



Original Article


A Study on Clinical Profile of Patients Undergoing CT Coronary Angiography at a Tertiary Care Hospital

Dr Raveendra N Mudiyanavara¹, Dr. K M Prabhuswamy², Dr Supriya A S³

¹Assistant Professor, Department of General Medicine, Shimoga Institute of Medical Sciences Shimoga Karnataka -577204

²Associate Professor, Department of General Medicine, Chamarajanagar Institute of Medical Sciences, Chamarajanagar Karnataka

³Assistant Professor, Department of Radiodiagnosis, subbaiah Institute of Medical Sciences, NH-13 H H Road, Purle, shimoga-577222 Karnataka

 OPEN ACCESS

Corresponding Author:

Dr Supriya A S

Assistant Professor, Department of Radiodiagnosis, subbaiah Institute of Medical Sciences, NH-13 H H Road, Purle, shimoga-577222 Karnataka

Received: 17-05-2026

Accepted: 08-06-2026

Available online: 23-06-2026

ABSTRACT

Background: Coronary artery disease (CAD) remains the leading cause of cardiac morbidity and mortality worldwide. Noninvasive imaging techniques, including coronary artery calcium scoring (CACS) and coronary computed tomography angiography (CTCA), are being used with increasing frequency to assess patients with suspected CAD. Calcium scoring gives an estimate of the calcified plaque burden. CTCA allows direct visualization of coronary artery stenosis and plaque morphology. The aim of the present study was to evaluate the clinical profile of symptomatic patients undergoing CT coronary angiography and to assess the diagnostic utility of coronary artery calcium scoring in relation to coronary artery disease burden.

Materials and Methods: A descriptive observational study was done in the Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysore, from January 2019 to August 2021. We included 45 symptomatic patients with referral for CT coronary angiography. All patients underwent coronary artery calcium scoring and contrast-enhanced CT coronary angiography on a 128-slice dual energy CT scanner. We analyzed demographic characteristics, cardiovascular risk factors, coronary artery calcium score, plaque morphology, vessel involvement and severity of stenosis. Diagnostic performance parameters for coronary artery calcium scoring were calculated and calcium scores were compared between obstructive and non-obstructive CAD.

Results: The mean age of the study population was 49.5 ± 16 years and 64.4% of patients were males. The most frequent symptom at presentation was chest pain (56%). The most frequent cardiovascular risk factors were hypertension and smoking (33% each). Coronary artery disease was found in 28 of 45 patients (62%) by CT coronarography. 22 patients had coronary calcification and 23 patients (51%) had a zero calcium score. The most commonly involved vessel was the left anterior descending artery (48%). Non-calcified plaques were the most common plaque morphology (53%) followed by calcified plaques (34%) and mixed plaques (13%). Of the patients with a calcium score of zero, nine had coronary artery disease and six had severe stenosis. Coronary artery calcium scoring had a sensitivity of 66.67%, specificity of 94.44%, positive predictive value of 94.74%, negative predictive value of 65.38% and diagnostic accuracy of 77.78%. Calcium score category was not significantly associated with obstructive coronary artery disease ($\chi^2 = 2.35$, $p = 0.503$).

Discussion: In this study we have shown that CT coronary angiography identified significant coronary artery disease in a large proportion of symptomatic patients including those with a calcium score of zero. The preponderance of non-calcified plaques and the presence of severe stenosis in patients without detectable coronary calcification highlight the limitations of calcium scoring as a stand-alone diagnostic tool. Similar observations have been published by Parsons et al and Cademartiri et al

They showed that absence of coronary calcification does not exclude obstructive coronary artery disease. The results highlight the better performance of CT coronary angiography in the assessment of plaque burden, plaque morphology and stenosis severity and consequently a more complete evaluation of coronary atherosclerosis.

Conclusion: CT coronary angiography is a valuable non-invasive imaging modality for the comprehensive evaluation of coronary artery disease. However, a zero calcium score does not exclude significant obstructive coronary artery disease and coronary artery calcium scoring alone may underestimate disease burden. CT coronary angiography is an important imaging modality in symptomatic patients with suspected coronary artery disease because of the superior diagnostic information it provides on plaque morphology, plaque burden and severity of stenosis.

Keywords: Coronary artery disease, CT coronary angiography, coronary artery calcium score, Agatston score, coronary plaque, coronary stenosis.

INTRODUCTION

Coronary artery disease (CAD) is a pathological process involving the coronary arteries that leads to narrowing or complete occlusion of the vascular lumen. The most common cause of the disease is atherosclerosis, a chronic inflammatory disease characterized by accumulation of cholesterol, lipid deposits, inflammatory cells and fibrous tissue within the arterial wall. Progressive plaque formation causes luminal narrowing and reduction of myocardial blood supply and eventually myocardial ischemia and infarction [1].

Coronary artery disease remains one of the biggest health problems in the world. Ischemic heart disease remains the leading etiology of death and premature mortality in the world with an estimated nine million deaths yearly worldwide [1]. The burden of CAD is increasing steadily in developing countries due to urbanization, sedentary lifestyles, smoking, diabetes mellitus, obesity, hypertension and dyslipidemia [1,5].

The pathophysiology of coronary artery disease is characterized by endothelial injury, lipid infiltration, inflammatory activation, smooth muscle proliferation, and finally plaque formation. Calcium gets deposited in the atherosclerotic lesions as the plaques progress. Coronary artery calcification is therefore considered as a marker of atherosclerotic disease and is rarely seen in normal coronary arteries [2]. Coronary artery calcification is very specific for atherosclerosis but does not necessarily reflect the severity of luminal obstruction [2].

Calcification can be found in both obstructive and non-obstructive plaques. Thus, the extent of coronary calcium at a specific site does not necessarily reflect the degree of stenosis. The relationship between coronary calcification and luminal narrowing is not a linear one and plaque composition, plaque remodeling and disease progression influence this relationship as shown in studies [3]. Therefore, although coronary artery calcium scoring has utility in cardiovascular risk assessment, it may not be an accurate reflection of the total burden of coronary artery disease.

