ISSN: 2581 – 3633

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at: https://www.ijmacr.com

Volume – 9, Issue – 4, August – 2026, Page No.: 577 – 587

Comprehensive Study of Doppler Ultrasound and CT Angiography in Peripheral Vascular Disease

[1]Dr. Lakhan Patidar, Junior Resident, Department of Radiodiagnosis, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India.

[2]Dr. Prateek Gehlot, Professor, Department of Radiodiagnosis, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India.

[3]Dr. Mohit Arora, Junior Resident, Department of Radiodiagnosis, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India.

Corresponding Author: Dr. Lakhan Patidar, Junior Resident, Department of Radiodiagnosis, R.D. Gardi Medical College, Ujjain, Madhya Pradesh, India.

How to citation this article: Dr. Lakhan Patidar, Dr. Prateek Gehlot, Dr. Mohit Arora, "Comprehensive Study of Doppler Ultrasound and CT Angiography in Peripheral Vascular Disease", IJMACR– August – 2026, Volume – 9, Issue –4, P. No. 577 – 587.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Peripheral arterial disease (PAD) is a common manifestation of systemic atherosclerosis and is associated with significant morbidity, limb ischemia, and cardiovascular risk. Accurate assessment of the location and severity of arterial stenos is and occlusion is essential for diagnosis and treatment planning. Colour Doppler Ultrasonography (USG) is a non-invasive, accessible and cost-effective first-line investigation that provides physiological information regarding arterial blood flow and stenos is. However, its diagnostic performance may be limited by operator dependence, arterial calcification, vessel depth and restricted visualization of the complete arterial tree. MDCT angiography (MDCTA) provides comprehensive anatomical visualization of the peripheral arterial system, including lesion length, severity, calcification, collateral circulation and arterial occlusion. The present study was undertaken to evaluate the diagnostic correlation between colourdoppler Ultrasonography and MDCT angiography in patients with suspected peripheral vascular disease and to assess their respective roles in determining disease severity and extent.

Materials and Methods: A prospective observational study was conducted in the Department of Radio diagnosis, R.D. Gardi Medical College and C.R. Gardi Hospital, Ujjain, Madhya Pradesh. A total of 61 patients aged above 18 years with clinical suspicion of peripheral vascular disease were included. Patients presenting with lower-limb pain or numbness, diminished or absent pulses, non-healing ulcers, dry gangrene or intermittent

claudication were eligible for inclusion. Patients with known malignancy, pregnancy or unwillingness to provide consent were excluded. All patients underwent colour Doppler Ultrasonography followed by MDCT angiography. Doppler assessment included evaluation of arterial stenos is, occlusion, thrombus, plaque morphology, peak systolic velocity and spectral waveform patterns. MDCT angiography was used to assess stenos is, occlusion, plaque characteristics, collateral circulation, and the length and severity of arterial lesions. Data were analysed using descriptive statistics, chi-square tests and diagnostic accuracy parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy. A p-value <0.05 was considered statistically significant.

Results: The mean age of the study population was 60.02 ± 7.27 years, with a male predominance (62.3%). Diabetes mellitus was the most common risk factor (39.34%), followed by mixed risk factors (22.95%) and smoking (19.67%). Claudication was the most frequent presenting complaint (73.8%). The mean ABI of the worst limb was 0.66 ± 0.16, with 49.2% of patients having moderate PAD and 16.4% having severe PAD. Femoral arteries were the most frequently affected arterial segment, followed by tibial and popliteal arteries. Colour Doppler and MDCT angiography demonstrated an overall stenos is-severity concordance of 73.8%. Concordance was highest for mild stenos is (81.8%) and critical stenos is ≥90% (88.9%), while it decreased to 50% for severe stenos is of 70–89%. For detection of ≥50% stenos is, Colour Doppler demonstrated 100% sensitivity, 95.65% specificity, 97.43% PPV, 100% NPV and 98.36% overall accuracy. For ≥70% stenos is, sensitivity decreased to 75%, with specificity of 85.36% and overall accuracy of 81.96%.

A strong correlation was observed between USG plaque score and CT calcium score ($\rho = 0.846$, $p < 0.001$). Overall, 72.1% of patients showed high concordance between USG and CT angiography findings, 18.0% showed partial concordance and 9.8% were discordant. ABI severity demonstrated a statistically significant association with the percentage of stenos is on CT angiography ($p = 0.001$), with mean CT stenos is increasing from 7.67% in patients with normal ABI to 77.00% in those with severe PAD. CT angiography detected arterial occlusion in 8 patients compared with only 1 patient detected by Colour Doppler, demonstrating the greater ability of MDCTA to identify complete occlusive disease.

