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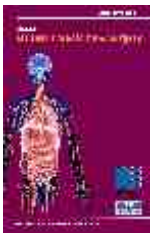

Research Article

Section:

Relationship of Femoral Artery Ultrasound Measures of Atherosclerosis in Chronic Kidney Disease: Assessing Atherosclerosis in CKD Via fiMT

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HIGHLIGHTS

- Femoral intima-media thickness indicates atherosclerosis
- CKD patients show increased FIMT values
- Ultrasound helps early vascular assessment
- Strong correlation between CKD and atherosclerosis
- Non-invasive tool for risk stratification.

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ABSTRACT

Background: Chronic kidney disease (CKD) substantially elevates the risk of cardiovascular complications, including peripheral arterial disease (PAD). However, the traditional method for PAD screening the ankle-brachial index (ABI)—may be less effective in CKD patients due to vascular calcification, which can compromise with the sensitivity of the test. Given this limitation, the study investigates femoral artery intima-media thickness (fIMT) as a potential early marker of atherosclerosis in individuals with CKD. **Methods:** A prospective observational study was conducted at Kempegowda Institute of Medical Sciences between April and September 2024. The study included 50 CKD patients under 50 years of age who underwent lower limb Doppler ultrasonography. Femoral artery intima-media thickness and the presence of plaques were assessed using a high-frequency ultrasound probe. The ABI was calculated for each patient, and renal function was evaluated using estimated glomerular filtration rate (eGFR). Additional clinical and demographic data including diabetes, hypertension, and smoking status were recorded. **Results:** Among the 50 participants, 18% showed increased femoral IMT, while 40% had detectable femoral artery plaques. The presence of plaques was more common in males, diabetics, hypertensives, and smokers. A significant positive correlation was observed between plaque formation and declining eGFR levels. Importantly, some patients with normal ABI values still demonstrated plaque presence on ultrasound, indicating that ABI alone may miss early or subclinical PAD in CKD populations. **Conclusion:** Femoral artery ultrasonography proved valuable in identifying early atherosclerotic changes in CKD patients, especially in cases where ABI results were within the normal range. These findings suggest that measuring fIMT and detecting plaques via ultrasound can serve as effective, non-invasive methods for early PAD detection in CKD, potentially enabling earlier intervention and improved cardiovascular risk management in this high-risk group.

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INTRODUCTION

Chronic kidney disease (CKD) is a significant global health issue, marked by the gradual and often irreversible loss of kidney function. It contributes substantially to morbidity and mortality worldwide. According to several studies, CKD is estimated to affect approximately 800 individuals per million population, with prevalence expected to rise due to aging populations and increasing incidence of diabetes and hypertension. CKD is not only a renal disorder but also a major cardiovascular risk factor, and patients with CKD frequently experience cardiovascular events at a much higher rate than the general population. Among the many cardiovascular complications seen in CKD, atherosclerosis plays a central role [1-3].

Atherosclerosis is characterized by the accumulation of lipids, calcium, and inflammatory cells within the arterial walls, leading to thickening and reduced elasticity of the vessels. In CKD patients, the progression of atherosclerosis is often more aggressive due to both traditional risk factors—such as hypertension, diabetes mellitus, and dyslipidemia—and non-traditional risk factors, including chronic inflammation, oxidative stress, endothelial dysfunction, and disturbances in calcium-phosphate metabolism. Importantly, CKD is closely linked with peripheral arterial disease (PAD), and both conditions independently contribute to an elevated risk of cardiovascular morbidity and mortality. PAD in CKD patients is often underdiagnosed, yet it significantly impacts functional status and quality of life while increasing the risk of adverse cardiovascular outcomes [4,5].

Traditionally, the ankle-brachial pressure index (ABPI) has served as the standard screening tool for the detection of PAD. ABPI compares the blood pressure in the ankle with that in the arm to detect blockages or narrowing in the peripheral arteries. However, while ABPI is widely used due to its simplicity and non-invasive nature, it may not reliably detect early or subclinical forms of PAD. This limitation is particularly pronounced in patients with CKD, who commonly present with stiff and calcified peripheral arteries. The calcification leads to non-compressible vessels, thereby producing falsely elevated ABPI readings and reducing the sensitivity of the test in identifying early atherosclerotic changes [6,7].

