Original Article

EVALUATION OF CHRONIC TOTAL OCCLUSION OF CORONARY ARTERY BY 64 SLICE MDCT BEFORE A PLANNED PCI

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ABSTRACT

BACKGROUND AND OBJECTIVE:Sixty-Four slice Multi-Detector Computed Tomography (MDCT) evaluation of Chronic Total Occlusion (CTO) appears to be a new tool for planning the procedural strategy for PCI and thereby increasing its success rate.

MDCT is done to define the lesion length, plaque morphology, calcium content and thus we can plan our strategy before going in for PCI to a CTO artery.

MATERIAL AND METHODS:Thirty-five patients who had elective coronary angiography following ACS and CTO of the at least single coronary artery was identified &they were referred for 64 Slice MDCT for evaluation of CTO vessel. MDCT was done in patients having sinus rhythm and heart rate of 60-70 /min. Patients having Serum creatinine of >1.5 mg/dl and inability to hold breath were excluded

RESULTS:Mean age was 53.84 ± 8.4 years. Mean BMI was 26.04 ±1.5.Thirty-one(88.57%) patients were males and four patients were females(11.4%). CTO vessel distribution was LAD 11(31.4%),LCx 12(34.28%) RCA 12(34.28%).Eleven (31.42%) patients had unstable angina FC II-III, sixteen (45.71%) patients had nonST elevation myocardial infarction (NSTEMI)and 08(23%) patients had ST-Elevation myocardial infarction (STEMI) Soft plaque morphology as adjudged on MDCT was present in twenty-two(62.85%) patients and, procedural success was achieved in nineteen (86.36%) of them. Thirteen (37.1%) patients had mixed plaque morphology on MDCT. Seven (53.8%) of them had successful PCI ,Six(46.6 %) patients had unsuccessful PCI. The lesion length ranges measured on MDCT of successful PCIs matched in 22(86%) of patients, three (11.53%) patients had lesion length more than the measured length on MDCT, one (3.8%)had stent size less than the measured length on MDCT.

CONCLUSION: 64 slice MDCT evaluation of CTO vessel in ACS patients for determining plaque morphology and lesion length is possible and does help in guiding for the procedural success of PCI.

High success rate of PCI was associated with soft plaque morphology as compared to mixed or calcified plaque morphology.

KEY WORDS: Chronic Total Occlusion(CTO), Multi-Detector Computed Tomography (MDCT), Plaque Morphology, Procedural success

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INTRODUCTION:

Chronic Total Occlusion (CTO) is a common entity encountered in patients undergoing Conventional Coronary Angiography (CCA).It is defined as total occlusion of a coronary artery of equal or more than three months after an acute coronary syndrome (ACS).The CTO usually is present due to heavy atherosclerotic burden.[1] Percutaneous coronary intervention(PCI) of CTO vessel is a challenging task despite constant improvement in the techniques and hardware. It has a variable success rate in high volume centers. CTO intervention has proved to be useful in relief of angina and in improving Left Ventricular(LV) function and long term survival.[2,3]

Evaluation of CTO on 64 Slice MDCT has proved useful as non invasive imaging modality before a planned percutaneous coronary intervention(PCI). MDCT has been able to define the presence of calcification , plaque morphology, lesion length and post-lesion vessel visibility. Pre-PCI knowledge of lesion length, calcification determined by the MDCT may help in planning a strategy to deal with CTO vessel. MDCT data of CTO can be superimposed on the invasive coronary angiogram of CTO for assistance in PCI regarding the the lesion length and post lesion

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vessel visiblity .[4,5]

MATERIAL AND METHODS:

The study was carried out in Punjab Institute of cardiology from Jan 2014 to December 2014 .The patients were included after an informed consent. A total of thirty-five patients were included .These patients had elective coronary angiogram after ACS. Their basic demographic data such as age, gender , BMI and risk factor profile was noted.

DEFINITIONS:

Chronic Total Occlusion (CTO) vessel was defined as a vessel with total occlusion of ≥3months after an acute coronary syndrome with or without calcification and had Thrombolysis in Myocardial Infarction (TIMI grade 0-1 flow.[6]

TIMI grade 0 was defined as no ante grade flow and TIMI Grade 1 flow defined as faint ante grade flow or retrograde filling from the opposite coronary artery or a collateral. The duration of occlusion was estimated on the basis of either history of angina or previous MI in the same territory or as proven by the previous angiography.

