



## Original Article

# Angiographic predictors of success in antegrade approach of Chronic Total Occlusion interventions in a South Indian population in the contemporary era



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## ABSTRACT

Chronic Total Occlusion (CTO) intervention is a challenging area in interventional cardiology. Presently about 70% of CTO interventions are successful.

**Materials and methods:** This was a single center prospective study of a cohort of all patients undergoing percutaneous coronary intervention (PCI) as elective or adhoc procedure for CTO from August 2014 to June 2015. Only antegrade CTO interventions were included. In all patients the following data were recorded.

**Results:** A total of 210 (8.9% of total PCI (2353) during the study period) CTO patients were followed up. The mean age was  $56.54 \pm 8.9$ . In the study sixty nine patients (32.9%) presented with chronic stable angina and rest of the patients had history of acute coronary syndrome of which 22.9% (n = 48) had unstable angina (UA) or non ST elevation myocardial infarction (NSTEMI) and 44.2% (n = 93) had ST Elevation Myocardial Infarction (STEMI). In those with history of ACS, 64.78% (n = 92) had ACS during the previous year and remaining 35.22% (n = 49) had ACS prior to that. Single vessel CTO was seen in 89.5% (n = 188) and two vessel CTO in 10.5% (n = 22). LAD was involved in 36.7% (n = 77), RCA in 48.1% (n = 101), and LCX in 15.2% (n = 32). Procedural success in the first attempt was 68.1% (n = 143), which increased to 71.42% (n = 150) after the second attempt. CTO interventions were more frequently successful when the calcium was absent or minimal (p < 0.05), CTO length was < 10 mm (p < 0.01) and good distal reformation (p < 0.01).

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## 1. Introduction

Coronary chronic total occlusion is defined as an occluded coronary segment with thrombolysis in myocardial Infarction (TIMI) flow 0 for  $\geq$ three months duration.<sup>1,2</sup> In clinical practice, coronary CTOs are commonly encountered, with a prevalence rate of 18–52% among patients undergoing coronary angiography.<sup>3,4</sup> The clinical benefit of CTO revascularization continues to be debated. Several observational studies have shown that successful CTO revascularization improves cardiovascular outcomes.<sup>5,6</sup> A meta-analysis by Hoebbers et al. found that successful revascularization of CTO improved the left ventricular ejection fraction,<sup>7</sup> which is not supported by EXPLORE trial results though improvement in subgroup of patient with viable CTO territory was seen.<sup>19</sup>

The DECISION-CTO trial whose results were presented in ACC 2016 March showed that routine CTO-PCI + OMT is not superior to OMT alone in reducing cardiovascular outcomes among patients with at least one CTO and the management of CTO patients is still a matter of debate.

Chronic Total Occlusion intervention is a demanding area in coronary interventions. CTO interventions are cumbersome requiring more time and hardware and are more costly. CTO interventions have a higher rate of complications when compared to non- CTO interventions. However dedicated equipments and better techniques have kindled the interest in CTO interventions. High rates of success and low rates of complications are now achieved by expert operators, even in complex cases.<sup>8,9</sup> The PROGRESS CTO complications scoring is a new and useful scoring system for predicting complications in patients undergoing CTO PCI.<sup>18</sup>

The last European Society of Cardiology guidelines assigned only a class IIa (level of evidence B) to CTO PCI in 'patients with

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expected ischaemia reduction in a corresponding myocardial territory and/or angina relief,<sup>10</sup> which is reasonable in view of the recent results of DECISION CTO trial and Explore trial.<sup>19</sup>

The J-CTO registry (multicenter CTO registry in Japan) led to the development of J-CTO (Japanese Multicenter CTO registry) score to predict the likelihood of successful guidewire crossing within 30 min.<sup>11</sup> Independent angiographic predictors of failure (each given one point) that made up the J-CTO score included prior failed attempt, angiographic evidence of heavy calcification, bending within the occluded segment, blunt proximal stump, and occlusion length >20 mm. Chronic total occlusions were then graded as easy, intermediate, difficult, and very difficult (J-CTO scores of 0, 1, 2, and ≥3, respectively).

## 2. Materials and methods

The study was a prospective study of a cohort of all patients undergoing PCI as elective or adhoc procedure for CTO in the department of Cardiology Government Medical College, Thiruvananthapuram from August 1st 2014 to June 30th 2015.

### 2.1. Inclusion criteria

All patients undergoing PCI as elective or adhoc procedure for CTO in the department of Cardiology Government Medical College, Thiruvananthapuram from August 1st 2014 to June 30th 2015 were included in the study.

CTO was defined as a high-grade coronary occlusion with reduced antegrade flow (Thrombolysis in Myocardial Infarction [TIMI] grade 0 flow) with estimated duration of at least 3 months.

