Original Article

Short-term Clinical Outcomes of Patients With Chronic Total Occlusion Who Underwent PCI Using the J-CTO Score

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ABSTRACT

Background: Percutaneous coronary intervention (PCI) for chronic total occlusion (CTO) remains a significant challenge in interventional cardiology. Advancements in technology and procedures have facilitated high technical and procedural success rates in PCI for CTO while ensuring a minimal risk of procedural complications. The objective of this study was to assess clinical improvement in patients with coronary CTO who underwent PCI based on the Multicenter Chronic Total Occlusion Registry of Japan (J-CTO) score.

Methods: A prospective observational study was carried out to evaluate clinical improvement in patients with coronary CTO who underwent percutaneous intervention according to the J-CTO score. This study was carried out in the cardiovascular department of Mansoura University Hospitals, Mansoura, Egypt, and was performed over 1 year, from January 2019 through January 2020.

Results: Receiver operating characteristic analysis was carried out to detect the optimal J-CTO score cutoff for the prediction of no improvement (failed cases). The best J-CTO score cutoff value was 2.50. The area under the curve was 0.736 (*P* = .002). Additionally, logistic regression analysis was carried out to predict major adverse coronary events (MACE) in patients, using laboratory data, demographic data, and J-CTO score as covariates. White blood cell count and J-CTO score were significant risk factors for MACE.

Conclusions: The J-CTO score is a valuable tool for predicting procedural success in patients undergoing CTO PCI, with higher scores associated with a greater likelihood of MACE.

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KEYWORDS: chronic total occlusion; percutaneous coronary intervention; J-Chronic Total Occlusions Score

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Chronic total occlusion (CTO) is defined by significant atherosclerotic plaque accumulation within the artery, resulting in total (or nearly total) vascular obstruction. A total occlusion must persist for a minimum of 3 months to qualify as a true CTO, but establishing the length of the occlusion based on clinical assessment is difficult.[1] The therapeutic approach for a case with CTO is customized according to the severity of symptoms, ischemia, and the extent of associated coronary artery disease (CAD).[2] Three likely benefits of CTO percutaneous coronary intervention (PCI) include alleviation of symptoms, enhancement of left ventricular (LV) function, and increased survival rates.[3] Despite these potential advantages, the attempt rates for CTO PCI are significantly lower than those for PCI involving other lesion categories.[4] PCI for CTO is correlated with significant usage of catheterization laboratory resources, with procedure and fluoroscopic durations being twice as long as those for PCI involving non-CTO lesions.[5] Coronary guidewires are now provided with hydrophilic coatings and reduced-profile tips. This enables wires to locate microchannels within the CTO that may facilitate access to the distal vessel. Wires are designed with enhanced support at the tip, enhancing torque control for the operator and facilitating the advancement of the wire tip through coronary occlusions with minimal change or deflection.[6] The Multicenter Chronic Total Occlusion Registry of Japan (J-CTO) score is significantly correlated with the overall success and efficiency of CTO interventions, depending on whether the entry of the true lumen is tapered or blunt, with 1 point assigned for a blunt entry. Furthermore, regardless of severity, 1 point is assigned if any obvious calcification is identified within the CTO segment. One point is assigned if a curve over 45° is identified within the CTO segment. Any tortuosity distinct from the CTO segment is excluded from this evaluation utilizing quality collateral pictures; the actual distance of occlusion should be measured, with 1 point assigned if the occlusion length exceeds 20 mm. One point is given if it is the second attempt following a prior failure. The difficulty categories are as follows: 0 points, easy; 1 point, intermediate; 2 points, difficult; and 3 points or more, very difficult.[7] The objective of the research was to evaluate clinical improvement in patients with coronary CTO undergoing PCI based on the J-CTO score.

METHODS

Study Design

This prospective observational research was carried out to assess clinical improvement in patients with CTO undergoing percutaneous intervention according to the J-CTO score. This study was conducted in the Cardiovascular Department of Mansoura University Hospitals, Mansoura, Egypt, over 1 year, from January 2019 through January 2020.

Ethical Consideration

This study was approved by the institutional review board of the Faculty of Medicine, Mansoura University. Every participant provided written informed consent prior to participation and was informed about the study's aim and procedures. Confidentiality and privacy were respected. Patients could freely withdraw from the study at any time. Patient data were not used for any purpose other than the study.

Inclusion Criteria

All patients with CTO who underwent PCI.

Exclusion Criteria

Exclusion criteria included patients with coronary artery total occlusion for less than 3 months, patients with previous PCI or coronary artery bypass grafting to the target vessel, patients with chronic renal failure, patients with end-stage liver disease, and patients with malignancy.