Calcified and non-calcified plaques are often found together, which is an important concept in modern cardiovascular imaging. Non-calcified plaques are often lipid-rich and prone to rupture, and are important contributors to acute coronary syndromes. Calcium scoring alone does not detect the presence of other non-calcified plaques, which are more likely to be present in patients with coronary calcification [4]. Therefore, a sole reliance on coronary artery calcium scoring may lead to an underestimation of the true disease burden.

There are several non-invasive imaging modalities currently available for assessment of coronary artery disease. These include exercise treadmill testing, stress echocardiography, myocardial perfusion imaging, single-photon emission computed tomography (SPECT), cardiac magnetic resonance imaging (MRI), coronary artery calcium scoring and coronary CT angiography [6]. These investigations are important in identifying patients at risk for coronary artery disease and in guiding subsequent management.

Invasive coronary angiography has been considered the gold standard for diagnosis of coronary artery disease. Invasive angiography provides better visualisation of coronary luminal anatomy but it is associated with a procedural risk, hospitalisation, vascular complications, contrast-related adverse effects and increased healthcare costs. Hence, there has been a growing interest in reliable non-invasive alternatives that can provide similar diagnostic information [7].

CT coronary angiography (CTCA) is a non-invasive imaging modality that has been developed due to the advances in multidetector computed tomography technology and is effective for evaluation of coronary arteries. Modern CT scanners have excellent spatial and temporal resolution and thus allow detailed visualization of coronary arteries, plaque morphology and luminal stenosis [8].

Coronary computed tomography angiography has several advantages over conventional calcium scoring. Besides quantification of coronary calcification, CTCA allows for direct visualization of calcified, non-calcified and mixed plaques. It allows the assessment of plaque composition, plaque burden, vessel remodeling, coronary anomalies, coronary dominance and stenosis severity [13]. In addition, CTCA can identify plaque features that confer vulnerability to rupture and are associated with future cardiovascular events, thereby improving risk stratification and clinical decision making [15,16].

Coronary CT angiography has demonstrated high diagnostic performance in several studies. This modality has demonstrated very good sensitivity and negative predictive value for ruling out significant coronary artery disease, and is therefore very useful in symptomatic patients with a low to intermediate pretest probability of CAD [8,13]. Thus, CTCA is increasingly being integrated into modern diagnostic algorithms for the evaluation of chest pain and suspected coronary artery disease.

However, despite the increasing use of coronary CT angiography in clinical practice, data on the clinical profile and CTCA findings in symptomatic Indian patients are still relatively limited. Furthermore, the correlation between coronary artery calcium scoring and the actual burden of coronary artery disease remains under investigation. Determining the prevalence of coronary artery disease, plaque morphology, vessel involvement and severity of stenosis in symptomatic patients may help improve diagnostic strategies and optimize patient selection.

Hence, this study was designed to evaluate the clinical profile of symptomatic patients undergoing CT coronary angiography in a tertiary care teaching hospital and to determine the diagnostic utility of coronary artery calcium scoring in comparison with CT coronary angiographic findings.

AIMS AND OBJECTIVES

Primary Objective

To determine the diagnostic yield of coronary artery calcium scoring and CT coronary angiography in symptomatic patients undergoing evaluation for coronary artery disease.

Secondary Objectives

1. To evaluate the clinical profile of patients undergoing CT coronary angiography.
2. To assess coronary artery plaque morphology and distribution.
3. To determine the pattern of coronary artery involvement among patients with coronary artery disease.
4. To compare Agatston coronary artery calcium scores in patients with obstructive and non-obstructive coronary artery disease.
5. To evaluate the diagnostic accuracy of coronary artery calcium scoring in predicting coronary artery disease detected on CT coronary angiography.

MATERIALS AND METHODS

Study Design

The present study was a hospital-based descriptive observational study conducted to evaluate the clinical profile and coronary CT angiographic findings among symptomatic patients referred for evaluation of suspected coronary artery disease.

Study Setting

The study was conducted in the Department of Radiodiagnosis, Mysore Medical College and Research Institute (MMCRI), Mysore, Karnataka, India.

Study Period

The study was carried out over a period of 18 months from January 2019 to August 2021.

Source of Data

The study population consisted of symptomatic patients referred to the hospitals attached to Mysore Medical College and Research Institute for CT coronary angiography during the study period. Patients were referred primarily for evaluation of suspected coronary artery disease based on clinical symptoms and cardiovascular risk profile.

Sample Size

A total of 45 patients were included in the study.

The sample size was calculated using the formula:

$$n = \frac{4PQ}{d^2}$$

where:

- **P** = prevalence of coronary artery disease evaluated by CT coronary angiography (7.8%)

- $Q = 100 - P$
- d = allowable error

The sample size calculation was based on a confidence level of 95%, statistical power of 80%, and precision of 8%. The final calculated sample size was 45 patients.

Sampling Technique

Purposive sampling technique was employed for patient selection.

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

1. Symptomatic patients presenting with symptoms suggestive of coronary artery disease.
2. Patients referred for CT coronary angiography.
3. Patients willing to provide written informed consent.

The most common symptom among study participants was chest pain.

Exclusion Criteria

Patients were excluded if they met any of the following criteria:

1. Known hypersensitivity to iodinated contrast agents.
2. Deranged renal function tests.
3. Pregnant women.

Ethical Considerations

Institutional ethical approval was obtained before commencement of the study. Written informed consent was obtained from all participants after explaining the purpose of the study, imaging procedure, benefits, and potential risks.

Patient confidentiality was maintained throughout the study.

DATA COLLECTION

A detailed clinical history was obtained from each participant before imaging evaluation.

Demographic details and cardiovascular risk factors were recorded using a structured questionnaire incorporated into the clinical research form.

The following information was documented:

- Age
- Sex
- Presenting symptoms
- Diabetes mellitus
- Hypertension
- Treatment for hypertension
- Dyslipidemia
- Smoking status
- Family history of coronary artery disease
- Relevant clinical history

All patients underwent detailed clinical examination and routine laboratory investigations before CT coronary angiography.