Given these diagnostic challenges, the focus has shifted to imaging-based techniques for assessing subclinical atherosclerosis. One such method involves measuring intima-media thickness (IMT) through ultrasonography. Carotid intima-media thickness (cIMT) has been extensively studied and has been associated with declining renal function in numerous studies. However, despite the strong evidence linking cIMT with CKD progression, limited research has been conducted on femoral artery intima-media thickness (fIMT), which may also serve as a reliable marker of systemic atherosclerosis. In fact, some studies have suggested that the femoral artery may reveal subclinical atherosclerotic changes earlier and more frequently than the carotid artery. The femoral artery, being a muscular artery located in the lower extremity, is particularly susceptible to atherosclerotic plaque deposition in high-risk individuals, including those with CKD [8,9].

The use of femoral Doppler ultrasonography allows for the direct visualization and measurement of fIMT, enabling clinicians to assess early vascular changes and detect atherosclerotic plaque formation. Given the limited data on the relationship between femoral artery changes and renal function, there is a compelling need to explore this association further. This study aims to evaluate the femoral intima-media thickness and its correlation with the presence of atherosclerosis in patients with chronic kidney disease using Doppler ultrasonography. By identifying early arterial changes, this approach may allow for timely intervention and better cardiovascular risk stratification in the CKD population [10,11].

Moreover, the findings of such research could significantly improve the early detection and management of peripheral arterial disease in CKD patients. Early identification of atherosclerotic changes, particularly in the femoral arteries, could guide therapeutic decisions aimed at slowing cardio-vascular disease progression. Ultimately, this would enhance overall outcomes and reduce cardiovascular morbidity and mortality in this vulnerable patient group. Therefore, assessing atherosclerosis via femoral IMT in CKD patients may represent a valuable addition to the diagnostic tools available for cardiovascular risk evaluation in nephrology practice [12].

MATERIAL AND METHODS

This prospective observational study was conducted at the Department of Radiodiagnosis at Kempegowda Institute of Medical Sciences, Bangalore from April 2024 to September 2024. Ethical approval has been obtained from the Ethical Approval Committee of Kempegowda Institute of Medical Sciences, Bangalore.

Study Population

This study include total of 50 patients diagnosed with chronic kidney disease (CKD), all under the age of 50 years, were enrolled. Patients with a history of above- or below-knee amputation or those already receiving treatment for peripheral arterial disease (PAD) were excluded. All participants underwent lower limb Doppler ultrasonography to evaluate femoral artery intima-media thickness (fIMT) and detect plaque formation. Serum creatinine was measured to estimate glomerular filtration rate (eGFR), and ankle-brachial index (ABI) was calculated using systolic blood pressure from brachial and ankle arteries.

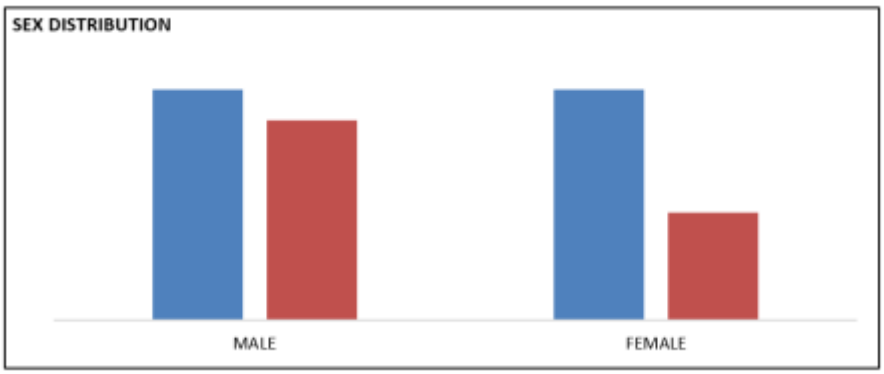
Data Analysis

In this study, data analysis was performed using appropriate

statistical methods, where continuous variables were expressed as mean and standard deviation, and categorical variables as frequencies. Associations between clinical characteristics like diabetes, hypertension, smoking, and atherosclerotic findings were evaluated using Chi-square or Fisher's exact test. ANOVA and correlation regression were applied for comparing quantitative variables, and a p-value of less than 0.05 was considered statistically significant to determine relevant clinical associations in the CKD population.

