Japanese scoring system as a prediction of successful guidewire crossing of below-the-knee chronic total occlusion

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Background
A condition known as chronic limb-threatening ischemia (CLTI) occurs when there is a drastic reduction in blood flow to the lower extremities because of arterial blockage.
Aim
To evaluate the efficacy of Japanese scoring system in our population as a prediction of successful guidewire crossing of below-the-knee chronic total occlusion.
Patients and methods
This study was conducted on 48 patients with 55 chronic total occlusion (CTO) lesions. Patient assessment included history taking, laboratory analysis, and radiological assessment of the affected limbs. Patients were prepared for intraoperative angiography and then we applied Japanese below-the-knee chronic total occlusion (J BTK-CTO) scoring in our patients with antegrade of BTK-CTO by using 0.018, 0.035 wire, or additional retrograde guidewire crossing.
Results
In the current study, 54.5% of the studied lesions showed technical success and 45.5% showed failure. The median J BTK-CTO score was statistically significantly higher in the cases with failed crossing as compared with the cases with successful crossing [4 (2–6) and 1 (0–4), respectively] ($P < 0.001$). The area under the curve for Japanese score in differentiating failure from success among the studied lesions is excellent with the best-detected cut-off point 3, yielding sensitivity of 83.3%, specificity of 96% and total accuracy 89.1%, and cut-off point 4 yielding sensitivity of 96.7%, specificity of 80% and total accuracy 89.1%.
Conclusion
Failure of guidewire crossing of below-the-knee chronic total occlusion is common and may be associated with serious complications. J BTK-CTO revealed high diagnostic accuracy for prediction of failure in these cases and this could provide a good prognostic score for careful management of limb ischemia. Lesions categorized as grade C or D (the J BTK-CTO score of 4–6) have a lower chance of S-GC. In such lesions, a retrograde approach using pedal artery wiring or a digital artery puncture should be considered after failure antegrade.

Keywords:
below-the-knee, chronic total occlusion, guidewire, Japanese scoring

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Introduction

Chronic limb-threatening ischemia (CLTI) is an advanced form of peripheral arterial disease in which the tissue viability is threatened due to rural decrease in arterial blood flow to the foot, resulting in rest pain, nonhealing foot ulcers, tissue necrosis and gangrene [1].

In those patients, surgical revascularization should be adopted as the treatment option in patients having suitable anatomical conditions; however, due to involvement of the pedal arteries by the atherosclerosis or high surgical risk in most of the patients, surgical bypass is not always feasible [1].

Endovascular treatment options are gaining acceptance as the primary therapeutic strategy with the development of new technologies, such as dedicated guidewire or low-profile catheter balloons. In fact, since its initial applications, endovascular recanalization of tibial vessels and foot arteries has proven to be a feasible and safe procedure that has revolutionized salvage of the ischemic limb [2].

The success rate for endovascular treatment of infrapopliteal stenosis is up to 100%, but failure rate for occlusion-type lesions ranges from 20 to 40% [3]. The technical success for revascularizing lower limb vessels is determined by factors such as lesion length, calcification, distal vessel run-off and operator experience [4].

Although some reports have mentioned the efficacy of retrograde approaches for below-the-knee (BTK) CTOs, there has been no report of a scoring system for successful guidewire crossing (S-GC) of BTK CTOs using first an antegrade approach followed by a retrograde approach if the former is not successful [5,6].

Patients and methods

This is prospective analytic study that had been performed at Vascular Surgery Center at Mansoura University, Mansoura, Egypt between March 2021 and May 2022.

The study included 48 patients with CLTI with 55 BTK CTO. All patients underwent angioplasty using the Japanese scoring system as prediction if guidewire crossing was BTK CTO or not.

The cases with the following criteria were excluded: acute limb ischemia was excluded from this study, allergy to contrast and patients who needed primary amputation.

The study is conducted in accordance with Helsinki Standards as revised in 2013 [7]. The study was conducted after obtaining the approval from the local ethics committee, Faculty of Medicine, Mansoura University, and after obtaining a written informed consent from the included cases.

Patient assessment

History taking for comorbid medical conditions and risk factors such as smoking, DM, HTN, and CRF.