Full medical history was obtained, including demographics (age, sex, residence, and education), medical history, and comorbidities. Risk factors for CAD were assessed, including hypertension, diabetes mellitus, and smoking status, alongside family history of CAD, renal impairment, recent surgery, trauma, rheumatoid arthritis, and cerebrovascular events.

Clinical assessment included measurement of vital signs (blood pressure, heart rate, and respiratory rate). General physical examination was performed with specific attention to signs of heart failure. Local cardiac examination focused on abnormal pulsations, heart sounds, and murmurs.

A standard 12-lead electrocardiography (ECG) was performed in accordance with European Society of Cardiology protocols, encompassing limb leads (I, II, III, aVR, aVL, and aVF) and chest leads (V_1–V_6) upon hospital admission.[8,9] Right precordial leads (V_3R–V_6R) and posterior chest leads (V_7–V_9) were used in selected patients to evaluate right ventricular infarction and posterior wall involvement. Baseline laboratory tests included serum urea, creatinine, and hemoglobin levels.

Primary PCI was performed for the infarct-related artery.[10] For CTO procedures, a loading dose of antiplatelet agents (300 mg of aspirin and either 180 mg of ticagrelor or 600 mg of clopidogrel) was administered, alongside low-molecular-weight heparin or intravenous unfractionated heparin. Arterial access was obtained via the femoral or radial approach. For the femoral approach, local anesthesia was administered 3 to 4 cm inferior to the inguinal ligament. Access was established using an 18-gauge needle, a Teflon-coated guidewire, and an appropriate sheath. For the radial approach, access was obtained approximately 2 cm proximal to the radial styloid using a single-wall anterior puncture technique. Angiographic imaging included visualization of the left and right coronary arteries.

Antegrade and Retrograde Techniques in CTO

Antegrade wire escalation, the most frequently used procedure for CTO crossing, involved the use of a Fielder XT guidewire for penetration of the proximal cap and lesion crossing. Antegrade dissection was performed using a knuckled guidewire. The knuckle was formed by pushing the guidewire without rotation to avoid fracture. The knuckled wire was advanced because it is safer than a straight guidewire, particularly in tortuous areas, as the blunt tip is less likely to penetrate the vessel wall. In this study, antegrade wire escalation was performed using a microcatheter.

The retrograde technique was initiated by crossing the collateral channel using a Sion guidewire through a microcatheter. The microcatheter was advanced via the collateral to the distal CTO cap, followed by retrograde crossing of the CTO. For short occlusions, retrograde wire escalation was sufficient. Nonetheless, for longer occlusions, a dissection/reentry strategy (reverse controlled antegrade and retrograde tracking [CART] procedure) was performed. This involved inflating a balloon on an antegrade guidewire and advancing the retrograde guidewire into the proximal true lumen, aided by the employment of a guide catheter extension within the antegrade guide catheter. Subsequently, guidewire externalization was performed using a 330-cm guidewire (RG3; Asahi Intecc), followed by standard PCI over the externalized guidewire. True lumen reentry during reverse CART was aided by the DRAFT (deflation, retraction, and advancement into fenestration) procedure, in which the antegrade subintimal balloon was deflated and retracted while the retrograde looped wire was advanced during temporary dissection flap fenestration.

Echocardiography: Two-dimensional echocardiographic assessment was performed during admission after successful PCI with the patient in the left lateral decubitus position to assess LV systolic function and tissue Doppler diastolic velocities.

Calculation of the J-CTO score: The J-CTO score was calculated according to Morino et al.[11] Variability in the J-CTO score was evaluated in 10 random CTO angiograms by the same operator (intraobserver variability) and by a different independent operator (interobserver variability). The J-CTO score is a scoring system in which 1 point is given for each of the following: blunt entry stump, calcification, bend greater than 45°, occlusion length greater than 20 mm, and prior failed attempts. Baseline clinical and angiographic characteristics and outcomes were compared among easy (J-CTO score = 0), intermediate (J-CTO score = 1), difficult (J-CTO score = 2), and very difficult (J-CTO score ≥ 3) CTO lesions.

Statistical Analysis

Data were analyzed using SPSS version 22 (IBM Corp). Normality was assessed using the Shapiro-Wilk test. Qualitative data are expressed as counts and percentages, and categorical variables were compared using the χ^2 or Fisher exact test. Quantitative data are expressed as mean (SD). Parametric and nonparametric continuous data were compared between the 2 independent groups using the independent-samples *t* test and the Mann-Whitney *U* test, respectively. Univariable and multivariable logistic regression analyses were drawn upon to identify independent predictors of categorical outcomes. Receiver operating characteristic (ROC) curve analysis was performed to evaluate diagnostic performance, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Statistical significance was defined as a *P* value of less than .05.