RESULTS

A prospective study of 50 chronic kidney disease (CKD) cases revealed that 56% of the patients were male and 44% were female. Among the male patients, 46% showed the presence of plaque, while 32% of the female patients had plaque, indicating a higher prevalence of plaque among males in this study population.

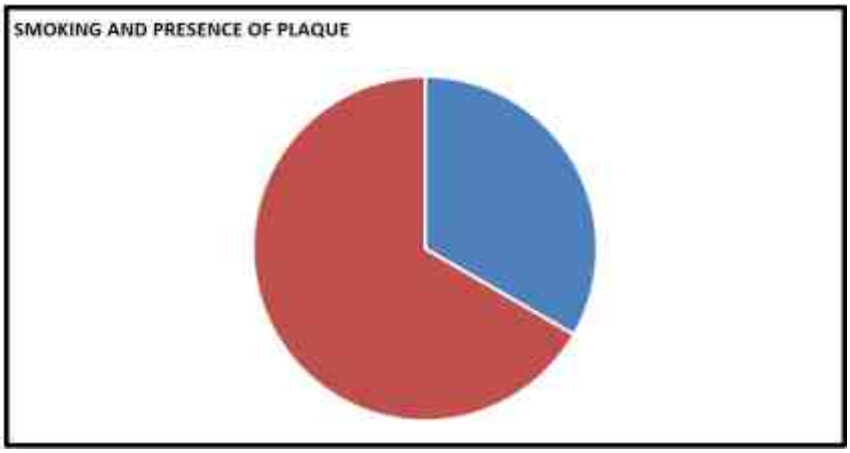


Graph: 1 Sex distribution

Table 1 : Smoking and Plaque Presence

Smoking Status	Number of Patients	Plaque Presence	Percentage
Smoker	12 (24%)	8	66%
Non-Smoker	38 (76%)	12	31.6%

Graph 2 : Smoking and presence of plaque

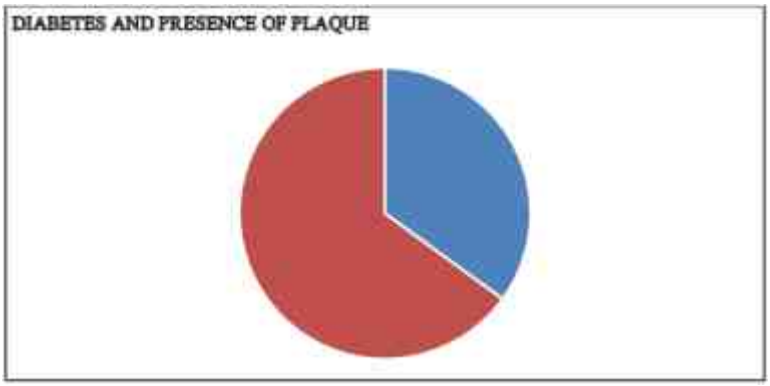


Out of 50 CKD patients, 24% were smokers and 76% were non-smokers; plaque was present in 66% of smokers compared to 31.6% of non-smokers, indicating a higher plaque prevalence among smokers.

Table 2 : Diabetes and Plaque Presence

Diabetes Status	Number of Patients	Plaque Presence	Increased IMT	Plaque %
Diabetic	20 (40%)	13	7	65%
Non-Diabetic	30 (60%)	7	2	23.3%

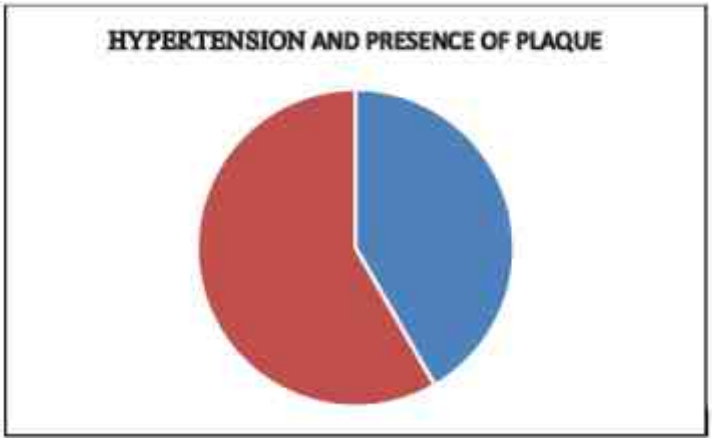
Graph 3 : Diabetes and presence of plaque



Among 50 CKD patients, 40% were diabetic and 60% were non-diabetic; plaque was present in 65% of diabetics versus 23.3% of non-diabetics, with increased IMT observed in 7 diabetic and 2 non-diabetic patients.

