the left thigh at maximal effort. A, On axial CT image, the left external iliac artery (arrowhead) appears smaller than its contralateral counterpart (arrow), with no visible thickening of the arterial wall. B, On maximum intensity projection of CT images, the endofibrosis lesion appears as a mild stenosis of the proximal third of the left iliac artery (arrowhead). C, Intra-arterial digital subtraction angiography, shows similar findings as CT angiography, the endofibrosis lesion appearing as a mild stenosis of the proximal third of the left iliac artery (arrowhead). Surgical findings and histology confirmed arterial endofibrosis of the left external iliac artery.

**Figure 4.** 42-year-old female triathlete with claudication of the right thigh at maximal effort. A, On maximum intensity projection of CT images, the endofibrosis lesion appears as a mild stenosis of the right external iliac artery involving more than two thirds of the arterial length (arrowheads). B, Intra-arterial digital subtraction angiography shows similar findings (arrowheads). Surgical findings and histology confirmed arterial endofibrosis of the right external iliac artery.

**Figure 5.** 29-year-old male cyclist with claudication of the left thigh at maximal effort. A, Axial CT image shows a short stenosis of the origin of the left lateral circumflex artery (arrow). B, The stenosis is also visible on CT angiography maximum intensity projection despite noisy images (arrow) and on (C), intra-arterial digital subtraction angiography (arrow). Surgical findings and histology confirmed arterial endofibrosis of the left lateral circumflex artery.

**Table 1.** Patient characteristics.

**Table 2.** Detection and quantification of arterial stenoses by CTA and DSA (per arterial segment analysis).

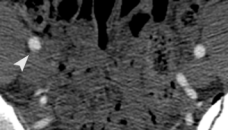
**Table 3.** Concordance between DSA and CTA findings.

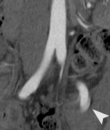
**Table 4.** Assessment of common iliac artery (C), external iliac artery (E) and deep femoral artery (D) categories by CTA and DSA.

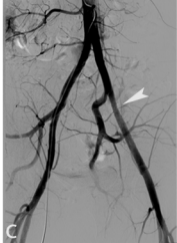
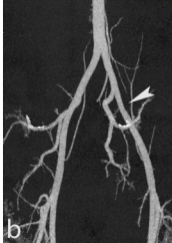
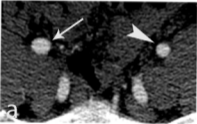
**Table 5.** Diagnosis of arterial endofibrosis by CTA and DSA (per limb analysis).

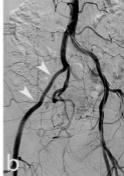
**Table 6.** Concordance between the three CTA readers.

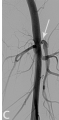
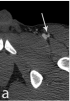
**Table 7.** Diagnostic performance of DSA and CTA using final long-term diagnosis as reference.











	Men (n = 39)	Women (n = 6)	Overall population (n = 45)	
Median age (IQR) (year)	27 (23-35)	41 (38-43)	30 (23-42)	
Median distance cycled at onset of symptoms (IQR) *	143,000 km (100,000-200,000)	45,000 km (15,500-150,000)	120,000 km (90,000-160,000)	
Median distance run at onset of symptoms (IQR) †	16,250 km (5,000-27,500)	11,250 km (7,500-15,000)	11,250 km (5,000-27,500)	
Sport	Cycling	33 (85%)	3 (50%)	36 (80%)
	Long-distance running	1 (2.5%)	2 (33%)	3 (7%)
	Triathlon	3 (7.5%)	1 (17%)	4 (9%)
	Football	1 (2.5%)	0	1 (2%)
	Football and tennis	1 (2.5%)	0	1 (2%)
Practice level	Professional	11 (28%)	1 (17%)	12 (27%)
	Competitive amateur	26 (67%)	5 (83%)	31 (69%)
	Recreational amateur	2 (5%)	0	2 (4%)

\* Cyclists and triathletes

† Long-distance runners and triathletes

IQR: interquartile range.