CT CORONARY ANGIOGRAPHY PROTOCOL

All examinations were performed using a:

SIEMENS SOMATOM DEFINITION EDGE 128-SLICE DUAL ENERGY CT SCANNER

Both coronary artery calcium scoring and CT coronary angiography were performed during the same imaging session.

Patient Preparation

Patients were instructed to remain fasting for 4–6 hours before the examination.

Prior to scanning:

- Renal function tests were reviewed and confirmed to be within normal limits.
- Baseline heart rate and blood pressure were recorded.
- Electrocardiographic monitoring was established.

Heart rate optimization was performed to improve image quality.

Beta-Blocker Administration

Most patients received beta-blockers for heart rate control.

If the heart rate exceeded 72 beats per minute at the time of scanning, intravenous metoprolol was administered immediately before image acquisition.

Vasodilatation

A sublingual nitroglycerin tablet was administered immediately before the scan to achieve coronary vasodilatation and improve visualization of coronary arteries.

CORONARY ARTERY CALCIUM SCORING

An ECG-gated non-contrast CT scan was initially obtained from the level of the carina to the diaphragm. Coronary artery calcium scoring was performed using the **Agatston scoring method**, which remains the standard method for quantifying coronary artery calcification. Based on Agatston score, patients were classified into the following categories:

Table 1. Classification of Coronary Artery Calcium Score

Agatston Score	Interpretation
0	No coronary calcification
10–99	Mild calcification
100–400	Moderate calcification
>400	Severe calcification

CONTRAST-ENHANCED CT CORONARY ANGIOGRAPHY

Following completion of the calcium score examination, contrast-enhanced coronary CT angiography was performed.

Contrast Administration

A nonionic iodinated contrast agent was administered using a pressure injector.

Contrast Protocol

Parameter	Value
Contrast Volume	100 mL
Injection Rate	5 mL/sec
Saline Chaser	40 mL
Saline Flow Rate	5 mL/sec

BOLUS TRACKING TECHNIQUE

To optimize timing of image acquisition, bolus tracking was performed. The region of interest (ROI) was placed in the descending thoracic aorta at the level of the pulmonary artery bifurcation. Image acquisition was automatically triggered when the attenuation threshold reached 100 Hounsfield Units (HU). Monitoring commenced after a delay of six seconds.

CT ACQUISITION PARAMETERS

The following imaging parameters were utilized:

Table 2. CT Scan Acquisition Parameters

Parameter	Value
Tube Voltage	100 kVp
Tube Current	20 mAs
Gantry Rotation Time	0.33 sec
Collimation	0.6 mm
Slice Thickness	0.65 mm

SCANNING TECHNIQUE

The examination consisted of three imaging phases:

1. Scanogram

A scanogram was obtained during suspended inspiration. This scan was used to determine the field of view and anatomical coverage for subsequent image acquisition.

2. Non-Contrast CT Scan

A non-enhanced ECG-gated scan was obtained for coronary artery calcium scoring. The scan extended from the carina to the diaphragm and was acquired during suspended inspiration.

3. Contrast-Enhanced CT Coronary Angiography

The field of view was selected from just distal to the coronary ostia to the cardiac apex, ensuring adequate coverage and minimizing respiratory motion artifacts.

Image acquisition was performed using ECG gating and bolus tracking.

ECG GATING TECHNIQUE

Retrospective ECG Gating

Retrospective ECG gating was used for the majority of patients.

This technique enabled image reconstruction at multiple phases of the cardiac cycle and facilitated assessment of coronary arteries during periods of minimal motion.

Prospective ECG Gating

Prospective ECG gating was utilized in patients with heart rates less than 60 beats per minute to reduce radiation exposure.

IMAGE RECONSTRUCTION

Raw imaging data were transferred to a dedicated workstation for post-processing.

Images were reconstructed at a slice thickness of 0.65 mm in multiple phases of the cardiac cycle.

The optimal systolic and diastolic phases demonstrating the least motion artifact were selected for interpretation.

The following post-processing techniques were employed:

1. Multiplanar Reformation (MPR)

Used for detailed evaluation of coronary arteries in different planes.

2. Curved Multiplanar Reformation (Curved MPR)

Enabled visualization of the entire coronary artery course within a single image.

3. Maximum Intensity Projection (MIP)

Improved visualization of vascular structures and coronary calcifications.

4. Volume Rendering Technique (VRT)

Provided three-dimensional assessment of coronary anatomy and vessel relationships.

IMAGE ANALYSIS

Each coronary artery was analyzed segment by segment for the presence of:

- Atherosclerotic plaque
- Coronary calcification
- Luminal stenosis
- Plaque morphology
- Coronary dominance
- Anatomical variations

The following coronary arteries were evaluated:

- Left Main Coronary Artery (LMCA)
- Left Anterior Descending Artery (LAD)
- Left Circumflex Artery (LCX)
- Right Coronary Artery (RCA)
- Diagonal branches
- Marginal branches
- Posterior Descending Artery (PDA)
- Ramus Intermedius (RI)

PLAQUE CHARACTERIZATION

Plaques identified on CT coronary angiography were classified into three categories:

Calcified Plaque

Plaques composed predominantly of calcified components with high attenuation.

Non-Calcified Plaque

Plaques consisting predominantly of soft tissue attenuation without visible calcification.

Mixed Plaque

Plaques containing both calcified and non-calcified components.

STENOSIS ASSESSMENT

The degree of luminal narrowing was evaluated and categorized into five grades.

Table 3. Grading of Coronary Artery Stenosis

Grade	Severity
Grade 1	Minimal stenosis
Grade 2	Mild stenosis
Grade 3	Moderate stenosis
Grade 4	Severe stenosis
Grade 5	Complete occlusion

For analytical purposes:

- **Non-obstructive CAD** included minimal and mild stenosis.
- **Obstructive CAD** included moderate, severe, and occlusive lesions.

OUTCOME MEASURES

The primary outcomes assessed were:

1. Presence of coronary artery disease.
2. Coronary artery calcium score.
3. Plaque morphology.
4. Coronary vessel involvement.
5. Degree of stenosis.