Conclusion: Colour Doppler Ultrasonography and MDCT angiography are complementary modalities in the evaluation of peripheral arterial disease. Colour Doppler demonstrated high diagnostic accuracy for mild to moderate stenos is and ≥50% arterial stenos is and remains a reliable, non-invasive and cost-effective first-line investigation. MDCT angiography provided superior anatomical delineation, particularly for severe stenosis, infrapopliteal disease, calcified vessels and complete arterial occlusions, and is valuable for defining disease extent and pre-interventional planning. The findings therefore support the complementary use of Colour Doppler as an initial screening and Haemodynamic assessment tool, with MDCT angiography providing detailed anatomical assessment when required.

Keywords: Peripheral Arterial Disease, Peripheral Vascular Disease, Colour Doppler Ultrasonography, Duplex Ultrasonography, MDCT Angiography, Computed Tomography Angiography, Lower Limb

Arterial Disease, Arterial Stenosis, Arterial Occlusion, Ankle-Brachial Index.

Introduction

Peripheral arterial disease (PAD) is a common manifestation of systemic atherosclerosis characterized by narrowing or occlusion of peripheral arteries, most frequently involving the abdominal aorta, iliac vessels, and arteries of the lower extremities. It is strongly associated with advancing age and established cardiovascular risk factors such as diabetes mellitus, smoking, hypertension, and dyslipidemia. Although intermittent claudication is a characteristic clinical presentation, a substantial proportion of patients remain asymptomatic or present with atypical symptoms. Progressive arterial insufficiency may result in ischemic rest pain, non-healing ulcers, tissue necrosis, gangrene, and ultimately limb loss. Furthermore, PAD represents an important marker of systemic atherosclerotic disease and is associated with an increased risk of cardiovascular events, including myocardial infarction and stroke.

Accurate assessment of the anatomical extent and Haemodynamic significance of arterial disease is essential for diagnosis, disease stratification, treatment planning, and follow-up. The ankle-brachial index (ABI) provides a simple, non-invasive assessment of lower-limb arterial perfusion and is an important initial diagnostic tool. However, imaging is required for detailed characterization of arterial stenos is, occlusion, plaque morphology, and collateral circulation.

Colour Doppler Ultrasonography (DUS) is widely used as a first-line imaging modality because it is non-invasive, readily available, relatively inexpensive, and free of ionizing radiation. It provides both morphological information regarding the arterial wall and plaque and physiological information through flow velocity and spectral waveform analysis. However, its diagnostic utility may be affected by operator dependence, obesity, bowel gas, vessel depth, and extensive arterial calcification. It may also provide an incomplete anatomical overview of the entire arterial tree.

Multi detector CT angiography (MDCTA) provides comprehensive visualization of the arterial system from the aorto-iliac vessels to the pedal arteries, allowing assessment of the location, length, severity, calcification, occlusion, and collateral circulation. Its high spatial resolution makes it particularly useful in advanced disease and pre-interventional planning. Previous studies cited in the dissertation have demonstrated substantial agreement between DUS and MDCTA, while also indicating an advantage of MDCTA in delineating extensive, calcified, and infrapopliteal disease.

Therefore, the present study evaluates and compares Colour Doppler Ultrasonography and MDCT angiography in peripheral arterial disease, with particular emphasis on their ability to characterize arterial lesions, determine stenos is severity, assess plaque morphology and correlate anatomical findings with physiological impairment.

Materials and Methods

A prospective observational study was conducted in the Department of Radio diagnosis, R.D. Gardi Medical College and C.R. Gardi Hospital, Ujjain, after institutional ethical approval and written informed consent. The study included 61 patients aged >18 years with clinical suspicion of peripheral vascular disease. Patients presenting with lower-limb pain or numbness, diminished pulses, non-healing ulcers, dry gangrene, or intermittent claudication were included, while patients with malignancy, pregnancy, or unwillingness to participate were excluded.

All participants underwent Colour Doppler Ultrasonography followed by MDCT angiography. Doppler evaluation assessed arterial stenos is, occlusion, thrombus, plaque morphology, peak systolic velocity, and spectral waveforms. MDCT angiography was performed using a 128-slice CT scanner to evaluate stenos is, occlusion, plaque characteristics, collateral vessels, and lesion extent. Findings from both modalities were compared. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated. Statistical significance was considered at $p < 0.05$.