RESULTS

A CONSORT flow chart of the study population is shown in Figure 1. Of the 75 patients with chronic total occlusion admitted to the Cardiology Department at Mansoura University Hospitals, 15 were excluded from the study: 9 refused consent, and 6 did not meet the inclusion criteria. Sixty patients participated in the study, and signed informed consent was obtained from their parents and caregivers after the study's objectives were explained. The patients were categorized into 4 groups based on the J-CTO score: Group I (easy; n = 6), Group II (intermediate; n = 17), Group III (difficult; n = 17), and Group IV (very difficult; n = 20).

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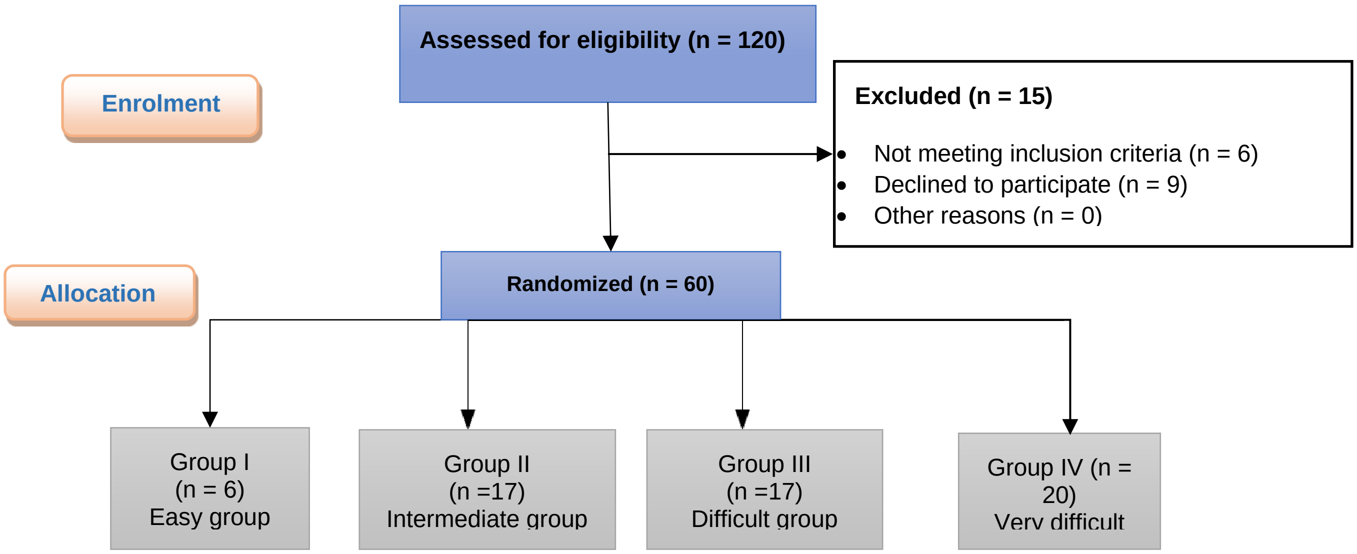

Figure 1. Flowchart of the studied groups

Table 1. Demographic and Clinical Characteristics of the Study Patients

Characteristic	Value (No. = 60)	
Age, mean (SD), y	55.07 (11.40)	
Sex, No. (%)	No.	%
Male	38	63.3
Female	22	36.7
Smoking, No. (%)	38	63.3
Diabetes mellitus, No. (%)	28	46.7
Hypertension, No. (%)	32	53.3
Dyslipidemia, No. (%)	44	73.3
Family history of coronary artery disease, No. (%)	28	46.7
Chronic Total Occlusion in Vessel		
Left anterior descending coronary artery	22	36.7
Right coronary artery	14	23.3
Left circumflex artery	15	25.0
Left anterior descending and right coronary arteries	6	10.0
Left anterior descending coronary artery and first obtuse marginal	3	5.0
Multicenter Chronic Total Occlusion Registry of Japan (J-CTO) Score, No. (%)		
Easy	6	10.0
Intermediate	17	28.3
Difficult	17	28.3
Very difficult	20	33.3

The present study included 60 patients with CTO (63.3% male). The mean (SD) age was 55.07 (11.40) years. Smoking, diabetes mellitus, hypertension, dyslipidemia, family history, and vessel involvement are presented in Table 1. Based on J-CTO scores, patients were classified into 4 groups: easy (n = 6), intermediate (n = 17), difficult (n = 17), and very difficult (n = 20) (Table 1).

The studied groups were matched with regard to diabetes mellitus and family history. There was a statistically significant difference among the groups with regard to sex, age, smoking, hypertension, and dyslipidemia (Table 2).

Moreover, there were highly significant differences regarding blood pressure, ejection fraction, and echocardiographic parameters among the 4 groups. In addition, higher J-CTO scores were associated with higher white blood cell count, total cholesterol, triglycerides, and low-density lipoprotein cholesterol and lower high-density lipoprotein cholesterol compared with the easy group, whereas no significant differences were detected for other parameters (Table 3).