Secondary outcomes included:

1. Relationship between coronary artery calcium score and coronary artery disease.
2. Diagnostic performance of coronary artery calcium scoring.
3. Comparison of calcium scores in obstructive and non-obstructive CAD.

STATISTICAL ANALYSIS

Data were entered into Microsoft Excel and analyzed using appropriate statistical methods.

Categorical variables were expressed as frequencies and percentages.

Continuous variables were summarized using means and standard deviations where applicable.

Diagnostic performance of coronary artery calcium scoring was evaluated using:

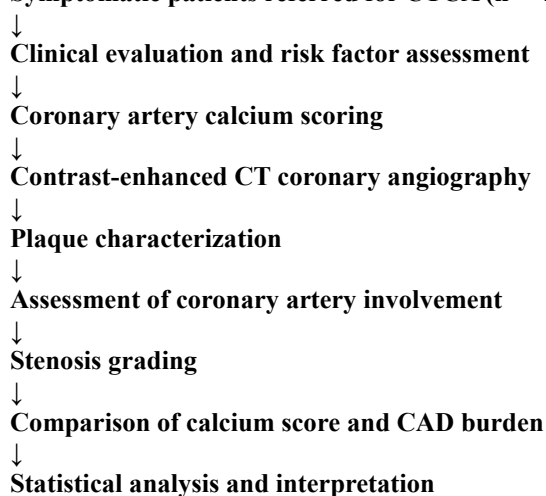
- Sensitivity
- Specificity
- Positive Predictive Value (PPV)
- Negative Predictive Value (NPV)
- Accuracy
- Positive Likelihood Ratio
- Negative Likelihood Ratio

Chi-square test was used to compare calcium score categories between obstructive and non-obstructive coronary artery disease.

A p-value less than 0.05 was considered statistically significant.

STUDY FLOW CHART

Symptomatic patients referred for CTCA (n = 45)



RESULTS

Overview of Study Population

A total of 45 symptomatic patients referred for CT coronary angiography (CTCA) were included in the study. All patients underwent coronary artery calcium scoring followed by contrast-enhanced CT coronary angiography. Demographic characteristics, cardiovascular risk factors, plaque morphology, vessel involvement, coronary artery calcium score, and stenosis severity were analyzed.

BASELINE CHARACTERISTICS OF THE STUDY POPULATION

Sex-wise Distribution

Among the 45 patients included in the study, 29 (64.4%) were males and 16 (35.6%) were females.

Table 4. Sex-wise Distribution of Study Population

Sex	Frequency	Percentage (%)
Male	29	64.4
Female	16	35.6
Total	45	100

Interpretation

Male patients constituted nearly two-thirds of the study population, indicating a higher prevalence of symptomatic coronary artery disease among men.

Age-wise Distribution

The study population ranged from 30 to 70 years of age. The mean age was **49.5 years**. The majority of patients belonged to the 40–60-year age group.

Table 5. Age-wise Distribution of Study Population

Age Group (Years)	Frequency	Percentage (%)
<40	9	20
40–49	14	31
50–60	15	33
>60	7	16
Total	45	100

Interpretation

Patients aged 40–60 years accounted for 64% of the study population, indicating that clinically significant coronary artery disease was most common in middle-aged individuals.

INDICATIONS FOR CT CORONARY ANGIOGRAPHY

Chest pain was the most common indication for referral for CT coronary angiography.

Table 6. Distribution of Patients According to Clinical Presentation

Symptom	Frequency	Percentage (%)
Chest pain	25	56
Breathing difficulty	9	20
Palpitations	4	9
Multiple risk factors	3	7
Diaphoresis	2	4
Easy fatigability	1	2
Nausea	1	2

Interpretation

Chest pain was the predominant presenting complaint, accounting for more than half of all referrals. Dyspnea represented the second most common indication.

CARDIOVASCULAR RISK FACTOR PROFILE

Hypertension, smoking, diabetes mellitus, and dyslipidemia were found to be almost equally prevalent among the study population.

Table 7. Distribution of Risk Factors Among Patients Referred for CTCA

Risk Factor	Frequency	Percentage (%)
Hypertension	15	33

Smoking	15	33
Diabetes Mellitus	14	31
Dyslipidemia	13	28

Interpretation

Hypertension and smoking were the most prevalent risk factors, followed closely by diabetes mellitus and dyslipidemia, indicating a substantial burden of modifiable cardiovascular risk factors among symptomatic patients.

CT CORONARY ANGIOGRAPHY FINDINGS

Presence of Coronary Artery Disease

Among the 45 patients who underwent CT coronary angiography, coronary artery disease was identified in 28 patients (62%), while 17 patients (38%) had no detectable coronary artery plaque.

Table 8. Presence of Coronary Artery Disease

Coronary Artery Disease	Frequency	Percentage (%)
Present	28	62
Absent	17	38
Total	45	100

Interpretation

Nearly two-thirds of symptomatic patients demonstrated evidence of coronary atherosclerotic disease on CT coronary angiography.

CORONARY ARTERY CALCIUM SCORE

Coronary artery calcium scoring was performed in all patients using the Agatston scoring method.

Table 9. Distribution of Coronary Artery Calcium Score

Agatston Score	Frequency	Percentage (%)
Zero	23	51
Mild (10–99)	14	31
Moderate (100–400)	8	18
Severe (>400)	0	0
Total	45	100

Interpretation

More than half of the patients demonstrated a calcium score of zero despite being symptomatic. Coronary calcification was identified in 22 patients, and the mean calcium score among calcified patients was 90.

AGE-WISE DISTRIBUTION OF CORONARY ARTERY PLAQUE

Table 10. Age-wise Distribution of Coronary Artery Disease

Age Group	Frequency	Percentage (%)
<40 years	4	14
40–49 years	9	32
50–60 years	9	32
>60 years	6	22
Total	28	100

Interpretation

The highest burden of coronary artery disease was observed among patients aged 40–60 years, accounting for nearly two-thirds of all CAD cases.