Investigations included laboratory investigations [complete blood count (CBC) and serum creatinine, HBA1C, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), serum albumin and viral markers hepatitis C virus (HCV), hepatitis B virus (HBV), and HIV].

The imaging investigations included duplex U/S, CTA in addition to intraoperative angiography.

Patients were admitted to the vascular surgery department and prepared for angioplasty and trial to pass a wire in all BTK CTO lesions with comparing the outcome with grading of JSS.

We applied JSS on CTO lesion by calcium in the lesion that was assessed using preoperative CTA (Fig. 1), where calcification takes one point in scoring.

During intraoperative angiography, we assess:

(1) Angiographic morphology of the proximal end of CTO was classified as 'tapered' if the occluded segment ended in a funnel-shaped form (Fig. 2) or 'blunt' if it did not (Fig. 3), where the blunt end takes one point in scoring.
(2) Reference vessel diameter that measured at the proximal part that was not occluded in the target vessel (Fig. 4). Reference vessel diameter (RVD) was classified as less than 2.0 or greater than or equal to 2.0 mm.
(3) RVD less than 2 mm takes one point in scoring.
(4) Occlusion length was measured from the proximal occlusion to the distal point where the vessel was filled during angiography (Fig. 5). If outflow of the

Figure 1

That shows calcification of tibial vessels in computed tomography.

target vessel was absent, it was measured from the proximal occlusion to a tibiotalar joint. Occlusion length was categorized as either less than 200 or greater than or equal to 200 mm and CTO greater than or equal to 200 takes one point in scoring.

(5) The presence or absence of the outflow, where its absence takes two points in scoring.

And the final grading is Grade A (0–1), Grade B (2–3), Grade C (4–5), and Grade D.

Statistical analysis

The data collected were coded, processed and analyzed with SPSS version 26 for Windows (Statistical Package for Social Sciences) (IBM, SPSS Inc, Chicago, IL, USA). Qualitative data as number (frequency) and percent were presented. The χ^2 test (Fisher's exact test/Monte Carlo test) made the comparison between groups. The Kolmogorov-Smirnov test tested quantitative data for normality. Data were shown as mean±SD.

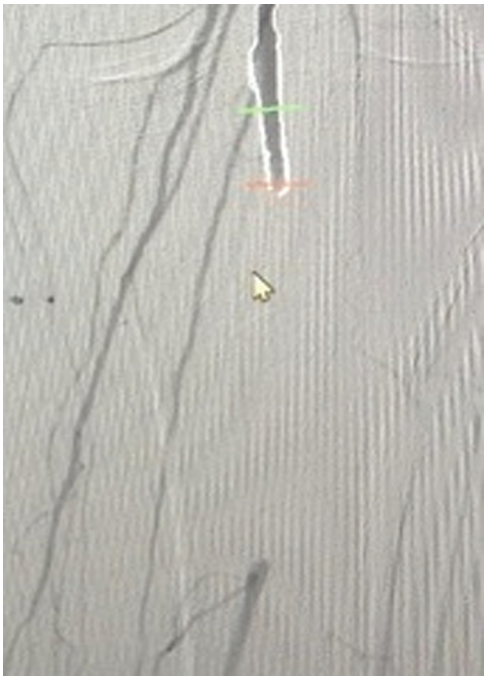
To compare two groups with normally distributed quantitative variables, independent samples (Student's) *t* test was used and Mann-Whitney *U* test was used if the data were abnormally distributed.

Univariate and multivariate regression analysis were used to assess the dependent and independent risk

Figure 2

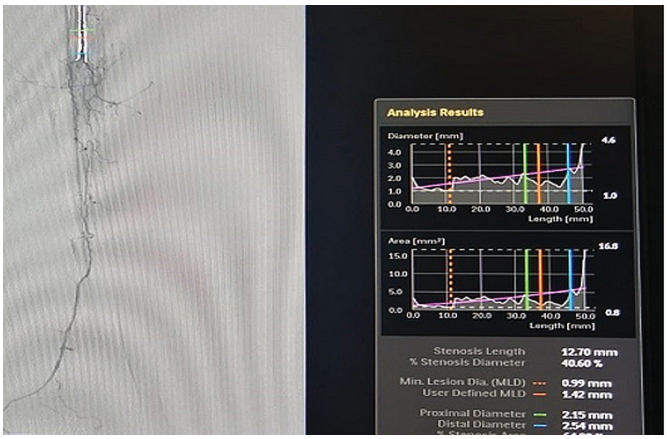
Intraoperative angiography with tapered end of ATA.