### 2.2. Exclusion criteria

Exclusion criteria included patients with an estimated CTO duration less than 3 months, CTO vessel size <2.5 mm, retrograde approach for CTO intervention, second or third attempt failed CTO interventions and second or third vessel CTO interventions of multi vessel CTO, in-stent total occlusion, status post Coronary Artery Bypass Graft surgery (CABG), Chronic Kidney Disease (CKD) with a baseline e GFR <30 ml/min/1.73 m<sup>2</sup>, retrograde approach for CTO, inability to take antiplatelets and left ventricular ejection fraction less than 30%.

### 2.3. Definitions

CTO was defined as a lesion showing a complete occlusion of the coronary vessel with antegrade TIMI 0 flow with an estimated 3 months or more duration.

Procedural success was defined as successful CTO recanalization with achievement of <30% residual diameter stenosis within the treated segment and restoration of TIMI grade-3 antegrade flow.

### 2.4. Procedure

All patients were pre-treated with aspirin and clopidogrel (a loading dose of 300 mg at least 6 h before the procedure). After the procedure, all patients were on dual antiplatelet therapy with aspirin and one of clopidogrel or prasugrel or ticagrelor. Baseline characteristics procedural and angiographic characteristics were recorded.

Peri-procedural complications were recorded and included coronary perforation with or without tamponade, heart failure (requiring NTG and diuretic), cardiogenic shock, sustained ventricular tachycardia (VT) and atrial fibrillation.

Immediate outcomes before the discharge of the patient which included death, ACS – STEMI, NSTEMI, unstable angina, stroke (ischemic/hemorrhagic), renal failure, need for urgent revascularization (PCI/CABG) and stent thrombosis and six month outcomes in terms of NYHA functional class of angina and dyspnea, death, ACS – STEMI, NSTEMI/UA, stroke-(ischemic/hemorrhagic), renal function, need for urgent revascularization (PCI/CABG), stent thrombosis, target vessel revascularization, heart failure requiring hospitalization, AF and sustained VT were recorded.

### 2.5. Data analysis

Continuous variables were analyzed by the student *T*-test, the discrete variables by chi-square test and paired ANOVA test wherever applicable. Statistical significance was assumed as *P* < 0.05.

## 3. Results

### 3.1. Baseline demographics

A total of 210 (8.9% of total PCI (2353) during the study period) CTO patients were followed up. The mean age was 56.54 ± 8.9. In the study sixty nine patients (32.9%) presented with chronic stable angina and rest o had history of acute coronary syndrome of which 22.9% (n = 48) had unstable angina (UA) or non ST elevation myocardial infarction (NSTEMI) and 44.2% (n = 93) had ST Elevation Myocardial Infarction (STEMI). In those with history of ACS, 64.78% (n = 92) had ACS during the previous year and remaining 35.22% (n = 49) had ACS prior to that. The base line patient characteristics are shown in [Table 1](#).

Single vessel CTO was seen in 89.5% (n = 188) and two vessel CTO in 10.5% (n = 22). LAD was involved in 36.7% (n = 77), RCA in 48.1% (n = 101), and LCX in 15.2% (n = 32).

### 3.2. Lesion characteristics

J-CTO score in the cohort was J- CTO < 1–13.3% (n = 28) J- CTO = 2–50.5% (n = 106), J- CTO > 3–36.2% (n = 76). The lesion characteristics are shown in [Table 2](#).

### 3.3. Procedural outcomes

Procedural success in the first attempt was 68.1% (n = 143), which increased to 71.42% (n = 150) after the second attempt.

The CTO interventions were more successful in younger patients and females. There were no difference in outcomes

**Table 1**  
Patient demographics.

		Frequency	Percentage
Age	≤60	133	63.3
	>60	77	36.7
Gender	Male	170	81.0
	Female	40	19.0
Diabetes mellitus	No	139	66.2
	Yes	71	33.8
Systemic Hypertension	No	100	47.6
	Yes	110	52.4
Smoking habit	No	111	52.9
	Yes	99	47.1

**Table 2**  
Nature of CTO Lesion.

		Frequency	Percentage
Size OF 1st CTO Vessel	2.5–2.9	94	44.8
	3.0–3.9	113	53.8
	>4	3	1.4
Ending of CTO	Blunt	162	77.1
	Tapering	48	22.9
Site of CTO	Ostial	26	12.4
	Proximal	81	38.6
	Mid	77	36.7
	Distal	26	12.4
Calcium	No	104	49.5
	Mild	38	18.1
	Moderate	43	20.5
	Severe	25	11.9
Length of CTO	<10	57	27.1
	10–20	90	42.9
	>20	63	30.0
Collateral	Absent	5	0.02
	Bridging	98	46.7
	Hetro	27	12.9
	Homo	80	38.09
Distal Reformation	None	7	3.3
	Poor	96	45.7
	Good	107	51.0