Inclusion Criteria

- Patients aged >18 years, irrespective of sex, with clinical suspicion of peripheral vascular disease.
- Patients presenting with pain/numbness of feet, diminished lower-limb pulses, non-healing ulcers, dry gangrene, or intermittent claudication.
- Patients willing to undergo MDCT angiography and provide informed consent.

Exclusion Criteria

- Patients with known malignancy.
- Pregnant women.
- Patients unwilling to participate or provide written informed consent

Equipment Used

Ultrasonography was performed using GE LOGIQ V5, Mind ray DC-80, and Mind ray DC-60 ultrasound systems. CT angiography was performed using a GE OPTIMA 660 128-slice MDCT scanner. All imaging examinations were performed under the supervision of experienced radiologists.

Patient Preparation

No special preparation was required prior to Colour Doppler Ultrasonography or MDCT angiography. Patients were explained the procedures in detail, and written informed consent was obtained. Relevant clinical history, demographic details, and physical examination findings were recorded before imaging.

Ultrasonography Technique

Colour Doppler Ultrasonography was performed using high-resolution ultrasound systems. The lower-limb arterial system was evaluated from the aorto-iliac segment to the dorsalispedis artery. Arterial stenos is, occlusion, and thrombus were assessed, along with plaque characterization as soft, calcified, or mixed. Haemodynamic assessment was performed using peak systolic velocity and spectral waveform analysis. Findings were documented for correlation with MDCT angiography.

Computed Tomography Technique

MDCT angiography was performed using a GE OPTIMA 660 128-slice MDCT scanner. Scanning was performed with the patient in the supine position, with acquisition parameters of 120–140 kV, 120–160 mAs, 5 mm collimation, and a pitch of 1.5:1. Intravenous non-ionic contrast was administered through an antecubital vein using an automated injector. The arterial tree was assessed for stenos is, occlusion, plaque type and location, collateral vessels, and the length and severity of steno tic segments.

Data collection

Relevant demographic details, clinical history, and physical examination findings were recorded using a structured case-record proforma. Findings from Colour Doppler and MDCT angiography, including stenosis, occlusion, thrombus, plaque morphology, flow characteristics, and collateral circulation, were documented for comparative assessment.

Outcome measures

The primary outcome was the correlation of stenos is, occlusion, and plaque type between Colour Doppler Ultrasonography and MDCT angiography. Secondary outcomes included assessment of collateral circulation and diagnostic accuracy in infrapopliteal and supra-inguinal arterial segments

Statistical Analysis

Quantitative variables were expressed as mean, median, standard deviation, and range, while qualitative variables were presented as frequencies and percentages. Chi-square tests were used for comparisons. Sensitivity, specificity, PPV, NPV, and overall accuracy were calculated. A p-value <0.05 was considered statistically significant.

Result

A total of 61 patients with clinically suspected peripheral vascular disease were included in the study and evaluated using both Colour Doppler Ultrasonography and MDCT angiography. The study population comprised 38 males (62.3%) and 23 females (37.7%), with a male-to-female ratio of approximately 1.65:1. The mean age of the patients was 60.02 ± 7.27 years, with the majority belonging to the 60–69-year age group. The mean duration of symptoms was 11.39 ± 5.46 months.

Among the recognized vascular risk factors, diabetes mellitus was the most common (39.34%), followed by mixed risk factors (22.95%), smoking (19.67%), and hypertension (16.39%). Clinically, claudication was the predominant presenting complaint, reported in 73.8% of patients, followed by rest pain and ulceration/gangrene. These findings demonstrate a predominantly older population with a substantial burden of established vascular risk factors.

The mean ankle-brachial index (ABI) of the worst affected limb was 0.66 ± 0.16. Based on ABI classification, moderate peripheral arterial disease constituted the largest group (49.2%), followed by mild disease (29.5%) and severe disease (16.4%). Only 4.9% of patients had an ABI within the normal range.

On arterial segment analysis, femoral arteries were the most frequently affected vessels on both Colour Doppler and MDCT angiography, followed by the tibial and popliteal arteries. The distribution of arterial involvement was broadly comparable between the two imaging modalities.

The comparison of stenos is severity demonstrated an overall concordance of 73.8% between Colour Doppler and MDCT. Agreement was highest for critical steno is of ≥ 90 % (88.9%) and mild stenos is (81.8%), whereas the lowest concordance was observed in severe stenos is of 70–89% (50.0%).