Table 2. Demographic and Clinical Characteristics by J-CTO Score

Parameter	Easy (n = 6)		Intermediate (n =17)		Difficult (n = 17)		Very Difficult (n = 20)		*P*
Age*, mean (SD), y	40.5 (5.24)		5 (7.19)		60.18 (3.94)		62.0 (11.5)		<.001
Sex, No. (%)	No.	%	No.	%	No.	%	No.	%	
Male	2	33.3	10	58.8	11	64.7	18	90.0	.036
Female	4	66.7	7	41.2	6	35.5	2	10.0	
Smoking, No. (%)	1	16.7	8	47.1	10	58.8	16	80.0	.029
Diabetes mellitus, No. (%)	1	16.7	7	41.2	8	47.1	5	25.0	.371
Hypertension, No. (%)	0	0	3	17.6	14	82.4	12	60.0	<.001
Dyslipidemia, No. (%)	0	0	15	88.2	12	70.6	15	75.0	.001
Family history, No. (%)	0	0	7	41.2	3	17.3	8	40.0	.123

X^2 test, ANOVA *. *P*, between 4 groups

Table 3. Echocardiographic and Laboratory Parameters by J-CTO Score

Parameter	Easy (n = 6)	Intermediate (n = 17)	Difficult (n =17)	Very Difficult (n = 20)	*P*
	Median (Min-Max)	Median (Min-Max)	Median (Min-Max)	Median (Min-Max)	
Systolic blood pressure, median (IQR) Diastolic blood pressure, median (IQR)	130.0 (110-130) 85.0 (70-85)	130.0 (110-150) 80.0 (70-100)	150.0 (140-180) 100.0 (85-100)	150.0 (100-170) 90.0 (60-110)	.004 .004
Ejection fraction, %	63.0 (62-64)	55.0 (50-62)	56.0 (48-60)	55.0 (45-64)	.003
Heart rate, bpm	66.0 (65-70)	66.0 (60-72)	63.0 (50-72)	66.0 (55-90)	.487
Left atrium, cm	3.6 (3.2-3.8)	3.0 (3.0-3.8)	4.0 (3.0-4.2)	3.8 (3.5-4.2)	.001
Aorta, cm	2.8 (2.8-3.0)	3.0 (3.0-3.4)	3.5 (2.8-3.8)	3.0 (2.8-3.8)	.007
Interventricular septal diastole, cm	1.2 (1.0-1.2)	1.0 (0.8-1.0)	1.1 (0.9-1.2)	1.0 (0.9-1.2)	.006
Left ventricular posterior wall diastole, cm	1.2 (1.0-1.2)	1.0 (0.8-1.0)	1.1 (0.9-1.2)	1.0 (0.9-1.2)	.006
Left ventricular internal diameter at end-diastole, cm	3.8 (3.5-3.8)	4.2 (3.5-4.5)	4.5 (4.0-5.0)	4.5 (3.9-5.8)	.001
Left ventricular internal diameter at end-systole, cm	2.9 (2.9-3.2)	3.3 (2.9-3.2)	3.4 (2.9-3.6)	3.2 (2.9-3.9)	.094
Hemoglobin, g/dL	15.5 (14 -16)	15.0 (12.5-16.5)	14.0 (12 -16)	14.0 (12 -16.5)	.305
White blood cell count, $\times 10^9$/L	5.0 (5.0-7.5)	9.0 (7.5-10.0)	7.0 (5.0-9.0)	7.0 (4.0-10.0)	<.001
Platelets, $\times 10^9$/L	240.0 (235-250)	222.0 (185-268)	235.0 (195-311)	230.0(198-310)	.508
Creatinine, mg/dL	1.0 (0.8-1.0)	1.0 (0.8-1.1)	1.0 (0.9-1.1)	1.0 (0.8-1.1)	.101
Urea, mg/dL	37.0 (34-37)	34.0 (20-48)	34.0 (29-42)	35.0 (24-47)	.523
Uric acid, mg/dL	5.5 (4-7)	7.2 (3.2-9.1)	5.5 (4.1-8.2)	5.6 (4.0-7.0)	.527
Total cholesterol, mg/dL	160.0 (160-190)	240.0 (180-280)	220.0 (170-285)	240.0 (150-285)	.008
Triglycerides, mg/dL	93.0 (75-100)	130.0 (86-250)	120.0 (70-220)	110.0 (76-250)	.048
Low-density lipoprotein cholesterol, mg/dL	101.9 (90-118)	163.0 (112-218)	164.0 (82-235)	182.5 (103-226)	.013
High-density lipoprotein cholesterol, mg/dL	44.5 (35-55)	35.0 (30-42)	32.0 (30-45)	35.0 (30-36)	.001

Data are presented as median (interquartile range [IQR]). Comparisons were performed using the Kruskal-Wallis test.