The Plaque morphology was defined on 64 slice MDCT and was interpreted as soft plaque if no calcium was detected in it at the site of occlusion and as calcified plaque, if calcification was found in the region of stenosis or occlusion on non contrast enhanced as well as on contrast-enhanced images.(Fig 1)

Calcified plaques were analyzed on cross section and were interpreted as mild calcification if less than one quadrant of vessel showed calcium, moderate calcification if 2-3 quadrant were seen as calcified and severe if all quadrants were seen as calcified (Fig 2).

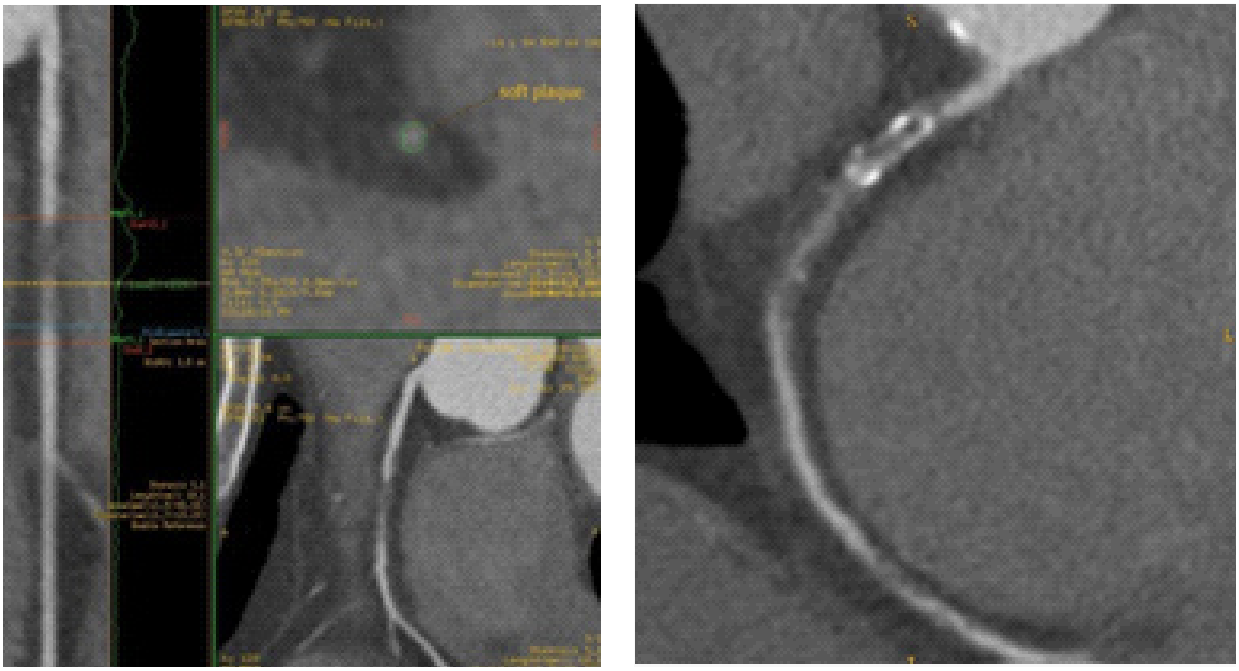
Lesion length was measured in straightened view as well as on MPR curved image as the length from the site of occlusion to the distal visible normal segment as shown in fig 3.

Successful PCI procedure was defined as the ability to advance the guide wire into the distal lumen with the achievement of less than 20 % stenosis and TIMI grade III flow after stent deployment.

Sixty-four slice MDCT was done, for defining the plaque morphology, calcification in the lesion, lesion length, and vessel after the occluded segment.