For detection of clinically significant ≥50% stenos is, Colour Doppler demonstrated excellent diagnostic performance, with 100% sensitivity, 95.65% specificity, 97.43% PPV, 100% NPV, and 98.36% accuracy. For ≥70% stenos are, diagnostic performance was comparatively lower, with sensitivity of 75% and overall accuracy of 81.96%.

A strong correlation was observed between ultrasound-based plaque assessment and CT calcium burden (ρ = 0.846, p <0.001). Furthermore, ABI severity showed a statistically significant association with CT-measured stenos is (p = 0.001), with mean CT stenos is increasing from 7.67% in patients with normal ABI to 77.00% among patients with severe PAD.

Finally, MDCT angiography identified eight arterial occlusions, compared with only one detected by Colour Doppler. Overall agreement for occlusion status was

88.5%, indicating that while the two modalities demonstrated substantial agreement overall, MDCT provided additional detection of complete occlusive disease

Table 1: Demographic and Clinical Profile of Study Participants.

Variables	Frequency (%)	Mean±SD
Age Group (years)		
40-49years	6 (9.8%)	
50-59years	22 (36.1%)	
60-69years	26 (42.6%)	
≥70years	7 (11.5%)	
Mean Age		60.02 ± 7.27 years
Sex Distribution		
Male	38 (62.3%)	
Female	23 (37.7%)	
Male: Female Ratio	1.65 :1	
Residence		
Urban	31 (50.8%)	
Rural	30 (49.2%)	
Risk Factors		
Smoking	12 (19.67%)	
Diabetes Mellitus	24 (39.34%)	
Hypertension	10 (16.39%)	
Mixed	14 (22.95%)	
None	1 (1.64%)	
Duration of Symptoms		11.39 ± 5.46 months
Chief Complaint		
Claudication	45 (73.8%)	
Claudication + Rest Pain	2 (3.3%)	
Leg fatigue	1 (1.6%)	
No symptoms/ Mild ache	3 (4.9%)	
Rest Pain	8 (13.1%)	
To edis coloration with pain	2 (3.3%)	
Ulcer/ Gangrene	10 (16.4%)	
Limb Involved		
Left	37 (60.7%)	
Right	24 (39.3%)	

Table 2: Distribution According to Ankle –Brachial Index (Worst Limb)

ABI Ranges	Severity Category	No. of Cases	Percentage (%)
0.91-1.00	Normal	3	4.9%
0.70-0.90	Mild PAD	18	29.5%
0.41-0.69	Moderate PAD	30	49.2%
≤ 0.40	Severe PAD	10	16.4%
Total		61	100.0%

Table 3: Distribution According to Affected Arterial Segment.

Segment Involved	USG		MDCT	
	No.	%	No.	%
Aorto-Iliac Arteries	4	6.6%	5	8.2%
Femoral Arteries	25	41.0%	22	36.1%
Pedal Arteries	1	1.6%	1	1.6%
Peroneal Artery	6	9.8%	6	9.8%
Popliteal Artery	9	14.8%	9	14.8%
Tibial Arteries	16	26.2%	15	24.6%
Total	61	100.0%	61	100.0%

Table 4: Correlation of Stenos is Severity Between USG and MDCT.

% Stenos is Range	No. of Cases (USG)	No. of Cases (CT)	Concordance %
0-29% (Mild)	9 (14.8%)	11 (18.0%)	81.8%
30-49% (Moderate)	13 (21.3%)	12 (19.7%)	76.9%
50-69% (Significant)	18 (29.5%)	18 (29.5%)	66.7%
70-89% (Severe)	12 (19.7%)	11 (18.0%)	50.0%
≥90%(Critical/Near occlusion)	9 (14.8%)	9 (14.8%)	88.9%
Total	61 (100.0%)	61 (100.0%)	73.8%

Table 5: Overall Concordance between USG and CT Angiography Findings.

Concordance Level	No. of Patients	Percentage (%)
High Concordance	44	72.1%
Partial Concordance	11	18.0%
Discordant	6	9.8%
Total	61	100.0%

Discussion

Demographic and Clinical Context

The study included 61 patients with a mean age of 60.02 ± 7.27 years, with the majority belonging to the 60–69-year age group. A male predominance was observed (62.3%). Diabetes mellitus was the most frequent risk factor (39.34%), while claudication was the predominant presenting symptom (73.8%). The mean ABI was 0.66 ± 0.16, and its significant association with CT-measured stenosis (p=0.001) demonstrated a close relationship between functional impairment and anatomical disease burden.