**Table 3**  
Patient demographic factors and success in the first attempt.

		Success (N = 143)		Failure (N = 67)		P value
		N	%	N	%	
Age	≤60	97	72.9	36	27.1	0.048
	>60	46	59.7	31	40.3	
Gender	Male	106	62.4	64	37.6	<0.001
	Female	37	92.5	3	7.5	
Diabetes mellitus	No	89	64	50	36	0.077
	Yes	54	76.1	17	23.9	
Systemic hypertension	No	65	65	35	35	0.359
	Yes	78	70.9	32	29.1	
Smoking	No	71	64	40	36	0.174
	Yes	72	72.7	27	27.3	

among diabetics, hypertensives or smokers. The relation between patient demographics and procedural success are shown in [Table 3](#).

### 3.4. Procedural success and lesion characteristics

CTO interventions were more frequently successful when the calcium was absent or minimal, CTO length was <10 mm and good distal reformation. [Table 4](#) shows the lesion characteristics and procedural success. Procedural success was more frequent in those with a J CTO score of ≤2 as shown in [Fig. 1](#).

### 3.5. Procedural success and procedural characteristics

Femoral route was the access site for most of the complicated lesions and contralateral injections was taken in the most complex lesions. Procedural characteristics are shown in [Table 5](#).

**Table 4**  
Nature of CTO occlusion lesion and successful intervention.

		Success (N = 143)		Failure (N = 67)		P value
		N	%	N	%	
CTO stump	Blunt	110	67.9	52	32.1	0.912
	Tapering	33	68.8	15	31.3	
Site of CTO	Ostial	17	65.4	9	34.6	0.010
	Proximal	45	55.6	36	44.4	
	Mid	60	77.9	17	22.1	
	Distal	21	80.8	5	19.2	
Calcification	No	75	72.1	29	27.9	0.005
	Mild	32	84.2	6	15.8	
	Moderate	24	55.8	19	44.2	
	Severe	12	48	13	52	
Length of CTO	<10	56	98.2	3	1.8	0.0001
	10–20	58	65.2	31	34.8	
	>20	29	46.8	33	53.2	
Collaterals	Absent	3	60	2	40	0.0001
	Bridging	50	51	48	49	
	Hetro	22	81.5	5	18.5	
	Homo	68	85	12	15	
Distal reformation	Poor	59	56.3	44	43.8	0.003
	Good	84	78.5	23	21.5	

### 3.6. Complications and in hospital outcomes

Access site complications occurred in 16 cases. This included TIMI minor bleed in 14 and pseudoaneurysms in 2 patients both were femoral. There were no major bleeds. Periprocedural myocardial infarction occurred in 10 cases. (4.8%). Coronary perforations occurred in 17 patients (8%), of which 12 were conservatively managed. Three cases required prolonged balloon inflation and two cases required pericardiocentesis. None required surgery. There were no in hospital death, acs or stroke.

### 3.7. Six months outcome

Angina class improved in 71.3% of those with procedural success and in 18.8% of failed cases. ( $p < 0.001$ ). Dyspnea improved in 79.7% of those with procedural success and in 25.5% of failed cases. Death occurred in 1.2% ( $n = 2$ ) and stroke in 1.2% ( $n = 2$ ). Heart failure requiring hospitalization occurred in 1.5% ( $n = 3$ ). There was no ACS or need for urgent revascularization.

## 4. Discussion

A total of 210 (8.9% of total PCI (2353) during the study period) CTO patients were followed up for a period of 6 months. The mean age of the patients was  $56.54 \pm 8.9$  A higher percentage of males underwent PCI for CTO in this study similar to the large UK registry database (78.8% males of 13443 CTO patients in UK data base).<sup>12</sup> 33.8% were diabetics, 52.4% were hypertensive and 47.1% were smokers.

There was involvement of LAD in 36.7% ( $n = 77$ ), RCA in 48.1% ( $n = 101$ ), and LCX in 15.2% ( $n = 32$ .) The JCTO score was  $\geq 3$  in 36.2%.

Procedural success in the first attempt was 68.1% ( $n = 143$ ). The procedural success was similar to other major studies. A meta-analysis by Patel et al.<sup>13</sup> of 65 studies with 18,061 patients and 18,941 target CTO vessels showed angiographic success 77%.