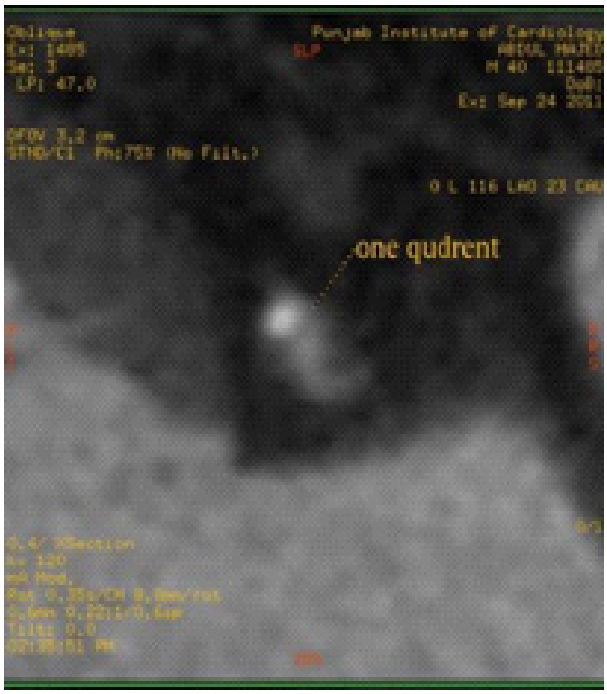
The inclusion criteria for MDCT of these patients was normal sinus rhythm, serum creatinine of less than 1 mg/dl, ability to hold breath for 15 seconds. Pre-procedure ECG was done to determine heart rate and sinus rhythm and if heart rate was more than 70/minute they were given Tab Mepressor 100

Fig-1: 64 slice MDCT MPR curved image showing soft plaque in (A) and calcified Plaque (B) in two different patients in Right Coronary artery

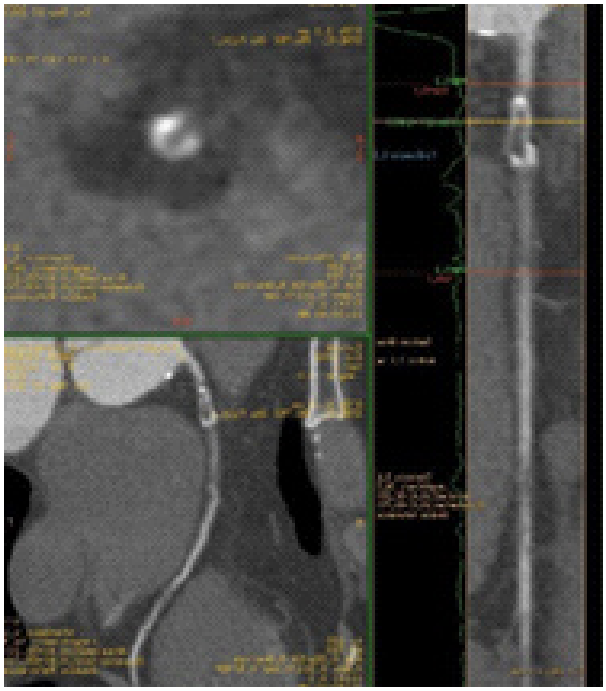


A B

Fig-2: 64 slice MDCT image cross section of oblique view for determining the calcification in quadrants the image C shows calcification in one quadrant and image D shows calcification in three quadrants.



C



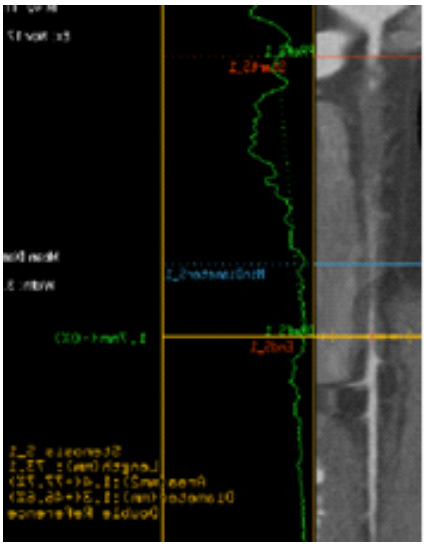
D

mg orally if the heart rate could not be controlled by oral dose an intravenous injection of Lopressor 5-20 mg was given to achieve the desired heart rate of 60 -65 /minute

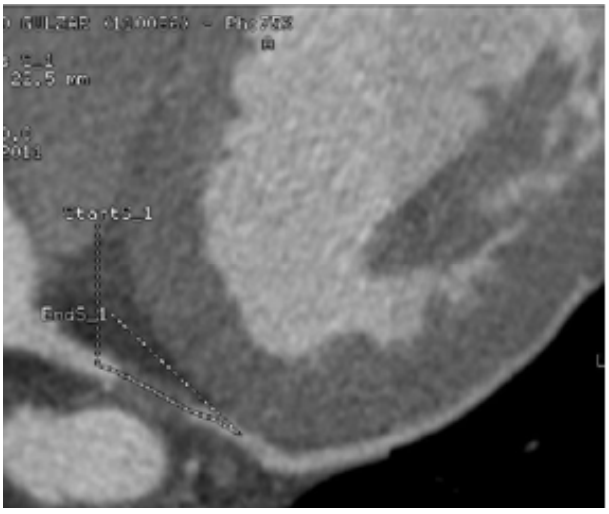
CT PROTOCOLS

The 64 slice MDCT scan (VCT; GE Healthcare, Milwaukee, WI, USA) parameters were used as electrocardiogram-triggered X-ray tube modulation, 64- detectors along the z-axis, tube voltage of