Diagnostic Efficacy

Colour Doppler Ultrasonography demonstrated good overall agreement with MDCT angiography, with 72.1% of patients showing high concordance, 18.0% partial concordance, and only 9.8% discordance. Concordance was particularly strong for mild (81.8%) and moderate (76.9%) stenosis, while it declined for significant and severe stenosis, reaching 50% for 70–89% stenosis. For detection of ≥50% stenosis, Doppler demonstrated excellent diagnostic performance, with 100% sensitivity, 95.65% specificity, 97.43% PPV, 100% NPV and 98.36% accuracy. However, for ≥70% stenosis, sensitivity declined to 75% and accuracy to 81.96%, indicating limitations in high-grade disease. Strong correlations were also observed between USG plaque score and CT calcium score ($\rho=0.846$, $p<0.001$). MDCT detected eight arterial occlusions compared with only one on Doppler, highlighting its superior capability in advanced occlusive disease.

Strengths and Limitations

The prospective design and paired evaluation of all 61 patients with both Colour Doppler ultrasonography and MDCT angiography allowed direct comparison of the two modalities within the same study population. Correlation with ABI and assessment of plaque and calcium burden further strengthened the evaluation. However, the study was conducted at a single centre with a relatively small sample size of 61 patients. Additionally, MDCT angiography was used as the comparative imaging modality, and the study did not include invasive digital subtraction angiography as a reference standard. These factors may limit the generalizability of the findings.

Comparative Literature and Advanced Modalities

The findings are broadly consistent with previous studies demonstrating that Colour Doppler and MDCT angiography are complementary modalities. Prasad et al. reported near-perfect Doppler accuracy for stenos is below 50% and 50–99%, although performance decreased in calcified plaques. Malaichamy et al. demonstrated high Doppler sensitivity across supra-inguinal, femoropopliteal and infrapopliteal segments, with substantial agreement with MDCTA. Conversely, Abu Eisha et al. reported superior diagnostic performance of CTA over DUS, particularly for infrapopliteal disease. Similarly, Kondeti et al. found that MDCTA detected more diseased segments and was superior for calcification, occlusion and thrombus. These findings support a stepwise approach in which Doppler provides an accessible initial Haemodynamic assessment, while MDCTA offers comprehensive anatomical mapping for advanced disease and intervention planning.

Conclusion

The present study demonstrates that Colour Doppler Ultrasonography and MDCT angiography have complementary roles in the evaluation of peripheral arterial disease. Doppler showed excellent diagnostic performance for clinically significant stenos is and strong correlation with CT-based assessment of plaque and

calcium burden, supporting its use as a first-line, non-invasive and cost-effective investigation. However, its diagnostic performance decreased with severe stenos is and complete occlusion. MDCT angiography provided superior anatomical delineation, particularly for infrapopliteal disease, calcified vessels, lesion extent and total occlusions. Therefore, Doppler is appropriate for initial assessment and follow-up, whereas MDCT angiography should be considered when detailed anatomical characterization, advanced disease assessment, or pre-interventional planning is required.

References

1. Gardner AW. Prevention, Management of lower extremity peripheral arterial disease. 2008. 28 (6): p. 349.
2. El Dein AIG, et al. Comparative study between duplex ultrasound and 160-multidetectors CTA in assessment of chronic lower limb ischemia. 2019. 50 (1): 1-8.
3. Rajpal K, Nawale A, Borde A. Role of CT Angiography &Colour Flow Imaging (USG) in Evaluation of Peripheral Arterial Diseases. Int J Sci Res. 2016; 5:580-591.
4. Shirol RJ, Shetty A, K CT. Role of MDCT in Evaluation of Peripheral Vascular Disease of the Lower Limb Arteries and Comparison with Colour Doppler. J Evol Med Dent Sci. 2015; 4 (54): 9336-9346. Available from: https://dx.doi.org/10.14260/jemds/2015/1357.
5. Catalano C, Fraioli F, Laghi A, Napoli A, Bezzi M, Pediconi F, et al. Infrarenal Aortic and Lower-Extremity Arterial Disease: Diagnostic Performance of Multi-Detector Row CT Angiography. Radiology. 2004; 231 (2): 555 - 563. Available from: https://dx.doi.org/ 10.1148/ radiol.2312020920.
6. Bueno DA, Acín F, Cañibano DC, Fernandez-Casado JL, Castillo E. Diagnostic Accuracy of Contrast-Enhanced Magnetic Resonance Angiography and Duplex Ultrasound in Patients with Peripheral Vascular Disease. Vasc Endo vasc Surg. 2010; 44 (7): 576-585. Available from: https:// dx. doi. org/ 10.1177/ 153857 4410 377018.
7. Willmann JK, Baumert B, Schertler T, et al. Aortoiliac and lower extremity arteries assessed with 16-detector row CT angiography: prospective comparison with digital subtraction angiography. Radiology. 2005; 236:1083-93. doi:10.1148/radiol.2362040895.
8. Ubbink DT, Fidler M, Legemate DA. Inter observer variability in aortoiliac and femoropopliteal duplex scanning. J Vasc Surg. 2001 Mar 1; 33(3):540-5.
9. Polak JF, Karmel MI, Mannick JA, O'Leary DH, Donaldson MC, Whitte more AD. Determination of the extent of lower-extremity peripheral arterial disease with color-assisted duplex sonography: comparison with angiography.AJR Am J Roentgenol. 1990 Nov; 155 (5): 1085-9.
10. Algazzar MAA, Elzawawi MSE, Alhawary KES, Mousa WA. Role of multi - detector computed tomography angiography in the evaluation of lower limb ischemia. Int J Med Imag. 2014;2(5):125-30.