Table 4. J-CTO Angiographic Parameters Categorized by J-CTO Score

Parameter	Easy (n = 6)		Intermediate (n = 17)		Difficult (n = 17)		Very Difficult (n = 20)		*P*
Entry morphology	No.	%	No	%	No	%	No.	%	
Tapered	6	100	14	82.4	14	82.4	8	40.0	.003
Blunt	0	0	3	17.3	3	17.3	12	60.0	
Calcification, No. (%)									
Absent	6	100	11	64.7	3	17.6	0	0	<.001
Present	0	0	6	35.3	14	82.4	20	100	
Bending, No. (%)									
<45°	6	100	12	70.6	14	82.4	12	60.0	.189
>45°	0	0	5	29.4	3	17.6	8	40.0	
Occlusion length, No. (%)									
<20 mm	6	100	14	82.4	3	17.6	0	0	<.001
>20 mm	0	0	3	17.3	14	82.4	20	100	
Retry, No. (%)									
No	6	100	17	100	17	100	17	85.0	.097
Yes	0	0	0	0	0	0	3	15.0	

Blunt entry, calcification, and occlusion length greater than 20 mm showed higher frequency among the very difficult and difficult groups compared with the other groups, with statistical significance, whereas no other significant differences were detected (Table 4).

Additionally, a highly significant difference was detected with regard to loading drug and PCI technique. The 3-month outcome (no improvement) and the 6-month outcome (recurrent hospitalization and sudden cardiac death) were more frequent in the very difficult group (Table 5).

There was no significant difference according to entry, demographic data, calcification, bending, and occlusion length between the improved and non-improved groups. Conversely, vessel involvement showed a statistically significant difference, as the right coronary artery (RCA) showed a higher frequency in the improved group than in the non-improved group, whereas the left anterior descending coronary artery (LAD) and blunt entry showed a higher frequency in the non-improved group than in the improved group. Moreover, the J-CTO score was significantly higher in the non-improved patients than in the improved patients (Table 6).

ROC curve analysis was performed to identify the optimal J-CTO score cutoff for prediction of non-improved patients (failed cases). The best J-CTO score cutoff value was 2.50. The area under the curve (AUC) was 0.736 ($P = .002$) (Table 7, Figure 2).

At the end of the 6-month follow-up period, the disease-free survival rate of the studied patients was estimated to be 88.3% at 3 months and 61.7% at 6 months. With respect to the J-CTO score, the disease-free survival estimates were 97.5% at 3 months and 77.5% at 6 months for the J-CTO score less than 2.5 group, whereas the disease-free survival estimates were 70.0% at 3 months and 30.0% at 6 months for the J-CTO score greater than 2.5 group, indicating a significant difference between the 2 groups ($P < .001$) (Figure 3 and Figure 4).

Further, logistic regression analysis was performed to predict MACE in patients, using laboratory data, demographic data, and J-CTO score as covariates. White blood cell count and J-CTO score were significant risk factors for MACE (Table 8).

Table 5. Procedural Characteristics and Follow-up Outcomes Categorized by J-CTO Score

Parameter	Easy (n = 6)		Intermediate (n = 17)		Difficult (n = 17)		Very Difficult (n = 20)		*P*
Loading antiplatelet drug, No. (%)	No.	%	No.	%	No.	%	No.	%	.003
Clopidogrel, 600 mg	0	0	14	82.4	8	47.1	8	40.0	
Ticagrelor, 180 mg	6	100	3	17.6	9	52.9	12	60.0	
PCI technique and flow results, No. (%)									.012
Antegrade, TIMI II to III flow	0	0	0	0	3	17.6	8	40.0	
Antegrade, TIMI III flow	6	100	14	82.4	14	82.4	9	45.0	
Antegrade to retrograde, TIMI II to III	0	0	3	17.6	0	0	3	15.0	
3-month outcome, No. (%)									.002
Improved	6	100	11	64.7	14	82.4	14	30.0	
Not improved	0	0	6	35.3	3	17.6	6	70.0	
6-month outcome, No. (%)									.001
Continued improvement	6	100	11	64.7	14	82.4	6	30.0	
Recurrent hospitalization for ACS	0	0	3	17.6	3	17.6	0	0	
Recurrent hospitalization for heart failure	0	0	0	0	0	0	5	25.0	
Recurrent hospitalization for arrhythmia	0	0	0	0	0	0	3	15.0	
Sudden cardiac death	0	0	3	17.6	0	0	6	30.0	

ACS: acute coronary syndrome; J-CTO: Multicenter Chronic Total Occlusion Registry of Japan; PCI: percutaneous coronary intervention; TIMI: Thrombolysis in Myocardial Infarction