Table 3: Hypertension and Plaque Presence

Hypertension Status	Number of Patients	Plaque Presence	Increased IMT	Plaque %
Hypertensive	24 (48%)	14	5	58%
Non-Hypertensive	26 (52%)	6	4	23.1%



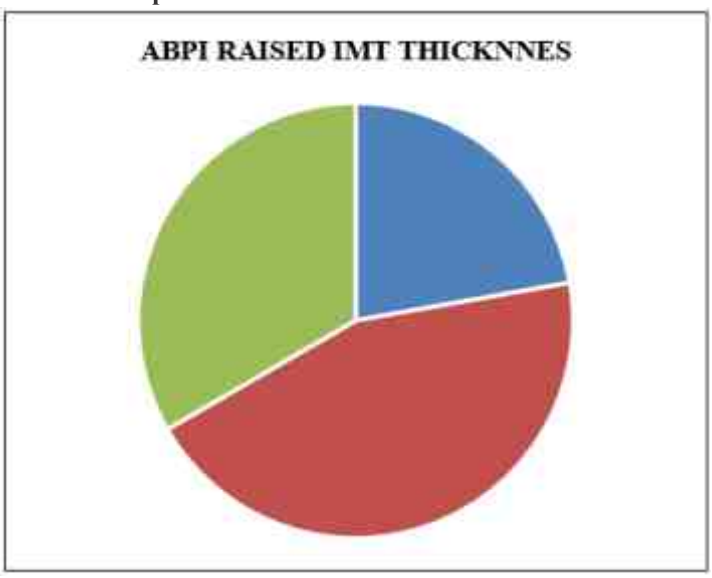
Graph 4: Hypertension and presence of plaque

Among 50 CKD patients, 48% were hypertensive and 52% were non-hypertensive; plaque was present in 58% of hypertensive patients compared to 23.1% of non-hypertensive patients, with increased IMT observed in 5 and 4 patients, respectively.

Table 4: ABPI and Increased IMT

ABPI Category	Number of Patients	Description
Low ABPI	18 (36%)	Increased IMT seen in some
Medium ABPI	19 (38%)	Most plaques fall here
High ABPI	13 (26%)	High IMT in many cases

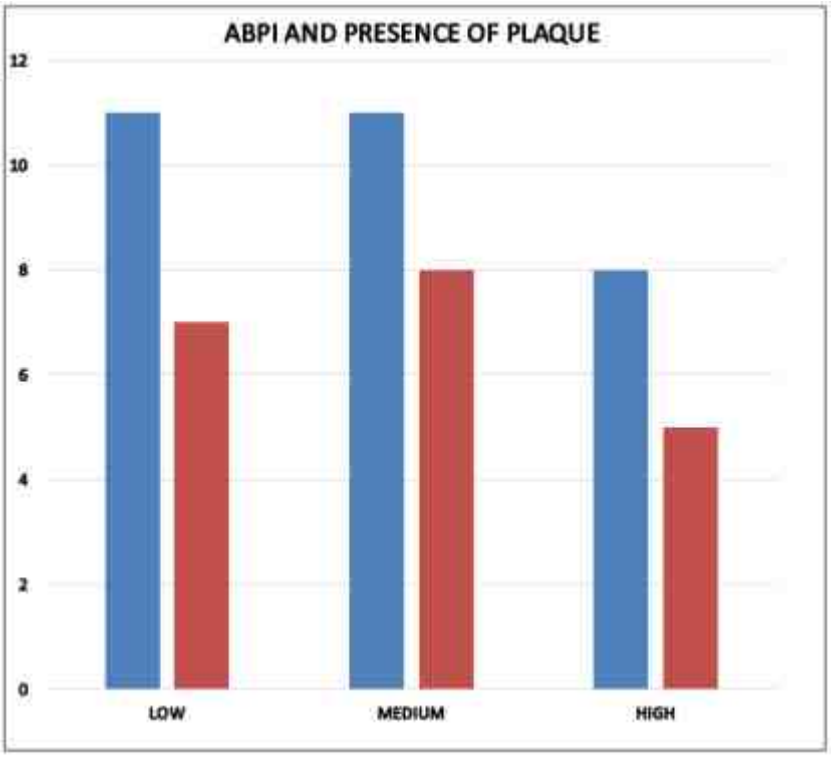
Graph 5 : ABPI and increased IMT thickness