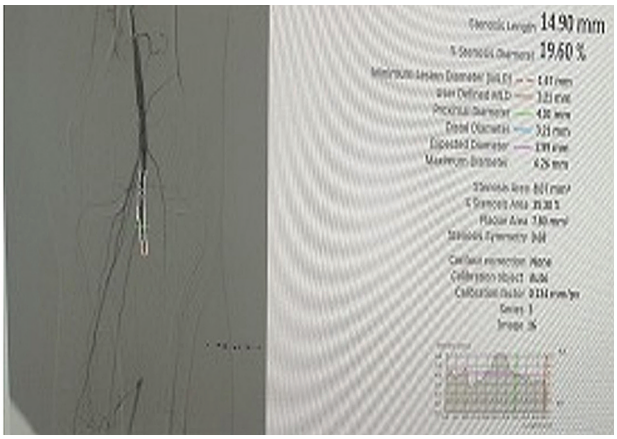
Figure 3



Intraoperative angiography with blunt end of peroneal.

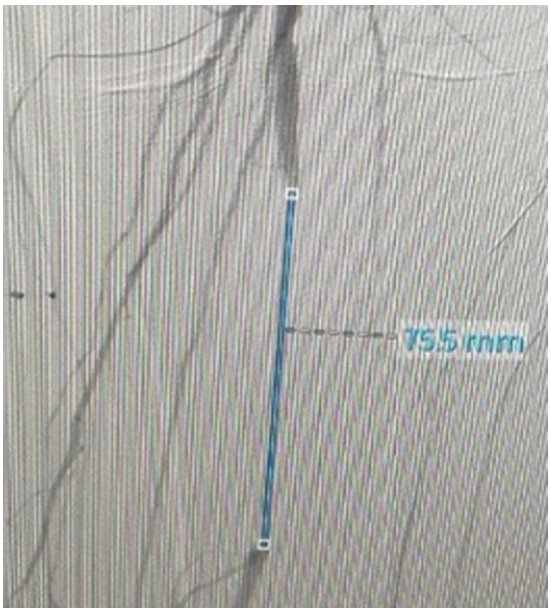
Figure 4





Diameter of the target vessels.

Figure 5



Measuring CTO length.

predictors of categorical outcome. The optimal cut-off value of a quantitative variable to differentiate between different groups was determined using Youden index J that is the farthest point on the receiver operator characteristic (ROC) curve and expressed in terms of sensitivity and specificity. For all tests, *P* values less than 0.05 are considered significant.

Results

Demographic data

A total number of 48 patients with 55 CTO lesions, the mean age was 63.75±8.37 SD (43–84) years, 25 were male and 23 were female (Table 1). Among our patients, there is high incidence of DM and smoker. Where history of patients shows that 75% of the studied cases are DM, 54.2% smokers, 16.7% chronic kidney disease (CKD), 37.5% hypertensive, 29.2% cardiac and 4.2% hypothyroidism (Table 1).

Table 1 Demographic characteristics, associated medical diseases of the studied cases

	n=48 (%)
Age (y), mean±SD (min-max)	63.75±8.37 (43–84)
Sex	
Male	25 (52.1)
Female	23 (47.9)
DM	36 (75)
Smoking	26 (54.2)
Chronic kidney diseases	8 (16.7)
Hypertension	18 (37.5)
Cardiac	14 (29.2)
Others (hypothyroidism)	2 (4.2)

Most of the patients were complaining from tissue lesion (30) and there were others with rest pain (18) with the affected lesions 31 lesions on the right side and 24 lesions on the left side, and the target vessels are distributed as the following: 56.4% anterior tibial artery (ATA), 23.6% posterior tibial artery (PTA) and 20% peroneal (Table 2).