Fig-3: Lesion length measured on MDCT in straightened view (Image E as well as in MPR Curved image (F) from normal proximal segment to normal distal visible segment two different patients having soft and mixed plaque morphology



E



F

120 kV, tube current of 350 to 650 mA (depending on patient BMI), scan field view of 25 cm, gantry rotation of 0.35 seconds per rotation, slice thickness of 0.625 mm, and helical pitch of 0.16. A single oral dose of 100 mg metoprolol tartrate was administrated 1 hour before CT angiography (CTA) if the patient's heart rate was >70 beats per minute. An Intravenous line with 18-gauge cannula was obtained in the antecubital vein. Patients were fasted for about 3-4 hours before the MDCT scan, and were placed in a supine position, and received sublingual isosorbide dinitrate spray 1-2 puffs before starting the scan (Isoket®, Spray; Schwarz Pharma, Munchenstein, Switzerland). After two localization scans, a low-dose native scan of the heart was performed for coronary calcium detection and scoring. The iodinated contrast of 60-80 mL of Ultravist-370 (370mg/ml Bayer Germany) was injected into an ante cubital vein via an 18-gauge catheter at a flow rate of 5 mL/sec followed by 40 mL normal saline solution as saline chaser. Bolus tracking was performed with a region of interest placed into the ascending aorta.

CORONARY ARTERY CALCIUM SCORING:

Coronary artery calcium scoring was performed using gated noncontrast images acquired prior to CTA. Images were analyzed using GE Advantage Workstation 4.4 (Advantage Workstation 4.4; GE Healthcare, Milwaukee, WI, USA) with smart score software. Using the Agatston method, calcium detection and quantification was performed by an electrocardiographically triggered, sequential step-and-shoot acquisition mode, with 120 kV tube voltage, 430 mA tube current, and 2.5 mm slice thickness.

MDCT DATA ANALYSIS:

Stenosis evaluation was done using a modified American College of Cardiology/American Heart Association(ACC/AHA) segmentation model . All CTA images were evaluated on a 3D image analysis workstation (Advantage Workstation 4.4). Images were analyzed by 2 experienced observers blinded to the catheterization results and CTO vessel was identified. First, each segment was evaluated for whether it was interpretable or not. Significant CAD was defined as vessels with ≥50% reduction in lumen diameter. Multi planner reformation (MPR) curved images were generated and evaluated for the plaque morphology, calcification, lesion length and post-lesion normal segment.

An association was sought for procedural success i.e. (ability to cross the wire and achieving TIMI III flow) of CTO vessel on basis of plaque morphology and lesion length on MDCT of CTO vessel.

STATISTICAL ANALYSIS:

Data analyses were carried out using SPSS version 14 statistical software . Continuous data were expressed as mean±standard deviation (SD) or median with interquartile ranges. Categorical data were reported as percentages. Chi square test was used to analyze the association of qualitative variables in both groups. P value of <0.05 was considered significant. All tests applied as two tailed.

RESULTS:

The basic demographic data in these thirty-five patients is as follows. 30 patients were diabetic i.e.,85.7%, hypertensive patients were28 (79%) and Smokers were 27 (77%). Mean age was 53.84 ± 8.4 years. Mean BMI was 26.04 ±1.5. Thirty-one (88.57%) patients were males and four patients were females (11.4%). CTO vessel distribution was LAD in 11(31.4%), LCx in 12(34.28%) and RCA in 12(34. 28%)patients. Eleven (31.42%) patients had exertional angina FC II-III, 16(45.71%) patients had non-ST elevation myocardial infarction (NSTEMI)and 08(23%) patients had ST-Elevation myocardial infarction (STEMI).Table 1