	DSA	CTA, Reader 1				CTA, Reader 2				CTA, Reader 3			
		0%	1-10%	11-50%	>50%	0%	1-10%	11-50%	>50%	0%	1-10%	11-50%	>50%
Common iliac artery	0%	61	4	1	0	64	0	2	0	60	5	1	0
	1-10%	3	4	3	1	4	4	2	1	3	3	4	1
	11-50%	2	6	5	0	1	3	9	0	4	4	5	0
	>50%	0	0	0	0	0	0	0	0	0	0	0	0
External iliac artery	0%	43	3	1	0	42	2	3	0	42	5	0	0
	1-10%	1	5	1	0	3	3	2	0	4	2	2	0
	11-50%	6	9	20	0	3	4	28	0	6	6	23	0
	>50%	0	0	0	0	0	0	0	0	0	0	0	0
Lateral circumflex femoral artery	0%	59	4	4	1	61	3	5	1	59	3	3	1
	1-10%	3	0	1	0	2	1	1	0	3	0	1	0
	11-50%	3	2	6	0	3	3	4	1	5	0	6	0
	>50%	3	0	2	0	0	1	2	2	1	0	2	2
Other locations on deep femoral artery	0%	78	1	0	0	81	0	0	0	74	1	2	0
	1-10%	4	0	0	0	2	0	1	1	3	0	1	0
	11-50%	2	1	0	0	1	1	1	0	1	0	2	0
	>50%	2	0	0	0	2	0	0	0	2	0	0	0

Arterial segments with image quality judged inadequate for diagnosis (image quality score of 0) were not interpreted; as a result, the number of assessed arterial segments varies from one reader to another. CTA: computed tomography angiography; DSA: digital subtraction angiography.



		Coefficient of correlation concordance [95%CI]		
		CTA Reader 1	CTA Reader 2	CTA Reader 3
Presence of stenosis	Common iliac artery	0.72 [0.51; 0.85]	0.79 [0.60; 0.91]	0.63 [0.42; 0.80]
	External iliac artery	0.75 [0.59; 0.88]	0.75 [0.60; 0.87]	0.66 [0.48; 0.80]
	Lateral circumflex artery	0.42 [0.18; 0.64]	0.58 [0.36; 0.75]	0.46 [0.21; 0.67]
	Other locations on deep femoral artery	0.15 [-0.04; 0.66]	0.59 [0.15; 0.85]	0.35 [-0.02 ; 0.71]
Degree of stenosis	Common iliac artery	0.66 [0.47; 0.78]	0.75 [0.56; 0.88]	0.58 [0.38; 0.74]
	External iliac artery	0.71 [0.56; 0.83]	0.78 [0.63; 0.88]	0.73 [0.58; 0.84]
	Lateral circumflex artery	0.40 [0.14; 0.63]	0.61 [0.38; 0.78]	0.57 [0.29; 0.76]
	Other locations on deep femoral artery	0.09 [-0.02; 0.56]	0.39 [0.07; 0.71]	0.31 [-0.03; 0.73]
CEF classification	C	0.65 [0.44; 0.80]	0.68 [0.48; 0.84]	0.56 [0.35; 0.74]
	E	0.60 [0.28; 0.84]	0.78 [0.59; 0.91]	0.56 [0.31; 0.79]
	F	0.23 [0.04; 0.58]	0.63 [0.37; 0.83]	0.47 [0.21; 0.72]
Diagnosis of endofibrosis		0.74 [0.59; 0.84]	0.77 [0.64; 0.85]	0.67 [0.49; 0.79]

CTA: computed tomography angiography; DSA: digital subtraction angiography; CI: confidence interval.