11. Catalano C, Fraioli F, Laghi A, Napoli A, Bezzi M, Pediconi F, et al. Infrarenal aortic and lower extremity arterial disease: diagnostic performance of multi-detector row CT angiography. Radiol. 2004 May; 231 (2):555-63.
12. Willmann JK, Baumert B, Schertler T, Wildermuth S, Pfammatter T, Verdun FR, et al. Aortoiliac and lower extremity arteries assessed with 16-detector row CT angiography: prospective comparison with digital subtraction angiography. Radiol. 2005 Sep; 236(3):1083-93.
13. Schernthaner R, Stadler A, Lomoschitz F, Weber M, Fleischmann D, Lammer J, et al. Multi-detector CT angiography in the assessment of peripheral arterial occlusive disease: accuracy in detecting the severity, number and length of stenoses. EurRadiol. 18:665-71.
14. Wintersperger B, Jakobs T, Herzog P, Schaller S, Nikolaou K, Suess C, et al. Aorto-iliac multidetector-row CT angiography with low kV settings: improved vessel enhancement and simultaneous reduction of radiation dose. Eur Radiol.
15. Tendera M, Aboyans V, Bartelink ML, Baumgartner I, Clément D, Collet JP, et al. ESC Guidelines on the diagnosis and treatment of peripheral artery diseases: Document covering atherosclerotic disease of extra cranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries: The Task Force on the Diagnosis and Treatment of Peripheral Artery Diseases of the European Society of Cardiology (ESC).Eur Heart J. 2011; 32(22):2851-906.
16. Aysert Yıldız P, Özdil T, Dizbay M, Güzel Tunçcan Ö, Hızel K. Peripheral arterial disease increases the risk of multidrug-resistant bacteria and amputation in diabetic foot infections. Turk J Med Sci. 2018; 48 (4): 845-50.
17. Yuksel A, Velioglu Y, Cayir MC, Kumtepe G, Gurbuz O. Current Status of Arterial Revascularization for the Treatment of Critical Limb Ischemia in Infrainguinal Atherosclerotic Disease. Int J Angiol. 2018; 27 (3):132-7.
18. Tan MNA, Lo ZJ, Lee SH, Teo RM, Tan WLG, Chandrasekar S. Review of Trans metatarsal Amputations in the Management of Peripheral Arterial Disease in an Asian Population. Ann Vasc Dis. 2018; 11(2):210-6.
19. AbdelRazek AA, Denewer AT, Hegazy MA, et al. Role of computed tomography angiography in the diagnosis of vascular stenosis in head and neck micro vascular free flap reconstruction. Int J Oral Maxillofac Surg. 2014; 43:811-5.
20. Algazzar MA, Elzawawi MS, Alhawary KE, et al. Role of multi - detector computed tomography angiography in the evaluation of lower limb ischemia. Int J Med Imaging. 2014;2(5):125-30.
21. Kandasamy G, Maithrayee A, Kailasanathan N. Lower limb arteries assessed with Doppler angiography: a prospective comparative study with multi detector CT angiography. Inter J Latest Res Sci Technol. 2015; 4(6): 70-83.

22. Shirol RJ, Shetty A, Chethan TK. Role of MDCT in evaluation of peripheral vascular disease of the lower limb arteries and comparison with colour Doppler. J Evol Med Dental Sci. 2015;4(54):9336-46.