SEX-WISE DISTRIBUTION OF CORONARY ARTERY DISEASE

Table 11. Sex-wise Distribution of CAD

Sex	Frequency	Percentage (%)
Male	20	71
Female	8	29
Total	28	100

Interpretation

Coronary artery disease was considerably more common among males than females.

RISK FACTOR PROFILE AMONG PATIENTS WITH CAD

Table 12. Distribution of Risk Factors Among Patients with Coronary Artery Disease

Risk Factor	Frequency
Smoking	14
Diabetes Mellitus	10
Dyslipidemia	10
Hypertension	8

Interpretation

Smoking emerged as the most common risk factor among patients with coronary artery disease, followed by diabetes mellitus and dyslipidemia.

DISTRIBUTION OF ATHEROSCLEROTIC PLAQUE IN CORONARY ARTERIES

Among patients with coronary artery disease, the left anterior descending artery (LAD) was the most commonly involved vessel.

Table 13. Distribution of Coronary Artery Involvement

Vessel	Frequency	Percentage (%)
LAD	24	48
RCA	9	18
LMCA	8	16
LCX	7	14
Diagonal	1	2
Ramus Intermedius	1	2
Marginal	0	0
PDA	0	0

Interpretation

The LAD was involved in nearly half of all coronary lesions, followed by the RCA and LMCA.

CORONARY DOMINANCE

Table 14. Coronary Dominance Pattern

Dominance	Frequency	Percentage (%)
Right Dominance	35	78
Left Dominance	10	22
Total	45	100

Interpretation

Right coronary dominance was the predominant pattern observed in the study population.

PRESENCE OF RAMUS INTERMEDIUS

Table 15. Presence of Ramus Intermedius

Status	Frequency	Percentage (%)
Present	12	27
Absent	33	73
Total	45	100

Interpretation

Ramus intermedius was identified in approximately one-fourth of patients.

PLAQUE MORPHOLOGY

Table 16. Plaque Characterization on CT Coronary Angiography

Plaque Morphology	Frequency	Percentage (%)
Non-calcified	24	53
Calcified	16	34
Mixed	6	13
Total	46*	100

*Some patients had plaques of more than one morphology.

Interpretation

Non-calcified plaque was the most common plaque type identified, accounting for more than half of all plaques detected.

STENOSIS CAUSED BY NON-CALCIFIED PLAQUES

Table 17. Stenosis Severity in Non-Calcified Plaques

Grade	Frequency	Percentage (%)
Minimal	5	21
Mild	4	16
Moderate	7	29
Severe	7	29
Occluded	1	4
Total	24	100

Interpretation

Moderate-to-severe stenosis accounted for 58% of lesions associated with non-calcified plaques.

STENOSIS CAUSED BY CALCIFIED PLAQUES

Table 18. Stenosis Severity in Calcified Plaques

Grade	Frequency	Percentage (%)
Minimal	11	69
Mild	3	19
Moderate	1	6
Severe	1	6
Total	16	100

Interpretation

Calcified plaques were predominantly associated with minimal stenosis.

STENOSIS CAUSED BY MIXED PLAQUES

Table 19. Stenosis Severity in Mixed Plaques

Grade	Frequency	Percentage (%)
Mild	1	17
Moderate	2	33
Severe	3	50
Total	6	100

Interpretation

Mixed plaques demonstrated the highest proportion of severe stenosis, indicating a greater tendency toward clinically significant disease.

DIAGNOSTIC PERFORMANCE OF CORONARY ARTERY CALCIUM SCORING

Table 20. Correlation of Coronary Artery Disease and Presence of Coronary Artery Calcification

Parameter	Value
True Positive	18
False Positive	1
False Negative	9
True Negative	17

Table 21. Diagnostic Accuracy of Coronary Artery Calcium Scoring

Statistic	Value
Sensitivity	66.67%
Specificity	94.44%
Positive Predictive Value	94.74%
Negative Predictive Value	65.38%
Positive Likelihood Ratio	12.00
Negative Likelihood Ratio	0.35
Accuracy	77.78%

Interpretation

Coronary artery calcium scoring demonstrated high specificity (94.44%) and positive predictive value (94.74%) but only moderate sensitivity (66.67%). These findings indicate that while the presence of coronary calcification strongly predicts coronary artery disease, absence of calcification does not reliably exclude disease.

CORONARY ARTERY CALCIUM SCORE IN OBSTRUCTIVE AND NON-OBSTRUCTIVE CAD

Table 22. Comparison of Calcium Score Between Obstructive and Non-Obstructive CAD

Calcium Score	Non-Obstructive CAD (n=10)	Obstructive CAD (n=18)
Zero	2 (20%)	7 (39%)
Mild (10–99)	6 (60%)	6 (33%)
Moderate (100–400)	2 (20%)	4 (22.5%)
Severe (>400)	0	1 (5.5%)

Statistical Analysis

- Chi-square = 2.3506
- Degrees of Freedom = 3
- p = 0.503

Interpretation

No statistically significant association was observed between calcium score category and the presence of obstructive coronary artery disease (p = 0.503). A notable finding was that seven patients with obstructive CAD had a calcium score of zero.

KEY FINDINGS OF THE STUDY

1. Coronary artery disease was detected in 62% of symptomatic patients.
2. The mean age of patients was 49.5 years.
3. Coronary calcification was present in 22 patients with a mean calcium score of 90.
4. LAD was the most commonly involved coronary artery.
5. Non-calcified plaque was the predominant plaque morphology.
6. Moderate-to-severe stenosis was predominantly associated with non-calcified and mixed plaques.
7. Nine patients with a calcium score of zero had coronary artery disease.
8. Six patients with a calcium score of zero demonstrated severe stenosis (70–99%).
9. Coronary artery calcium scoring showed high specificity but only moderate sensitivity.
10. No significant association was observed between Agatston score and obstructive coronary artery disease (p = 0.503).