Among 50 CKD patients, 36% had low ABPI with increased IMT in some, 38% had medium ABPI where most were observed, and 26% had high ABPI with high IMT noted in many cases

Table 5: ABPI and Plaque Presence

	Plaque Absence	Plaque Presence	Total
Low	11	7	18
Medium	11	8	19
High	8	5	13

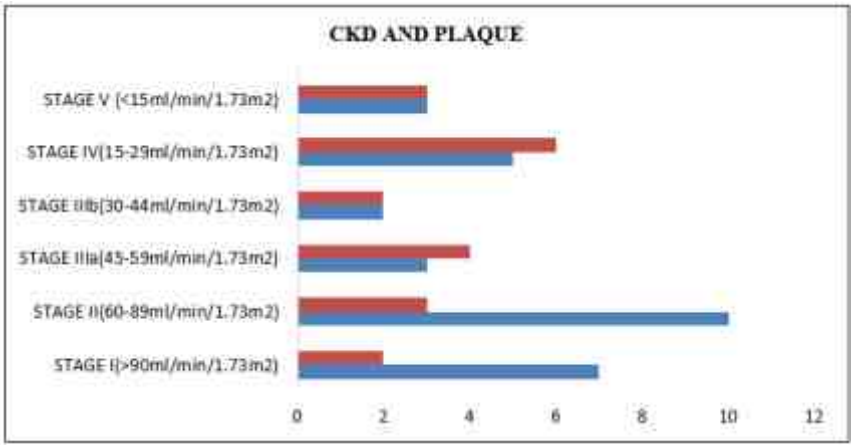


Graph 6 : ABPI and plaque presence

Among 50 CKD patients, plaque presence was observed in 7 of 18 with low ABPI, 8 of 19 with medium ABPI, and 5 of 13 with high ABPI, indicating plaque distribution across all ABPI levels with a slightly higher occurrence in the medium category

Table 6: CKD Stage and eGFR Distribution

	eGFR Range (mL/min/1.73m²)	No. of Patients	Percentage
Stage I	>90	9	18%
Stage II	60–89	13	26%
Stage IIIa	45–59	7	14%
Stage IIIb	30–44	4	8%
Stage IV	15–29	11	22.22%
Stage V	<15	6	12%

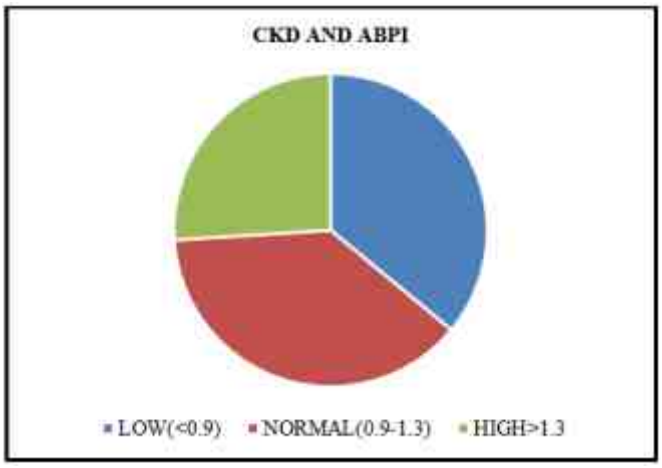


Graph 7 : CKD Stage and eGFR Distribution

Among 50 CKD patients, 18% were in Stage I (eGFR >90), 26% in Stage II (60–89), 14% in Stage IIIa (45–59), 8% in Stage IIIb (30–44), 22.22% in Stage IV (15–29), and 12% Stage V (eGFR <15), showing a wide distribution across all stages with the highest proportion in Stage II.