X^2 test* *P*, between 4 groups

Table 6. Patient Characteristics and J-CTO Parameters Categorized by 3-Month Clinical Improvement

Parameter	Improved (n = 37)		Not improved (n = 23)		*P*
Age, mean (SD), y	54.32 (11.79)		56.7 (10.20)		.429
J-CTO score, mean (SD)	1.54 (0.96)		2.48 (1.03)		.001
Sex, No. (%)	No.	%	No.	%	.464
Male	24	64.9	17	73.9	
Female	13	35.1	6	26.1	
Smoking, No. (%)	21	56.8	14	60.9	.753
Diabetes mellitus, No. (%)	13	35.1	8	34.8	.978
Hypertension, No. (%)	17	45.9	12	52.2	.639
Dyslipidemia, No. (%)	28	75.7	14	60.95	.224
Family history, No. (%)	8	21.6	10	43.5	.072
CTO vessel, No. (%)					<.001
LAD	8	21.6	14	60.9	
RCA	15	40.5	0	0	
LCx	11	29.7	3	13.0	
LAD and RCA	0	0.0	6	26.1	
LAD and OM1	3	8.1	0	0	
Entry morphology, No. (%)					.003
Tapered	31	83.8	11	47.8	
Blunt	6	16.2	12	52.2	
Calcification, No. (%)					.348
Absent	14	37.8	6	26.1	
Present	23	62.2	17	73.9	
Bending, No. (%)					.262
<45°	29	78.4	15	65.2	
>45°	8	21.6	8	34.85	
Occlusion length, No. (%)					.124
<20 mm	17	45.9	6	26.15	
>20 mm	20	54.1	17	73.9	
Retry, No. (%)					.052

No	37	100	20	87.0	
Yes	0	0	3	13.0	

CTO: chronic total occlusion; J-CTO: Multicenter Chronic Total Occlusion Registry of Japan; LAD: left anterior descending artery; LCx: left circumflex artery; OM1: first obtuse marginal branch; RCA: right coronary artery

X^2 test, independent-sample *t* test*. *P*, between 2 groups

Table 7. Receiver Operating Characteristic Analysis of J-CTO Score for Prediction of Lack of Clinical Improvement

	AUC	SE	***P***	95% CI	Cutoff	Sensitivity (%)	Specificity (%)
J-CTO score	0.736	0.068	.002	0.601-0.870	≥2.50	60.9%	83.8%

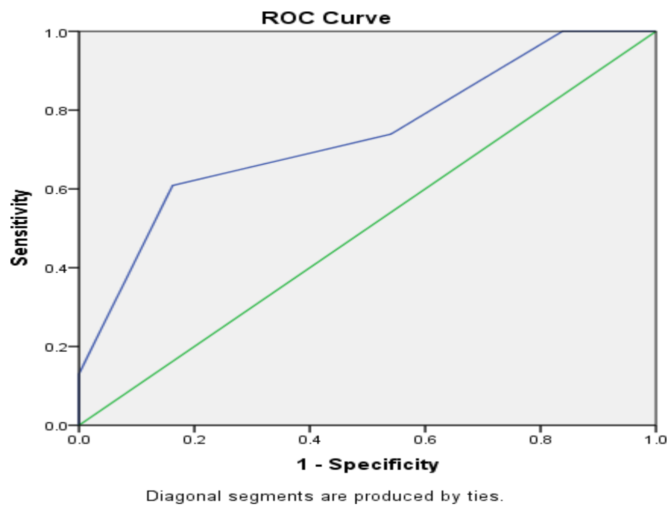

Figure 2. Receiver operating characteristic (ROC) curve of the J-CTO score for predicting a lack of clinical improvement at 3-month follow-up