Soft plaque morphology as adjudged on MDCT was present in twenty-two(62.85%) patients (table 2)and procedural success was achieved in nineteen (86.36%) of them.The wires used to cross the lesions were 0.014 BMW in 7 patients (36.8%), 0.014BMW wire with Balloon support was used in four patients(21%), BMW with Pilot 50 wire was used in five (26%) and BMW with Cross IT wire was used in 2(10.52) patients, Three wires i.e. BMW,

Table 1 Baseline demographic variables

Age	53.84±8.4 years
Male	31(88.57%)
Female	04(11.4%)
Diabetes	30(85.7%)
Hypertension	28(79%)
Smoking	27(77%)
BMI	26.04±1.5
LAD	11(31.4%)
LCX	12(34.28%)
RCA	12(34.28%)
NSTEMI	16(45.71%)
Angina	11 (31.42%)
STEMI	08(23%)

Table 2: Procedural success of PCI based on plaque morphology.

Plaque Morphology	Number of Patients	Procedural Success	Procedural Failure
Soft	22 (62.85%)	19(86.6%)	3(14.4%)
Calcified	13 (37.1%)	7(53.8%)	6(46.6&)
	Total = 35	Total = 26	Total = 9

Table 3: Procedural Success according to lesion charcteristics

Number of Patients	Plaque Morphology	Lesion Length on MDCT	Procedural Success	Procedural Failure	P value
3	Soft (3)	10-20	3 (100%)	0	No p value
13	Soft (11)	21-30	11 (84.6%)	0	0.15
	Mixed (02)		1 (7.69%)	1(7.69%)	
9	Soft (4)	31-40	3 (33.33%)	1(11.11%)	1.00
	Mixed(5)		3 (33.33%)	2(22.22%)	
3	Mixed (3)	41-50	1(33%)	2(66.67%)	No p value
5	Soft(3)	51-60	2(40%)	1(20%)	1.00
	Mixed(2)		2(40%)	0	
2	Soft(1)	61-80	0	1(100%)	No p value
	Mixed(1)		0	1(100%)	
Total = 35			Total = 26	Total = 9	

Pilot 50 and Cross IT was used in one (5%) .Three patients(13.6%) with soft plaque morphology had an unsuccessful procedure and all patients were abandoned after at least more than two wires were used to cross the lesion. The patients with soft plaque morphology single wire was used in seven patients (31.8%) and multiple wires were used in 11(50%) patients and single wire with balloon support was used in four (18.2%).

Thirteen (37.1%) had mixed plaque morphology on MDCT. Six(46 %) patients had the presence of calcium in one quadrant and all patients had the procedural success of PCI,as was predicted on MDCT based on plaque morphology. Four patients (66.6%) had multiple wires used for crossing the lesion which included cross IT and pilot 50. In one patient (16.6%) the lesion was crossed with BMW and in one patient (16.6%) BMW wire was used with balloon support to cross the lesion.

Seven (53.8%) patients had either two quadrants or trans mural /circumferential calcification on MDCT and Five(71.4%) of them did not have successful PCI and all five patients had multiple wires used for crossing the lesion .Only two(28.6%) patient had successful PCI in this group .

As regards the lesion length, three patients (8.6%) had lesion length on MDCT in the range of 10-20 mm which corresponded in all (100%) with stent size and all three had successful PCI, 13(37.14%) patients had lesion length between 21-30 mm on MDCT which corresponded with stent size in 12(92.3%) patients in this group who had successful PCI and plaque morphology was soft in these patients. 01 (7.6%) had unsuccessful PCI and which had Calcified plaque. 09(25.7%) had lesion length in the range of 31-40 mm and out of this 6 patient (66.6%) had successful PCI, four patients had lesion length in the predicted range and one patient lesion length was more than the predicted and one had less than predicted length on MDCT, 03(33.3%) patients had unsuccessful PCI in this group. 03(8.6%) had lesion length on MDCT in the range of 41-50 mm and 02 (75%) had unsuccessful PCI only one (25%) patient had successful PCI in which stent size corresponded with the predicted lesion length. Five (14.2%) patients had lesion length on MDCT in the range of 51-60 mm and two (40%) patients had stent length more than the predicted range on MDCT one (20%) had lesion length in the same range ,two (20%) had unsuccessful PCI . Two (5.7%) patients had lesion length in the range of 61-80 mm stent size corresponded with predicted length and one (50%) had successful PCI and one (50%) had unsuccessful PCI.