DISCUSSION

Despite the great advances in preventive cardiology, diagnostic imaging and revascularization strategies, coronary artery disease (CAD) remains the main cause of cardiovascular morbidity and mortality worldwide [1]. Timely intervention and adequate risk stratification are essential for the early detection of coronary atherosclerosis, which can substantially decrease cardiovascular events and enhance survival. Coronary computed tomography angiography (CTCA) has emerged as a useful non-invasive imaging technique that can provide detailed information on coronary anatomy, plaque morphology and luminal stenosis, in the last few years. In this study we examined the clinical profile of symptomatic patients undergoing CT coronary angiography and the diagnostic value of coronary artery calcium scoring in relation to the burden of coronary artery disease.

The study population consisted of 45 symptomatic patients with a mean age of 49.5 years. The predominant age range of the patients was 40–60 years, accounting for about two-thirds of the study group. This is consistent with the natural history of atherosclerosis which develops gradually over decades prior to clinical presentation. Similar age distributions have been reported in previous reports on CT coronary angiography, where middle-aged patients were the predominant population evaluated for suspected coronary artery disease [7,18].

The current study showed a definite male preponderance. Males constituted 64.4% of the total study population and 71% of the patients diagnosed with coronary artery disease. This is consistent with previous epidemiological studies that have shown a higher prevalence of CAD in men, particularly before the sixth decade of life [1,5]. The higher incidence in males may be related to earlier exposure to cardiovascular risk factors, lifestyle differences, and the cardioprotective effects of estrogen in premenopausal women. Similar findings have been reported by Min et al and other investigators in the evaluation of coronary artery disease by multidetector CT angiography [7].

The most common presenting symptom was chest pain (56% of all referrals for CT coronary angiography). The second common indication was dyspnea (20%). These findings are consistent with current clinical practice, where chest pain remains the primary symptom prompting investigation for coronary artery disease [13]. Current European Society of Cardiology and National Institute for Health and Care Excellence guidelines recommend CT coronary angiography as an appropriate first-line imaging modality in patients presenting with stable chest pain and suspected coronary artery disease due to its high sensitivity and excellent negative predictive value [13].

The present study revealed the high prevalence of traditional cardiovascular risk factors. Hypertension and smoking were found in 33% of patients each, followed by diabetes mellitus (31%) and dyslipidemia (28%). These findings are consistent with the known pathophysiological role of these risk factors in promoting endothelial dysfunction, oxidative stress, lipid accumulation and plaque progression [5,6]. The INTERHEART study demonstrated that smoking, hypertension, diabetes and dyslipidemia represent the majority of the risk of myocardial infarction worldwide [16]. The high prevalence of these risk factors in patients in this study further emphasizes their importance in the development of coronary artery disease.

In 28 of the 45 patients (62%) coronary artery disease was present. This finding underscores the large disease burden of atherosclerosis in symptomatic patients undergoing CT coronary angiography. Corresponding prevalence rates were reported in studies assessing symptomatic patients with intermediate pretest probability for CAD [18,19]. The main advantage of CT coronary angiography over functional testing techniques is that it can detect obstructive and non-obstructive disease, while functional testing techniques may not identify early atherosclerotic lesions.

A significant finding in the current study was that over half of the patients (51%) had a coronary artery calcium score of 0. A classical association of a zero calcium score has been low probability of coronary artery disease and good cardiovascular prognosis [12]. The present study, however, clearly shows that the absence of coronary calcification does not exclude significant coronary atherosclerosis per se. Nine patients with coronary artery disease had a calcium score of zero and six of these patients had severe coronary stenosis. These results highlight the limitations of coronary artery calcium scoring as a stand-alone diagnostic tool.

Analysis of diagnostic performance showed sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of coronary artery calcium scoring of 66.67%, 94.44%, 94.74%, 65.38%, and 77.78%, respectively. The high specificity in the present study indicates that presence of coronary calcification is highly predictive of underlying coronary artery disease. However, the relatively low sensitivity means that a substantial proportion of patients with CAD may not have detectable coronary calcification.

These findings align with those reported by Parsons et al. who found that coronary artery calcium scoring has excellent specificity for coronary atherosclerosis but lacks sensitivity to rule out clinically significant disease. In their study, they found that non-calcified plaques are commonly associated with significant coronary stenosis despite the absence of detectable coronary calcification. This means that calcium scoring alone may underestimate the real burden of coronary artery disease.

Similarly, Cademartiri et al. reported that patients with a calcium score of zero may still have significant coronary plaques that can be visualized on CT coronary angiography. They found that non-calcified plaques constitute an important part of coronary atherosclerosis and could play a significant role in coronary stenosis even in the absence of coronary calcification. The current study observations are similar to these findings and contribute to the growing evidence that calcium scoring alone is not reliable for excluding obstructive coronary artery disease.

Analysis of coronary vessel involvement revealed that the most frequent involved vessel was the LAD, comprising 48% of all lesions. This finding is in agreement with previous angiographic and CT angiographic studies that have shown a predilection for atherosclerotic plaque formation in the LAD [7,20]. The LAD perfuses a large area of the myocardium and is subjected to significant hemodynamic stress, making it particularly prone to atherosclerotic disease. Clinically, significant LAD stenosis is associated with adverse cardiovascular events and a higher risk of myocardial infarction.

Assessment of coronary dominance revealed a right dominance in 78 % of patients and a left dominance in 22 % which is consistent with the normal anatomical distribution described in the general population [21]. Ramus intermedius was present in 27% of patients, being a common anatomical variant seen in coronary imaging.

The characterization of plaque morphology was one of the most clinically relevant findings in the present study. The most prevalent plaque subtype was non-calcified plaques (53% of all detected plaques). Calcified plaques accounted for 34 percent, mixed plaques 13 percent. These results are clinically relevant since non-calcified plaques are often associated with plaque vulnerability and acute coronary syndromes [15,16]. Histopathological studies have shown that lipid rich plaques with thin fibrous caps are prone to rupture and thrombosis even if the luminal narrowing is only moderate [22].

Assessment of stenosis severity by plaque morphology demonstrated significant differences. Calcified plaques were the main cause of minimal stenosis, whereas non-calcified plaques were frequently associated with moderate-to-severe stenosis. Mixed plaques had the highest percentage of severe stenosis, with 50% causing severe narrowing of the lumen. These results are consistent with the results published by Pflederer et al. and Nakazato et al. who showed a strong association between mixed plaque morphology and clinically significant coronary artery disease [15,16].