Table 7: CKD and ABPI Categories

ABPI Range	Number of Patients	Percentage
Low (<0.9)	18	36%
Normal (0.9–1.3)	19	38%
High (>1.3)	13	26%



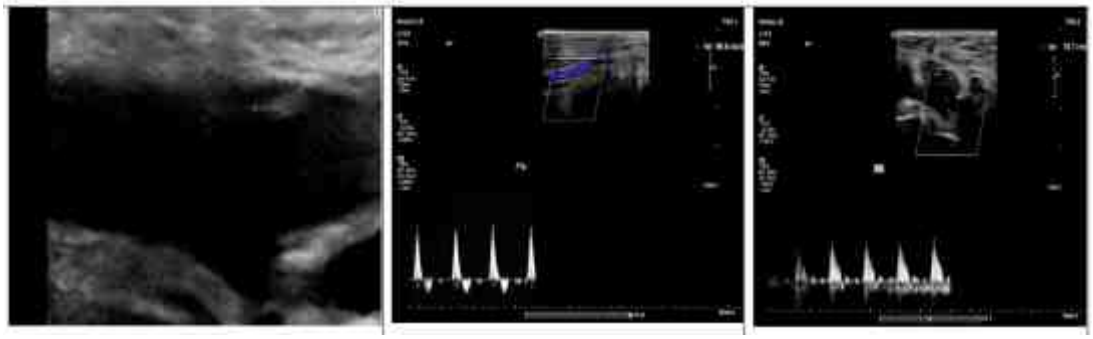
Graph 8: CKD and ABPI Categories

Among 50 CKD patients, 36% had low ABPI (<0.9), 38% had normal ABPI (0.9–1.3), and 26% had high ABPI (>1.3), indicating that abnormal ABPI values were present in a significant portion of the study population.

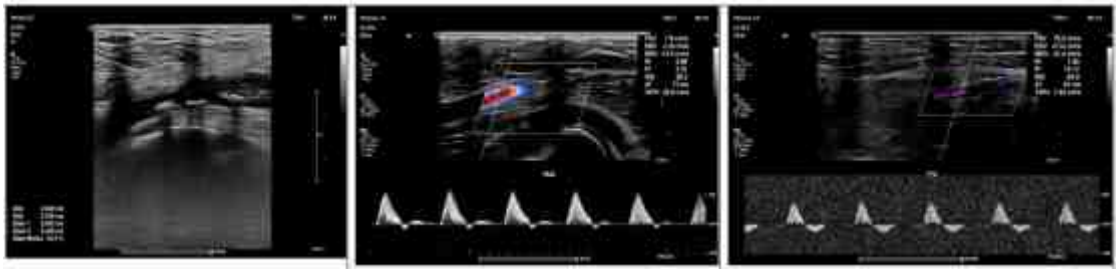
REPRESENTATIVE CASES

AGE/SEX	HT	WT	DIABETES	Hte	SMOKING	S.Cret	EGFR	STAGE OF CKD	PTA PSV	BRACHIAL PSV	ABPI	PLAQUE PRESENCE	FEMORAL INT
42/F	167	71	YES	YES	NO	1.3	54	IIIa	86	77	1.2(NORMAL)	NONE	0.1(NORMAL)
48/M	169	66	NO	YES	YES	0.9	92	I	76	115	0.6(LOW)	PRESENT	0.7(NORMAL)

Case-1



Case-2



DISCUSSION

The present study highlights the relationship between femoral artery ultrasound measures and subclinical atherosclerosis in patients with chronic kidney disease (CKD), specifically focusing on the role of femoral intima-media thickness (fIMT) and plaque detection. Given the limitations of traditional diagnostic tools like the ankle-brachial index (ABI), which may be rendered less reliable in CKD patients due to arterial calcification, this investigation presents a compelling case for the use of Doppler ultrasonography in early atherosclerotic evaluation. Garimella PS, et. al; 2014 indicated a substantial prevalence of atherosclerosis among CKD patients,

reinforcing the hypothesis that CKD is closely intertwined with vascular pathology, and particularly with peripheral arterial disease (PAD) [13,14].

In this study, the femoral artery was selected as the imaging target for atherosclerosis evaluation due to its anatomical susceptibility to early plaque formation. Among the 50 patients evaluated, 40% exhibited femoral artery plaques, and 18% had increased fIMT. These values, although modest, gain significance when considering the relatively young age of the study cohort (all under 50 years), suggesting early onset vascular changes in CKD. Males showed a higher prevalence of plaques (46%) compared to females (32%), consistent with the broader literature that identifies male sex as a cardiovascular risk factor. Similarly, higher plaque prevalence was observed among smokers (66%), diabetics (65%), and hypertensives (58%), underscoring the cumulative impact of traditional cardiovascular risk factors in the CKD population [15].