The patient demographic predictors of success were younger age, absence of diabetes mellitus and history of ACS. Procedural

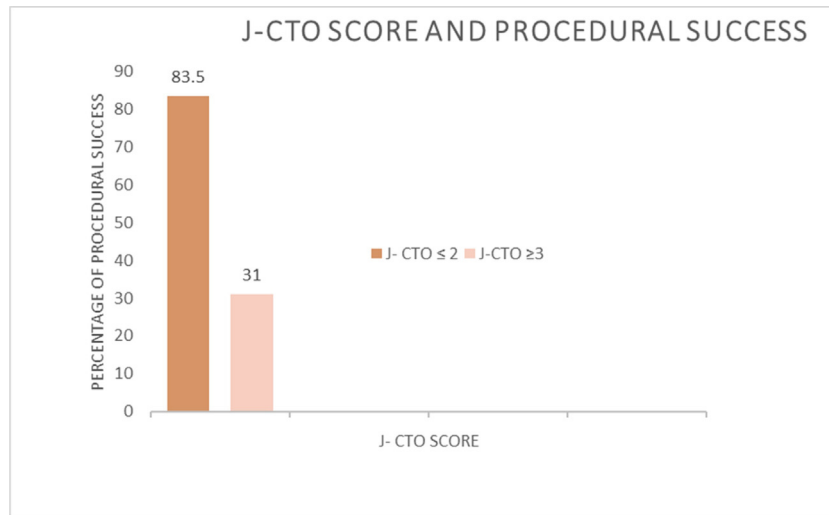


Fig. 1. J-CTO score and procedural success.

**Table 5**  
Procedural success and procedural characteristics.

		Success N = 143		Failure N = 67		Total		p
		N	%	N	%			
Route	Radial	43	74.1	15	25.9	58	100	0.246
	Femoral	100	65.8	52	34.2	152	100	
Contralateral Injection	No	113	71.5	45	28.5	158	100	0.064
	Yes	30	57.7	22	42.3	52	100	
Guide Catheter Size	7F	87	65.9	45	34.1	132	100	0.377
	6F	56	71.8	22	28.2	78	100	
Guide Catheter	CLS	73	72.3	28	27.7	101	100	0.114
	JR	49	70	21	30	70	100	
	AL	21	55.3	17	44.7	38	100	
	JL	0	0	1	100	1	100	
Side Hole	No	115	73.7	41	26.3	156	100	0.003
	Yes	28	51.9	26	48.1	54	100	
Wire Used to Cross the Lesion	BMW	11	100	0	0	11	100	
	Whisper XT	16	84.2	3	15.8	19	100	
	Fielder XT	11	100	0	0	11	100	
	Cross IT 100 XT	48	82.8	10	17.2	58	100	
	Cross IT 200 XT	10	83.3	2	16.7	12	100	
	Cross IT 300 XT	1	50	1	50	2	100	
	Progress 40	1	33.3	2	66.7	3	100	
	Progress 80	30	69.8	13	30.2	43	100	
	Progress 120	7	28	18	72	25	100	
	Progress 140	7	41.2	10	58.8	17	100	
	Progress 200	1	11.1	8	88.9	9	100	

success was higher in younger patients (<60 years – 72.9% v/s 59.7% for those >60 years, p 0.048) similar to another large study.<sup>14</sup> Procedural success was higher in female patients and was statistically significant (92.5% v/s 62.4% in males p < 0.001) which is much higher than seen in another large study (65.4% in females v/s 61.3% in males).<sup>12</sup>

The angiographic predictors of success were site CTO in mid and distal vessel, good distal reformation, short CTOs and absence of calcification or mild calcification similar to other registry data.<sup>12,15</sup>

Procedural success however was not affected by presence of bridging collaterals or nature of the stump which are usually highlighted as major negative factors. However a similar finding

was observed by Salarifer et al.<sup>16</sup> Coronary perforation rate (8%) was similar to the Japanese CTO registry (7.2%).<sup>17</sup>

## 5. Limitations

Small vessel CTOs (<2.5 mm) were not included in the study. Retrograde approach was not included.

## 6. Conclusions

PCI is now an effective and safe modality of treatment in CTO with relatively high success rates and low complications with use

of better wires and other gadgets and refined techniques in the contemporary era. However case selection is crucial and in this regard identifying the predictive factors for successful CTO intervention in a specific population is useful in selecting most suitable candidates for PCI.

A simplified expression of the results of our study is as follows. About 2/3 of the patients who underwent CTO intervention were aged less than 60 years. Nearly 1/3 of the patients were diabetic and 1/2 were smokers. Roughly 1/2 had right coronary artery CTO. 1/3 had J CTO score  $\geq 3$ .

The predictors of procedural success were site of CTO being in the mid or distal portion of the vessel, short segment occlusion, lesions without calcification or minimal calcification and good distal reformation.

The presence of bridging collaterals or absent collaterals or a blunt stump were not found to be significantly affecting the procedural success rates.

### Conflict of interest

There is no conflict of interest with any of the authors and the subject dealt.

### Finance

No finance was required for the study.

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