	DSA	CTA, Reader 1					CTA, Reader 2					CTA, Reader 3							
		0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Common iliac artery (C)	0	61	1	0	4	0	0	64	0	0	2	0	0	60	1	3	2	0	0
	1	0	2	2	0	0	0	0	3	0	1	0	0	0	2	1	1	0	0
	2	3	0	0	2	0	0	1	1	1	2	0	0	2	0	1	0	2	0
	3	2	2	0	7	2	0	4	0	2	5	2	0	4	0	1	7	1	0
	4	0	1	0	1	0	0	0	1	0	1	0	0	1	1	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
External iliac artery (E)	0	43	3	1	0	0	0	42	4	1	0	0	0	42	2	3	0	0	0
	1	5	28	1	0	0	0	6	28	0	0	0	0	9	23	2	0	0	0
	2	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0
	3	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
	4	2	1	0	1	2	0	0	2	0	1	3	0	1	3	0	0	2	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Deep femoral artery (F)	0	56	7	1	0	1	0	58	7	1	0	1	0	54	4	2	1	1	0
	1	3	4	1	0	0	0	2	5	1	0	0	0	5	2	1	0	0	0
	2	2	0	4	0	0	0	2	1	3	0	0	0	0	0	4	1	0	0
	3	2	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0
	4	5	1	0	0	1	0	1	2	0	1	3	0	2	2	0	1	2	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CTA: computed tomography angiography; DSA: digital subtraction angiography. Arterial segments with image quality judged inadequate for diagnosis (image quality score of 0) were not interpreted; as a result, the number of assessed CEF categories varies from one reader to another.

DSA	CTA, Reader 1			CTA, Reader 2			CTA, Reader 3		
	Positive	Uncertain	Negative	Positive	Uncertain	Negative	Positive	Uncertain	Negative
Positive	30 (34%)	2 (2%)	3 (3%)	29 (33%)	4 (4%)	2 (2%)	27 (31%)	5 (5%)	3 (3%)
Uncertain	8 (9%)	7 (8%)	5 (5%)	5 (5%)	8 (9%)	7 (8%)	7 (8%)	8 (9%)	5 (5%)
Negative	1 (1%)	6 (7%)	28 (31%)	1 (1%)	5 (5%)	29 (33%)	3 (3%)	6 (7%)	26 (29%)

CTA: computed tomography angiography; DSA: intra-arterial digital subtraction angiography.

		Coefficient of correlation concordance [95%CI]
Diagnosis of endofibrosis	Common iliac artery	0.71 [0.56; 0.83]
	External iliac artery	0.71 [0.59; 0.82]
	Lateral circumflex femoral artery	0.68 [0.51; 0.82]
	Other locations on deep femoral artery	0.48 [0.12; 0.76]
Percentage of stenosis	Common iliac artery	0.76 [0.61; 0.88]
	External iliac artery	0.80 [0.70; 0.87]
	Lateral circumflex femoral artery	0.69 [0.54; 0.84]
	Other locations on deep femoral artery	0.39 [0.11; 0.58]
Length of stenosis	Common iliac artery	0.71 [0.57; 0.83]
	External iliac artery	0.77 [0.68; 0.86]
	Lateral circumflex femoral artery	0.67 [0.53; 0.79]
	Other locations on deep femoral artery	0.48 [0.12; 0.76]

CI = confidence interval

		Long-term diagnosis	
		Endofibrosis	No endofibrosis
DSA	Positive	29 (38%)	1 (1%)
	Uncertain	10 (13%)	7 (9%)
	Normal	5 (7%)	24 (32%)
CTA, reader 1	Positive	30 (39%)	2 (3%)
	Uncertain	9 (12%)	3 (4%)
	Normal	5 (7%)	27 (35%)
CTA, reader 2	Positive	31 (40%)	2 (3%)
	Uncertain	7 (9%)	6 (8%)
	Normal	6 (8%)	24 (32%)
CTA, reader 3	Positive	26 (34%)	2 (3%)
	Uncertain	11 (14%)	6 (8%)
	Normal	7 (9%)	24 (32%)

Fourteen limbs were excluded from long-term diagnosis due to a follow-up of less than 12 months.