The observed correlation between declining estimated glomerular filtration rate (eGFR) and increased plaque burden aligns with prior studies, such as the NEFRONA study, which demonstrated an incremental rise in subclinical atheromatosis with advancing CKD stages. In the present analysis, plaque prevalence peaked at Stage IIIa (57%) and Stage IV (54%), reinforcing the concept that vascular injury in CKD is progressive and exacerbated as renal function deteriorates. Interestingly, even patients in Stage I and II exhibited notable plaque prevalence (22% and 23%, respectively), suggesting that vascular changes may precede significant renal function decline [16].

ABI, a widely used screening tool for PAD, demonstrated limited sensitivity in this cohort. Plaques were identified in patients across all ABI categories, including those with normal ABI values (42%), highlighting the potential for missed diagnoses if relying on ABI alone. In fact, plaque prevalence was notable even in patients with high ABI (62%), a value typically associated with non-compressible arteries and vascular stiffness, both common in CKD. Sillesen H, et. al; 2012 reinforced the hypothesis that ABI, though useful in general populations, may not be sufficiently reliable in CKD patients, thus justifying the exploration of imaging-based alternatives such as fIMT assessment via ultrasound [17,18].

Femoral IMT was found to be increased in 35% of diabetic patients and 20% of hypertensive patients, pointing toward the synergistic effect of metabolic and vascular stressors in promoting arterial wall thickening. The study also showed a higher prevalence of plaques among smokers (66%), a well-documented vascular toxin. These associations strengthen the clinical argument for intensified cardiovascular risk management in CKD patients with co-existing metabolic disorders or smoking history. Interestingly, although 9 out of 50 patients showed increased IMT, 20 were found to have plaques, indicating that plaque detection might be a more sensitive marker of atherosclerosis than IMT alone in this patient population [19].

The study's cross-sectional design provides a valuable snapshot of the vascular health in patients with chronic kidney disease (CKD), though it carries limitations in determining cause-and-effect relationships. Dasmahapatra P, et. al; 2011 supported the hypothesis that subclinical atherosclerosis is both common and frequently underdiagnosed in individuals with CKD. The observed prevalence of vascular plaques aligns with previously reported trends, reinforcing the idea that these results are not isolated but represent a broader pattern of increased atherosclerotic burden in the CKD population [20].

The potential clinical application of these findings is significant. Doppler ultrasound, being non-invasive, cost-effective, and easily repeatable, can be a valuable tool in the nephrologist's diagnostic arsenal, especially for early cardiovascular risk stratification. Identifying subclinical plaques could allow for the initiation of preventive therapies before the manifestation of overt cardiovascular disease. In particular, targeting high-risk groups such as diabetics, hypertensives, and smokers with early intervention could significantly reduce the burden of cardiovascular events in the CKD population [21].

This study underscores the limitations of ABI in detecting early PAD in CKD patients and advocates for the integration of femoral artery ultrasound as a more sensitive alternative. The high prevalence of plaque even among patients with normal ABI and early-stage CKD supports the urgency for revisiting cardiovascular screening protocols in nephrology. Incorporating fIMT and plaque evaluation into routine clinical practice may facilitate earlier identification of at-risk individuals, thus improving cardiovascular outcomes through timely management strategies. The evidence presented makes a strong case for larger, multicentric, longitudinal studies to further elucidate the prognostic value of femoral artery imaging in chronic kidney disease [22,23].

CONCLUSION

This study revealed a high rate of atherosclerosis in chronic kidney disease (CKD) patients, particularly among older adults and males. Ultrasound-detected femoral artery plaques were independently linked to lower estimated glomerular filtration rate (eGFR), suggesting a connection between vascular damage and declining kidney function. Importantly, this relationship was present even in patients with normal ankle-brachial index (ABI) readings, indicating that femoral artery ultrasound may detect early atherosclerosis missed by ABI alone. These findings support the use of femoral artery ultrasonography as an effective tool for early detection and management of cardiovascular risk in CKD patients.

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