Table 2 Analysis of the criteria of the lesions, Japanese score and the technical success

	n=55 (%)
Site of lesion in the targed vessel	
LT	24 (43.6)
RT	31 (56.4)
Complaint	
Rest pain	18 (48) (37.5)
Tissue lesion	30 (48) (62.5)
Target vessels	
PTA	13 (23.6)
Peroneal	11 (20.0)
ATA	31 (56.4)
Japanese scoring system	
Proximal stump	
Tapered	24 (43.6)
Blunt	31 (56.4)
Calcification	
–ve	19 (34.5)
+ve	36 (65.5)
RVD (mm)	
Median (min-max)	1.81 (0.9–3.56)
CTO length (mm)	
Median (min-max)	140 (21.8–320)
Outflow	
Absent	17 (30.9)
Present	38 (69.1)
Score	
0	7 (12.7)
1	10 (18.2)
2	9 (16.4)
3	8 (14.5)
4	10 (18.2)
5	5 (9.1)
6	6 (10.9)
Median (min-max)	3 (0–6)
Grade	
A	17 (30.9)
B	17 (30.9)
C	15 (27.3)
D	6 (10.9)
Type of wire	
Wire 0.035	36 (65.5)
Wire 0.018	8 (14.5)
Both	11 (20.0)
Outcome	
Failure in high score	25 (45.5)
Success in low score	30 (54.5)
Complications	*n*=14
Dissection	3 (21.5)
Perforation	11 (78.5)

Table 3 Relation between all the tested variables and outcome among studied lesions

	Failure *N*=25 (%)	Success *N*=30 (%)	*P* value
Age (y)			0.356
Median (min-max)	65 (52–75)	62.5 (43–84)	
Sex			
Male	14 (56.0)	15 (50.0)	0.657
Female	11 (44.0)	15 (50.0)	
Complaining limb			
LTLLCLI	11 (44)	13 (43.3)	0.960
RTLLCLI	14 (56)	17 (56.7)	
Diabetes mellitus	21 (84.0)	19 (63.3)	0.087
Smoker	15 (60)	16 (53.3)	0.620
Chronic kidney disease	4 (16)	5 (16.7)	0.947
HTN	9 (36)	11 (36.7)	0.959
Cardiac	8 (32)	7 (23.3)	0.472
Hypothyroidism	1 (4.0)	1 (3.3)	0.895
Target vessels			
PTA	6 (24)	7 (23.3)	0.788
Peroneal	4 (16)	7 (23.3)	
ATA	15 (60)	16 (53.3)	
Proximal stump			
Tapered	6 (24)	18 (60)	0.007*
Blunt	19 (76)	12 (40)	
Calcification			
–ve	4 (16)	15 (50)	0.008*
+ve	21 (84)	15 (50)	
RVD (mm)	1.8 (0.9–3.1)	2.29 (1.04–3.56)	0.075
CTO length (mm)	225 (130–320)	95.25 (21.8–210)	<0.001*
Outflow			
Absent	16 (64)	1 (3.3)	<0.001*
Present	9 (36)	29 (96.7)	
Score			
0	0	7 (23.3)	<0.001*
1	0	10 (33.3)	
2	1 (4.0)	8 (26.7)	
3	4 (16)	4 (13.3)	
4	9 (36)	1 (3.3)	
5	5 (20)	0	
6	6 (24)	0	
Median (min-max)	4 (2–6)	1 (0–4)	<0.001*
Grade			
A	0	17 (56.7)	<0.001*
B	5 (20)	12 (40)	
C	14 (56)	1 (3.3)	
D	6 (24)	0	
Type of wire			
Wire 0.035	15 (60)	21 (70)	0.008*
Wire 0.018	1 (4.0)	7 (23.3)	
Both	9 (36.0)	2 (6.7)	
Complications			
Dissection	3 (21.5)	0	<0.001*
Perforation	11 (78.5)	0	

* Good *p* value.
LTLLCLI, left lower limb critical limb ischemia; RTLLCLI, right lower limb critical limb ischemia.

About the Japanese score system, describing the lesion is distributed as the following: 56.4% blunt proximal stump, 65.5% positive calcification, median RVD is 1.81 ranging from 0.9 to 3.56 mm and median CTO length is 140 ranging from 21.8 to 320 mm. Outflow of the studied lesions is distributed as the following:

69.1% present outflow and 30.9% absent outflow (Table 2), 18.2% score 4, score 1, 16.4% score 2, 14.5% score 3, 12.7% score 0 and 9.1% score 6.