Comparison of calcium score categories between obstructive and non-obstructive CAD showed no statistically significant difference (Chi-square=2.35, p=0.503). This suggests Agatston calcium score alone was not a good predictor of obstructive

coronary artery disease in the present study population. Importantly, 7 patients with obstructive CAD had zero calcium score. This observation further supports the notion that calcification is only one component of the atherosclerotic process and that significant luminal stenosis may exist in the absence of detectable calcium deposits.

The results of the present study provide strong support for the complementary role of CT coronary angiography and coronary artery calcium scoring. Although calcium scoring is useful for prognosis based on calcified plaque burden and assessment of cardiovascular risk, CT coronary angiography allows a more complete visualization of the coronary arterial tree, including non-calcified plaques, mixed plaques, vessel remodeling and the severity of stenosis. Therefore, CT coronary angiography provides considerably more diagnostic information than calcium scoring alone.

In conclusion, the present study confirms the high value of CT coronary angiography as a non-invasive imaging modality for evaluation of symptomatic patients with suspected coronary artery disease. The study also emphasizes the limitations of coronary artery calcium scoring and the need for a complete evaluation of coronary arteries using contrast-enhanced CT coronary angiography.

Strengths of the Study

1. Use of a 128-slice dual-energy CT scanner enabled high-resolution coronary imaging.
2. Both calcium scoring and CT coronary angiography were performed in all patients.
3. Detailed assessment of plaque morphology, vessel involvement, and stenosis severity was undertaken.
4. Diagnostic performance of coronary artery calcium scoring was systematically evaluated.

Limitations of the Study

1. Relatively small sample size (n = 45).
2. Single-center study design.
3. Lack of routine invasive coronary angiography for confirmation in all patients.
4. Absence of long-term follow-up to evaluate cardiovascular outcomes.
5. Advanced plaque vulnerability markers were not assessed.

The findings nevertheless provide important evidence regarding the clinical utility of CT coronary angiography and the limitations of calcium scoring in symptomatic patients with suspected coronary artery disease.

CONCLUSION

The present study evaluated the clinical profile and coronary CT angiographic findings among symptomatic patients undergoing assessment for suspected coronary artery disease at a tertiary care hospital. Coronary artery disease was identified in 62% of patients undergoing CT coronary angiography, indicating a substantial burden of atherosclerotic disease among symptomatic individuals.

The study population was predominantly male, with a mean age of 49.5 years, and the majority of patients belonged to the 40–60-year age group. Chest pain was the most common presenting symptom, while hypertension, smoking, diabetes mellitus, and dyslipidemia constituted the major cardiovascular risk factors.

Coronary artery calcium scoring demonstrated high specificity (94.44%) and positive predictive value (94.74%) but only moderate sensitivity (66.67%) and negative predictive value (65.38%) for detection of coronary artery disease. These findings indicate that the presence of coronary calcification strongly predicts coronary artery disease; however, the absence of calcification does not reliably exclude significant coronary atherosclerosis.

A particularly important observation was the presence of coronary artery disease in nine patients with a calcium score of zero, six of whom demonstrated severe coronary stenosis. Furthermore, no statistically significant association was observed between Agatston calcium score and obstructive coronary artery disease ($\chi^2 = 2.35$, $p = 0.503$). These findings suggest that coronary artery calcium scoring alone may underestimate the true burden of coronary artery disease.

The left anterior descending artery was the most commonly involved coronary vessel, while non-calcified plaques represented the predominant plaque morphology. Non-calcified and mixed plaques were more frequently associated with clinically significant stenosis than calcified plaques.

Overall, CT coronary angiography proved to be a highly valuable non-invasive imaging modality that provided comprehensive information regarding coronary artery anatomy, plaque morphology, vessel involvement, and stenosis severity. Compared with calcium scoring alone, CT coronary angiography offered superior diagnostic assessment and more accurate estimation of coronary artery disease burden.

CLINICAL IMPLICATIONS

The findings of the present study have several important clinical implications:

1. Coronary artery calcium scoring should not be used as the sole diagnostic modality in symptomatic patients with suspected coronary artery disease.
2. Significant obstructive coronary artery disease may be present despite a calcium score of zero.
3. CT coronary angiography provides additional diagnostic information regarding plaque burden and plaque composition that cannot be obtained through calcium scoring alone.
4. Identification of non-calcified and mixed plaques is important because these plaques are more frequently associated with clinically significant stenosis and future cardiovascular events.
5. CT coronary angiography can improve patient risk stratification and facilitate timely therapeutic decision-making.
6. The study supports the increasing use of CT coronary angiography as a first-line imaging modality for evaluation of symptomatic patients with suspected coronary artery disease.

LIMITATIONS OF THE STUDY

The present study has certain limitations:

1. The study was conducted at a single tertiary care center, which may limit generalizability of the findings.
2. The sample size was relatively small (45 patients).
3. Invasive coronary angiography was not available in all patients for direct comparison with CT coronary angiography findings.
4. Long-term follow-up data regarding cardiovascular outcomes were not available.
5. Advanced plaque vulnerability characteristics such as positive remodeling index, napkin-ring sign, and low attenuation plaque were not systematically evaluated.

Despite these limitations, the study provides valuable insights into the clinical utility of CT coronary angiography and the diagnostic limitations of coronary artery calcium scoring.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. Larger multicentric studies should be conducted to validate the findings of the present study.
2. Longitudinal studies evaluating cardiovascular outcomes based on plaque morphology should be undertaken.
3. Future studies should incorporate advanced plaque characterization techniques and quantitative plaque analysis.
4. Comparative studies between CT coronary angiography, invasive coronary angiography, and functional imaging modalities would further clarify diagnostic performance.
5. Artificial intelligence-based coronary plaque quantification may improve diagnostic accuracy and risk prediction in future cardiovascular imaging research.

ACKNOWLEDGEMENTS

The authors acknowledge the Department of Radiodiagnosis, Mysore Medical College and Research Institute, Mysore, for providing technical support and infrastructure necessary for conducting this study. The authors are grateful to all study participants for their cooperation.

