Femoral artery stress in the adductor canal due to leg muscle contraction

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Introduction:

The adductor canal is a tunnel in the middle third of the thigh through which the femoral artery and vein pass. It is well known that peripheral arterial disease is prevalent within the canal[1]. Factors such as artery curvature and stress from external factors are thought to increase the frequency of disease at this site. Generally, the adductor canal is completely surrounded by muscle which can generate a substantial compressive stress on the artery within. This is in contrast to other sites in the leg, such as the popliteal fossa, where neighboring fat and bone may alleviate pressure from muscle tension. In this study, we use time-of-flight (TOF) imaging at 3T to compare the shape of the femoral artery in the adductor canal to that of the popliteal artery in the popliteal fossa during muscle relaxation and tension.

Methods:

Eight healthy volunteers (four male, four female, mean ± st. dev. age = 32 ± 8) were imaged on a 3T scanner (Excite, GE). Signal reception was provided by a custom eight channel knee coil. The coil consisted of eight rectangular (7x25cm^2) elements distributed azimuthally around a 17.8cm diameter cylindrical former. The coil was positioned on the volunteer's right leg covering the mid-thigh to the knee. First, a TOF scout scan was used to locate the vessel within the popliteal fossa and adductor canal. Next, a single slice axial 2D fast spoiled gradient echo TOF image was prescribed with the following parameters: TR/TE/α=8.6ms/2.4ms/60°, BW=31kHz, FOV=36cm, 512x256 acquisition matrix, NEX = 1, and slice thickness = 7mm. Cardiac gating was used to reduce pulsation artifacts, resulting in a scan time of approximately 10 sec. Two images were acquired at each site (popliteal fossa and adductor canal) and in each muscle state (relaxed, flexed). To improve reliability, this process was repeated at slightly different locations within the popliteal fossa and adductor canal (~1.5cm offset). For the flexed scan, the volunteer was asked to straighten their leg with isometric contraction of the thigh muscles. The artery cross section was approximately elliptical. Correspondingly, in each image, the eccentricity $e=\sqrt{1-(b^2/a^2)}$ was measured to characterize the vessel shape, where a and b are the lengths of the artery's major and minor axes, respectively. From these data, the mean eccentricity was calculated for each volunteer at each site and muscle state.

Results:

Example image sets from two volunteers are shown in Figure 1. The images show that in the adductor canal (top row), the artery is squeezed during isometric contraction (solid arrows) while the artery is relatively undisturbed (open arrows) in the popliteal fossa (bottom row). Table 1 lists the eccentricity statistics. The p-values from the paired student's t-test show that the femoral artery was significantly deformed within the adductor canal during leg flexion ($p<0.0001$), while the popliteal artery in the fossa experienced insignificant deformation ($p>0.25$).

Table 1. Mean ± standard deviation of artery eccentricity from eight volunteers.

	Artery eccentricity (e)		
Location	Relaxed	Flexed	p-value
Adductor canal	0.41 ± 0.07	0.64 ± 0.06	<0.0001
Popliteal fossa	0.40 ± 0.07	0.45 ± 0.12	>0.25

Discussion and Conclusions:

We demonstrate that the thigh muscles compress the femoral artery in the adductor canal during leg flexion. The femoral artery is sandwiched between the quadriceps and hamstring muscles which act together to deform the artery. This repetitive mechanical stress can be a significant source of trauma and may help explain the frequent occurrence of atherosclerotic disease in the adductor canal. In contrast, it was found that the popliteal artery was protected from compression in the popliteal fossa, where it is surrounded by fat and bone.

The TOF sequence proved appropriate for our application as it provided good contrast between the artery and background tissue in a short acquisition time. Short scan time was essential, as long periods of leg flexion are likely to result in motion artifacts and artery blurring. A disadvantage of the TOF sequence is that the artery wall cannot be visualized, which somewhat limits the accuracy of the experiment. However, this was countered by acquiring multiple data points from each volunteer. A limitation not addressed here is the variable force of the leg muscle contraction between subjects. This could potentially be overcome by using a tourniquet to administer a regulated amount of tension on the leg.

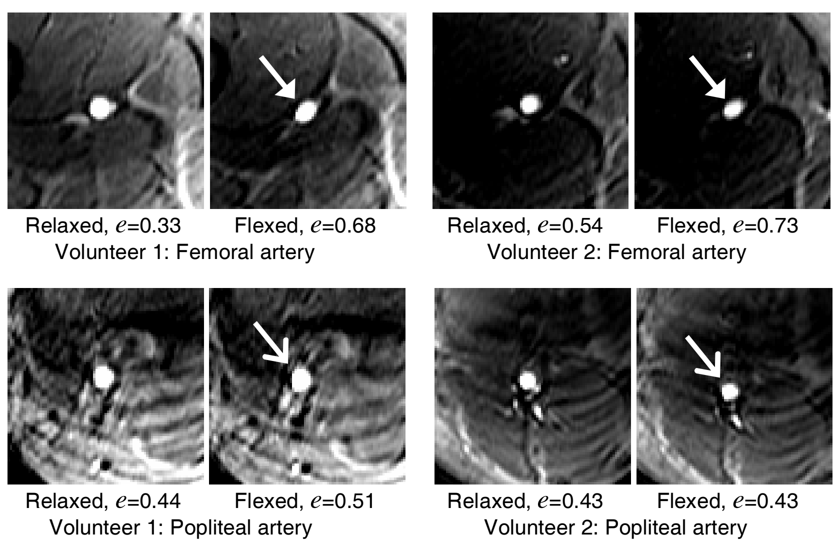

Figure 1. Image sets from two volunteers showing the femoral (top row) and popliteal (bottom row) arteries. Note the dramatic change in femoral artery shape during leg flexion (closed arrows), while the popliteal artery remains undisturbed (open arrows). Eccentricity values for the given images are provided. The FOV of the cropped images is 6x6cm^2 with 0.7x0.7mm^2 resolution

References:

1. Linhart J, Dejdar R, Prerovsky I, Hlavova A. Location of occlusive arterial disease of lower extremity. *Invest Radiol* 1968;3:188-198.