BACKGROUND
Peripheral arterial disease (PAD) describes the impairment of blood flow to the extremities as a result of stenoses and/or occlusions of the lower limb arteries. The goals of treatment for patients with claudication are to relieve their symptoms, improve their quality of life and reduce the overall risk of cardiovascular mortality with risk-factor modification and pharmaceutical therapies. Revascularization is indicated for severe claudication, for rest pain and tissue loss and includes endovascular procedures (percutaneous transluminal angioplasty (PTA) with/without stent deployment) or surgical procedures (endarterectomy, bypass using autologous vein or synthetic conduits).

Evaluation of PAD includes clinical history, physical examination, measurement of ankle-brachial index (ABI) and radiological investigations such as color duplex ultrasound (CDUS), computed tomography angiography (CTA), magnetic resonance angiography (MRA) and digital subtraction angiography (DSA). These imaging modalities are accurate and provide significant information about the distribution of macrovascular lesions of the limbs (stenoses, occlusions) but not for the local microvascular perfusion of the feet.

Non conventional imaging techniques such as diffusion weighted imaging (DWI) and perfusion weighted imaging (PWI) are well validated techniques for the diagnosis and the selection of appropriate therapeutic treatment for many diseases, especially of the brain parenchyma and the myocardial perfusion. The use of these imaging techniques in the study of PAD or CLI is not widespread because imaging modalities such as CDUS, CTA and MRA are capable of depicting stenoses and/or occlusions of peripheral arteries. However, these approaches do not measure direct blood flow to the limb and don’t provide information about the local microvascular perfusion of the feet.

METHODS
This is a prospective single-center study aiming to examine the role of DCE-MRI in the evaluation of hypoperfusion in patients with CLI and the changes of quantitative parameters after PTA. Exclusion criteria were all common contraindications to MRI, like pacemakers, ferromagnetic implants, claustrophobia and contraindications for administration of Gadolinium contrast medium.

Between March 2015 and April 2017, 8 patients (5 male, 3 female) with PAD underwent DCE-MRI of the foot with an appropriate imaging protocol before and after endovascular treatment. The median age was 68 years (range 58-79 years). All patients presented with CLI and according to Rutherford classification of PAD, two patient were allocated to class 4 PAD, five patients to class 5 PAD and 1 patient to class 6 PAD.

Studies were performed on a 1.5T clinical MR Scanner (Vision/Sonata Hybrid system, Siemens, Erlangen, Germany). The imaging protocol, apart from the conventional sequences, included DCE-MRI quantitative techniques. T1W DCE perfusion MR imaging of the lower limb was performed by utilizing a 3D VIBE (volume interpolated breath hold examination) sequence in the sagittal plane with variable flip angles (FA = 5°, 10°, 15°, 20°, 25°, 30°) for the initial calculation of the parametric T1 maps. Consequently, an intravenous continual injection of paramagnetic CA (0.1 mmol/kg) was administered for approximately one minute. The aforesaid T1W DCE VIBE perfusion sequence was continuously repeated for ten minutes after the intravenous injection of the CA with the following imaging parameters: FA=15°, TE=2.73 ms, TR=7.8 ms, matrix size=512×512, FOV=250×250 and slice thickness=3 mm.

MR images were transferred and analyzed with a commercially available software (nordicICe v4.0, NNL, Bergen, Norway). DCE-analysis was performed utilizing an extended Tofts model (3-parameter fitting). Quantitative perfusion maps based on pharmacokinetic parameters such us, relative blood flow (BF), \( K_{\text{trans}} \) and \( K_{\text{ep}} \) were created from parametric data fitted to the extended Tofts model utilizing a population-based AIF. Subsequently, multiple ROIs were placed around the entire foot, on the dermis and muscles tissues in the pre- and post-procedure examination and the change in the relative perfusion parameters was calculated.

Statistical analysis was performed utilizing MedCalc software (vs 12 Medcalc Software, Mariakerke, Belgium). Wilcoxon signed rank tests were used to compare pre-PTA and post-PTA perfusion parameters such as BF, \( K_{\text{trans}} \) and \( K_{\text{ep}} \).

RESULTS
Technical success was achieved in all patients (8/8) and there were no major complications after endovascular treatment. There was significant clinical improvement in all patients and the ankle brachial index (ABI) increased from 0.35 ± 0.2 to 0.76 ± 0.25 after revascularization (p<0.05). The patients were followed-up for a mean duration period of 18 months. During follow-up one patient died due to acute myocardial infarction and there were two minor toe amputations.

Successful revascularization led to a significant change in perfusion parameters. After PTA, mean BF increased from 6.18 ± 3.221 to 9.788 ± 3.346, \( K_{\text{trans}} \) increased from 0.063 ± 0.024 to 0.106 ± 0.045 and Kep increased from 0.102 ± 0.026 to 0.145 ± 0.026 (p<0.05).

CONCLUSION
DCE-MRI may be a useful means for the diagnosis of foot hypoperfusion and estimation of PTA outcome in patients with CLI. This information can be used to predict the outcome of patients with CLI and the planning of the revascularization strategy.