Author Contributions

Dr Raveendra N Mudiyyammanavara: Conceptualization, study design, data acquisition, data analysis and interpretation, manuscript drafting, and final approval of the manuscript.

Dr K M Prabhuswamy: Methodology, supervision, interpretation of results, critical revision of the manuscript for important intellectual content, and final approval of the manuscript.

Dr Supriya A S: Literature review, data curation, validation of results, manuscript editing and critical revision, and final approval of the manuscript.

All authors contributed substantially to the work, reviewed the manuscript critically, approved the final version for publication, and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to this study.

FUNDING

No external funding was received for this study.

ETHICAL APPROVAL

The study was conducted after obtaining approval from the Institutional Ethics Committee of Mysore Medical College and Research Institute. Written informed consent was obtained from all participants prior to enrollment.

REFERENCES

1. Khan MA, Hashim MJ, Mustafa H, Baniyas MY, Al Suwaidi SKBM, AlKatheeri R, et al. Global epidemiology of ischemic heart disease: Results from the Global Burden of Disease Study. *Cureus*. 2020;12(7):e9349.

2. Wexler L, Brundage B, Crouse J, Detrano R, Fuster V, Maddahi J, et al. Coronary artery calcification: Pathophysiology, epidemiology, imaging methods, and clinical implications. *Circulation*. 1996;94(5):1175–1192.
3. Falk E, Shah PK, Fuster V. Coronary plaque disruption. *Circulation*. 1995;92(3):657–671.
4. Beckman JA, Ganz J, Creager MA, Ganz P, Kinlay S. Relationship of clinical presentation and calcification of culprit coronary artery stenoses. *Arterioscler Thromb Vasc Biol*. 2001;21(10):1618–1622.
5. Sayols-Baixeras S, Lluís-Ganella C, Lucas G, Elosua R. Pathogenesis of coronary artery disease: Focus on genetic risk factors and identification of genetic variants. *Appl Clin Genet*. 2014;7:15–32.
6. Peters SAE, den Ruijter HM, Bots ML, Moons KGM. Improvements in risk stratification for cardiovascular disease by imaging subclinical atherosclerosis: A systematic review. *Heart*. 2012;98(3):177–184.
7. Sandfort V, Lima JAC, Bluemke DA. Noninvasive imaging of atherosclerotic plaque progression: Status of coronary computed tomography angiography. *Circ Cardiovasc Imaging*. 2015;8(7):e003316.
8. Schoepf UJ, Zwerner PL, Savino G, Herzog C, Kerl JM, Costello P. Coronary CT angiography. *Radiology*. 2007;244(1):48–63.
9. Shuman WP, Branch KR, May JM, Mitsumori LM, Lockhart DW, Dubinsky TJ, et al. Prospective versus retrospective ECG gating for 64-detector CT of the coronary arteries: Comparison of image quality and patient radiation dose. *Radiology*. 2008;248(2):431–437.
10. Desjardins B, Kazerooni EA. ECG-gated cardiac CT. *AJR Am J Roentgenol*. 2004;182(4):993–1010.
11. Arjmand Shabestari A. Coronary artery calcium score: A review. *Iran Red Crescent Med J*. 2013;15(12):e16616.
12. Raff GL, Abidov A, Achenbach S, Berman DS, Boxt LM, Budoff MJ, et al. SCCT guidelines for the interpretation and reporting of coronary computed tomographic angiography. *J Cardiovasc Comput Tomogr*. 2009;3(2):122–136.
13. Pfleiderer T, Marwan M, Schepis T, Ropers D, Seltmann M, Muschiol G, et al. Characterization of culprit lesions in acute coronary syndromes using coronary dual-source CT angiography. *Atherosclerosis*. 2010;211(2):437–444.
14. Nakazato R, Otake H, Konishi A, Iwasaki M, Koo BK, Fukuya H, et al. Atherosclerotic plaque characterization by CT angiography for identification of high-risk coronary artery lesions: A comparison with optical coherence tomography. *Eur Heart J Cardiovasc Imaging*. 2014;15(4):373–379.
15. Tian J, Ren X, Vergallo R, Xing L, Yu H, Jia H, et al. Distinct morphological features of ruptured culprit plaques for acute coronary events compared with silent rupture and thin-cap fibroatheroma. *J Am Coll Cardiol*. 2014;63(21):2209–2216.
16. Pundziute G, Schuijf JD, Jukema JW, Decramer I, Sarno G, Vanhoenacker PK, et al. Head-to-head comparison of coronary plaque evaluation between multislice computed tomography and intravascular ultrasound radiofrequency data analysis. *JACC Cardiovasc Interv*. 2008;1(2):176–182.
17. Hur J, Kim YJ, Lee HJ, Nam JE, Choe KO, Seo JS, et al. Quantification and characterization of obstructive coronary plaques using 64-slice computed tomography: A comparison with intravascular ultrasound. *J Comput Assist Tomogr*. 2009;33(2):186–192.
18. Kohsaka S, Makaryus AN. Coronary angiography using noninvasive imaging techniques of cardiac CT and MRI. *Curr Cardiol Rev*. 2008;4(4):323–330.
19. Meijboom WB, Meijjs MF, Schuijf JD, Cramer MJ, Mollet NR, van Mieghem CA, et al. Diagnostic accuracy of 64-slice computed tomography coronary angiography: A prospective multicenter study. *J Am Coll Cardiol*. 2008;52(25):2135–2144.
20. Parsons A, Witberg G, Miller JM, Hulten EA. Coronary artery calcium scoring and the detection of obstructive coronary artery disease: Current evidence and limitations. *J Cardiovasc Comput Tomogr*. 2017;11(2):123–130.
21. Cademartiri F, Maffei E, Palumbo A, Martini C, Seitun S, Tedeschi C, et al. Diagnostic accuracy of coronary CT angiography in patients with a zero calcium score. *Int J Cardiovasc Imaging*. 2010;26(4):437–445.
22. James TN. Anatomy of the coronary arteries. *Circulation*. 1965;32(6):1020–1033.