The lesion length ranges measured on MDCT matched in 22(86%) of the successful 26 patients with respect to stent size, three (11.53%) patients had lesion length more than the measured length on MDCT, one (3.8%)had stent size less than the measured length on MDCT.

The procedure was complicated in two patients, one of them had pericardial effusion and one patient was referred for early bypass surgery due to perforation of RCA.

DISCUSSION:

About one third of patients who undergo invasive coronary angiography has CTO of coronary artery.[7]Intervention of CTO vessel by PCI results in improvement of ante grade flow. Establishing ante grade flow in CTO vessel is known to improve the angina symptoms, left ventricular function and long term survival.[8] Patients selection who will benefit from intervention of CTO vessel remains an important step for ensuring the success of PCI. This selection was largely dependent on the morphological appearance of CTO on invasive angiography. The calcified plaque identified on MDCT was predictor of difficulty in advancing the guide wire and was the cause of failure in performing the PCI as compared to soft plaque morphology[9]Contrast enhanced MDCT is being used increasingly these days for evaluation of

coronary artery disease which includes CTOs. With advancement in this technology special features of CTO can be identified with ease on MDCT. This includes plaque morphology, tortuousity before the lesion, collaterals visualization, lesion length and post lesion segment of coronary artery. Presence or absence of calcification in the plaque, tortuousity, lesion length can be very helpful in deciding about the intervening a CTO and in choosing the guide wire to cross the lesion.[10]

There was a need for evaluation of CTO noninvasively before the planned PCI.MDCT has proved to be a good non invasive imaging modality for the evaluation of such lesion in coronary arteries and its use is on the increase in CTO evaluation. MDCT has the potential to analyze the lesion characteristics and their morphological details. MDCT has the ability to look in to the wall of CTO vessel for plaque characteristic. Determining the morphology of plaque as soft or calcified before the intervention is very helpful in planning the PCI and in selecting the hardware.[11,12]MDCT has been a better tool to define calcium in non occluded segment as well as the missing segment in CTO. The length of the occluded segment is better visualized on MDCT [13]. The detailed anatomical data provided by MDCT on of CTO helps to plan the procedure and plane the interventional strategy.

The present study the success rate of the PCI was more in patients having soft plaque morphology on MDCT and short lesion length. The patients having calcified plaque had failure rate of the procedure of around 46 %. The multiple wires were used to cross the lesion in patient having calcified plaque two or more quadrants and transluminal calcium. The Pre procedure knowledge of lesion length was very helpful in planning the procedure. The stent size corresponded with lesion length measured on MDCT in about 86% of the patients.

The morphological characteristics on MDCT such as calcium, lesion length, tortuousity, and presence of collaterals are helpful in planning the procedure. The high inflation pressure of balloons can be used to pre dilate the lesion of CTO with calcium. Selection of wires can be influenced by lesion characteristics.

Inability to cross the lesion with a guide wire was the reason for failure in >75% of unsuccessful attempts.[14] The length of lesion and morphological characteristics of CTO was difficult with conventional angiography as compared to MDCT. These characteristic of CTO are possible with MDCT which enables the operator to plan a strategy for CTO intervention. The overall success rate with MDCT guided CTO intervention was around 74.4% where as the successful recanalization of CTO vessel without MDCT is variable between 51-73 %.[15]

The factors for failure of CTO intervention like absence of tapered stump, presence of bridging collaterals and presence of side branch at occlusion are better evaluable on CCA[16,17], where as tortuosity, lesion length and calcification can be better predicted on MDCT.

The anatomical data achieved on MDCT can predict the failure or success of PCI better than conventional angiography.The CTO intervention with help of MDCT data has few limitations as well. It may increase the radiation dose and contrast used in such patients. The new scanners with the help of dose modulation and and prospective gating can reduce the radiation dose[13].

LIMITATIONS OF STUDY:

The CTO intervention was done by different operators that may have influenced the procedure success rate in these patients and the time to cross the lesion with the different wires was not recorded.

CONCLUSION:

MDCT coronary angiography of CTO is possible before a planned PCI for evaluation of plaque morphology, lesion length and post occlusion vessel assessment.It can predict the success of PCI on the basis of morphological characteristics of the lesions.

Author's Contribution

TN: Conducted the study, collected and evaluated overall study data and wrote the article. BSM: Did intervention of CTO vessels. MA: CT data evaluation. NHM: Supervised overall study and was involved in CTO intervention.

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