According to the grade of JSS, there was 30.9% of the studied lesions that are grade A, 30.9% grade B, 27.3% grade C and 10.9% grade D (Table 2). And according to the wire used, 65.5% wire 0.035 and 14.5% wire 0.018.

The wire can pass in 54.5% of the studied lesions, 45.5% failure (Table 2), among failure group's 11 lesions complicated with perforation and 3 lesions complicated with dissection.

In our prospective study, there is no statistically significant difference between success and failure among studied lesions as regards age and sex of the studied cases. Also, Table 3 illustrates a non–statistically significant difference between success and failure as regards complaining limb and complaining form ($P > 0.05$).

Also, a non–statistically significant difference between success and failure as regards presence of diabetes mellitus (DM), CKD, hypertension, cardiac disease and hypothyroidism. Failure of the studied lesions is distributed as the following: 84% DM, 60% smoker, 36% hypertensive, and 32% cardiac. Moreover, there was no statistically significant difference between failure and success of the studied lesions as regards target vessels. Of the cases failed, 60% ATA, 24% PTA and 16% peroneal.

But, there was a statistically significant difference between success and failure as regards Japanese score, including the following items: proximal stump, calcification, RVD, CTO length, outflow and total Japanese score. Among lesions with failure, 76% blunt proximal stump, 84% positive calcification and 64% absent outflow. Median RVD is lower among failed than succeeded cases (1.8 and 2.29), respectively. Higher median CTO length among failed than succeeded cases (225 vs. 95.25). Higher Japanese score is detected among failed than succeeded cases (4 vs. 1, respectively).

There was a statistically significant higher grade among failed than succeeded lesions. Among failed cases, 56% grade C, 24% grade D and 20% grade B. For failed lesions, the type of wire is distributed as the following: 60% wire 0.035, 36% both wire 0.035 and wire 0.018 and 4% wire 0.018. There was a statistically significant difference between failed and succeeded lesions as regards complications. None of the succeeded cases have complications, whereas for failed cases, 11 lesions have perforation, and 3 lesions dissection.

The following factors are predictors of success by univariate analysis of the studied factors: lesions with tapered proximal stump have 4.75 more times success than cases with blunt stump. An increase in CTO length decreases success chance (odds ratio = 0.952). The presence of outflow increases the chance of success by 51.55 more times than absent outflow. The increase in Japanese score decreases the chance for success (odds ratio = 0.097). Using a wire of 0.035 increases the chance of success 6.3 more times than using both types of wire and using of wire 0.018 increases the chance of success by 31.5 more times. Multivariate analysis of predictors of success demonstrates that decreased CTO length, presence of outflow and use of a single wire, either wire 0.035 or wire 0.018, increases the chance for success with the overall percent predicted 85.5% (Table 4).

The area under the curve for Japanese score in differentiating failure from success among the studied lesions is excellent with the best-detected cut-off point 3, yielding sensitivity of 83.3%, specificity of 96% and total accuracy 89.1%, and cut-off point 4 yielding sensitivity of 96.7%, specificity of 80% and total accuracy 89.1% (Table 5, Fig. 6).

Discussion

Our prospective study was conducted to evaluate the efficacy of Japanese scoring system in our population as a prediction of successful guide wire crossing of BTK CTO.

The current study included 48 patients with 55 CTO lesions (lower limb ischemia with BTK CTO) who were recruited from cardio-thoracic and vascular surgery, vascular surgery department, Mansoura University.

In our prospective study, the mean age of the studied cases is 63.75 years ranging from 43 to 84 years, and regarding the sex distribution, 52.1% are males.

Many studies stated that PAD is more prevalent in population aging 50-70 s and accounts for ~25% in population over 80 years [8–10].