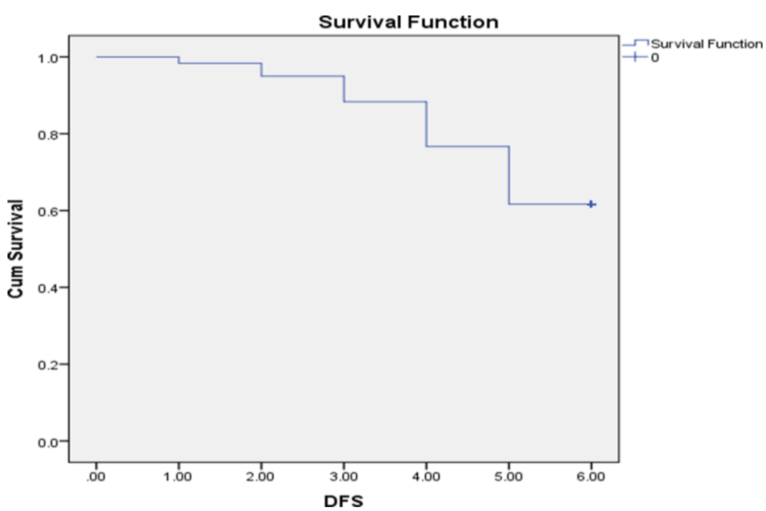

Figure 3. Disease-free survival among the study participants

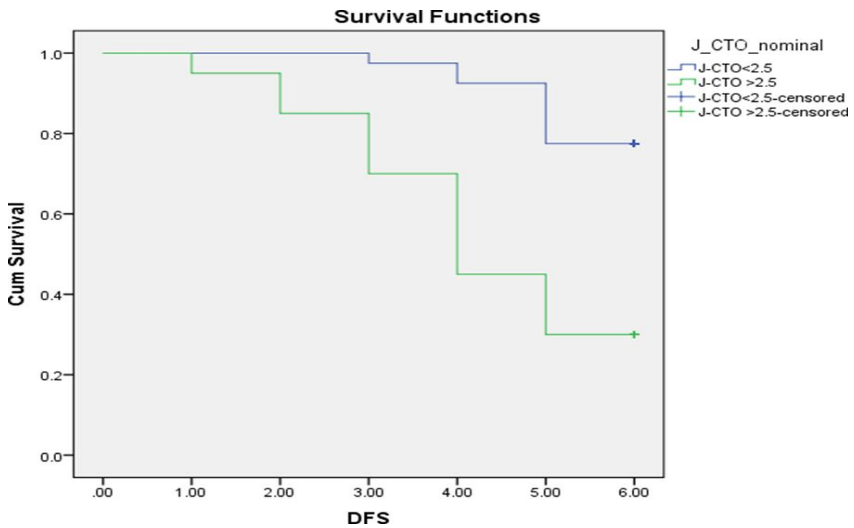

Figure 4. Disease free survival in relation to J-CTO score

Table 8. Regression Analysis for the Prediction of MACE Among the Study Participants

	Univariable Analysis				Multivariable Analysis			
	P	HR	95% CI		*P*	HR	95% CI	
Age	.423	1.020	0.972	1.07				
Sex (male)	.465	0.652	0.206	2.05				
Smoking	.753	1.185	0.410	3.42				
Hypertension	.639	1.283	0.452	3.64				
Dyslipidemia	.227	0.500	0.162	1.540				
Family history	.077	2.78	0.895	8.69				
Diabetes mellitus	.978	0.985	0.330	2.934				
J-CTO score	.001	8.03	2.395	26.96	<.001	15.49	6.27	33.60
White blood cell count	.009	1.598	1.122	2.274	.001	2.835	1.518	5.294
Total cholesterol	.535	1.004	0.992	1.016				
Triglycerides	.092	0.990	0.979	1.00				
Low-density lipoprotein cholesterol	.270	1.006	0.995	1.018				
High-density lipoprotein cholesterol	.240	0.940	0.848	1.042				

DISCUSSION

CTO of the coronary arteries is the final phase of the coronary atherosclerotic process, and such complex lesions are detected in approximately 15% to 30% of all coronary angiographies.[12] PCI for CTO lesions is a major technical challenge in contemporary interventional cardiology. With significant improvements in interventional procedures over the past decade, the safety and success rate of PCI in patients with CTO has improved.[13]

Moreover, successful CTO PCI has been found to decrease the risk of cardiac death and postoperative myocardial infarction and to improve long-term survival compared with failed CTO PCI.[14] Consequently, the objective of this study was to assess clinical improvement in patients with coronary CTO undergoing PCI according to the J-CTO score.

Concerning the demographic data of patients, the present study revealed that the difficult and very difficult groups were older than the easy and intermediate groups and were more likely to be male. Furthermore, a history of smoking, hypertension, and dyslipidemia was significantly more frequent in the higher J-CTO score groups. No significant difference was observed vis-à-vis the history of diabetes mellitus and family history among the studied groups. This finding agrees with Christopoulos et al,[15] who reported that patients with J-CTO scores of 3 or higher were older (*P* = .002), more likely to be male (*P* = .019), and more likely to have dyslipidemia (*P* = .012) and to be smokers (*P* = .036). Additionally, no significant difference as regards diabetes mellitus and hypertension was detected. In contrast to these results, Nombela-Franco et al[16] reported that there was no significant difference pertaining to age, sex, hypertension, dyslipidemia, and smoking among the different J-CTO groups.

Apropos the comparison of laboratory parameters among J-CTO score groups, the present research showed that the greater the J-CTO score, the greater the white blood cell count, total cholesterol, triglycerides, and low-density lipoprotein cholesterol and the lower the high-density lipoprotein cholesterol when compared with the easy group. Otherwise, no other significance could be detected with respect to other parameters. This could be explained as inflammation and dyslipidemia playing a central role in CAD. To our knowledge, no other study has compared laboratory parameters among J-CTO score groups. With regard to J-CTO parameters among J-CTO score groups, the present study noted that blunt entry, calcification, and occlusion lengths of greater than 20 mm showed a higher frequency among very difficult and difficult groups compared with others with statistical significance. Otherwise, no other significance could be detected. These results are concordant with Christopoulos et al,[15] who stated that the distribution of parameters utilized for J-CTO score calculation significantly differed across the 4 J-CTO groups (*P* < .001).

Regarding PCI technique, 3-month outcome, and 6-month outcome among J-CTO score groups, the present study reported a highly significant difference with regard to loading drug and PCI technique. Moreover, the 3-month outcome (no improvement) and the 6-month outcome (recurrent hospitalization and sudden cardiac death) were more frequent in the very difficult group. A similar result was obtained by Christopoulos et al,[15] who reported that MACE increased among higher J-CTO groups. Furthermore, the probability of success using the retrograde approach was enhanced with an increasing J-CTO score, whereas the opposite was true for the antegrade approach. As regards individual characteristics among the studied groups that improved or did not improve, the present study revealed no significant difference relating to demographic data between the 2 groups. Nevertheless, vessel involvement showed a statistically significant difference, as the RCA showed a higher frequency in the improved group than in the non-improved group. In addition, the LAD showed a higher frequency in the non-improved group than in the improved group. In line with these results, Grossman et al[17] stated that there was no significant difference regarding age, cardiovascular risk factors (hypertension, diabetes mellitus, dyslipidemia, and current smoking) between successful and failed cases. Similarly, Nakachi et al[18] reported no significant difference regarding age, sex, diabetes mellitus, smoking, and hyperlipidemia between patients with failed or successful procedures, and the RCA showed a higher frequency in successful CTO PCI. In contrast to these results, Jin et al[19] noted that male sex was significantly more frequent in successful cases. Additionally, the frequency of the LAD and RCA was equal in patients with successful CTO recanalization with PCI, whereas the frequency of the RCA was significantly higher in failed cases.

Apropos of the J-CTO score and parameters among the studied groups that improved or did not improve, the present study found that the J-CTO score was significantly higher in non-improved patients compared with improved patients. Moreover, blunt entry showed a significantly higher frequency in non-improved patients than in improved patients. Otherwise, no other significant differences were detected. This finding agrees with Nakachi et al,[18] who reported that CTO lesions in failed cases had more advanced angiographic findings, including bending, blunt stump, and occlusion lengths of 20 mm or more. Reattempted CTO PCI was more commonly reported in patients with failed CTO PCI. The J-CTO score was higher among failed cases (mean [SD], 2.24 [1.06] vs 1.90 [0.99]; $P < .001$).

As to performance characteristics of the J-CTO score for prediction of non-improved patients, ROC curve analysis was performed to identify the optimal J-CTO score cutoff for the prediction of non-improved patients (failed cases). The best J-CTO score cutoff value was 2.50, with an AUC of 0.736 ($P = .002$). These results are in agreement with Nombela-Franco et al,[16] who reported that the ROC curve for probability of guidewire crossing success within 30 minutes revealed an AUC of 0.770 ($P < .001$), whereas the ROC curve for global success rate had an AUC of 0.399 ($P = .136$).

Survival analysis for disease-free survival or MACE–free survival revealed that disease-free survival estimates were 97.5% at 3 months and 77.5% at 6 months in the J-CTO score less than 2.5 group and 70.0% at 3 months and 30.0% at 6 months in the J-CTO score greater than 2.5 group, with a significant difference between the 2 groups ($P < .001$). Chiming with these results, Wu et al[20] reported that the Kaplan-Meier curve revealed that a J-CTO score of 3 or higher was associated with a significantly higher 1-year MACE rate compared with a J-CTO score below 3 in patients undergoing PCI ($P = .009$). Similarly, Forouzandeh et al[21] noted that the 3-year MACE–free probability was higher among patients with lower (0-2) J-CTO scores than in those with higher (≥3) J-CTO scores ($P = .01$).

Pertaining to regression analysis for the prediction of major adverse cardiac events in patients, the current study reported that white blood cell count and J-CTO score were significant risk factors for major adverse cardiac events. Wu et al[20] reported that the regression model identified J-CTO score (hazard ratio [HR], 2.10; 95% CI, 1.09 to 4.04; $P = .026$) and successful CTO PCI (HR, 0.17; 95% CI, 0.05 to 0.59; $P = .005$) as significant independent predictors of major adverse cardiac events.

CONCLUSIONS

The J-CTO score remains a valuable tool for predicting procedural success in patients undergoing CTO PCI, and higher scores are associated with a greater likelihood of MACE. Routine calculation of the J-CTO score remains valuable for identifying challenging cases that may require more extensive planning or proctoring.

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