The reported male predominance in the study patients (70%) can be explained, possibly, by the increased PAD incidence among Egyptian male sex than females,

Table 4 Univariate and multivariate analysis for prediction of success

	Univariate analysis		Multivariate analysis		
	P value	COR (95% CI)	β	*P* value	AOR (95% CI)
Age (y)	0.398	0.972 (0.909–1.04)			
Sex					
Male (r)	0.657	1			
Female		1.27 (0.438–3.69)			
DM					
–ve	0.094	3.04 (0.827–11.17)			
+ve (r)					
Smoker					
Nonsmoker (r)	0.620	1.31 (0.448–3.84)			
CKD					
–ve	0.947	0.952 (0.226–4.01)			
+ve (r)					
HTN					
–ve	0.959	0.972 (0.322–2.93)			
+ve (r)					
Cardiac					
–ve	0.474	1.55 (0.469–5.09)			
+ve (r)					
Complaining limb					
LTLLCLI (r)	0.960	1			
RTLLCLI		1.03 (0.352–2.99)			
Target vessels					
PTA (r)	0.629	1			
Peroneal	0.895	1.5 (0.290–7.75)			
ATA		0.914 (0.250–3.35)			
Proximal stump					
Tapered	0.009*	4.75 (1.47–15.35)	3.49	0.260	32.77 (0.075–60.25)
Blunt (r)		1			
Calcification				0.840	1.50 (0.029–78.7)
–ve	0.012*	5.25 (1.45–19.01)	0.408		
+ve (r)		1			
RVD.MM	0.081	2.23 (0.906–5.49)			
CTO.LENGTH.MM	<0.001*	0.952 (0.928–0.975)	–0.043	0.02*	0.958 (0.924–0.994)
Outflow					
Absent (r)	<0.001*	1	4.14	<0.001*	62.56(6.7-52.9)
Present		51.55 (5.98–444.48)			
Japanese scoring system	0.001*	0.097 (0.026–0.365)	–3.29	0.085	0.037 (0.001–1.57)
Grade					
A	0.998	Undefined			
B	0.999				
C	0.999				
D (r)					
Type of wire					
Wire 0.035	0.031*	6.3 (1.18–33.44)	2.18	0.027*	8.91 (1.28–62)
Wire 0.018	0.009*	31.5 (2.35–422.29)	3.92	0.027*	50.4 (1.57–62.5)
Both (r)		1			1

* Good *p* value.
LTLLCLI, left lower limb critical limb ischemia; r, Reference group; RTLLCLI, right lower limb critical limb ischemia.

increased smoking among males more than females resulting in more PAD or a more severe form of PAD, that is, CLTI, is found more in males. Other findings reported different sex incidences of PAD in different communities and socio-economic classes. However, they stated that the severe form of PAD is more common in males [11].

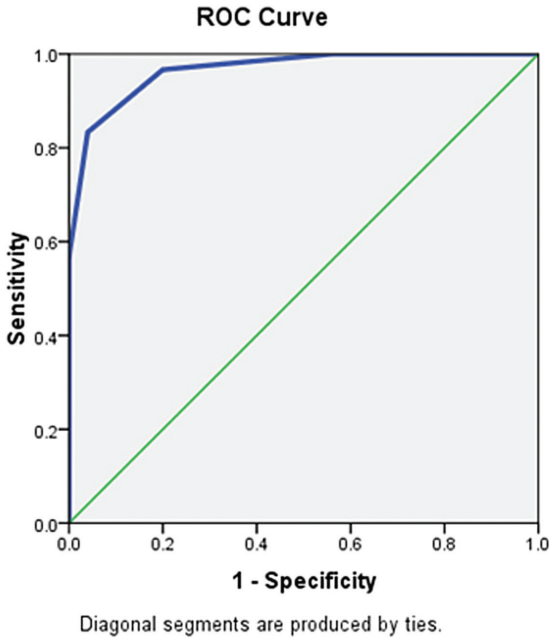
Also, DM was the most associated comorbidity among the included cases. DM was detected in 75% of the

Table 5 Validity of Japanese score in differentiating success from failure

	AUC (95% CI)	*P* value	Cut-off point	Sensitivity%	Specificity%	PPV%	NPV%	Accuracy%
Score	0.966 (0.925–1.01)	<0.001*	≤3	83.3	96.0	96.2	82.8	89.1
			≤4	96.7	80.0	85.3	95.2	89.1

* Good *p* value.
AUC, area under curve; NPV, negative predictive value; PPV, positive predictive value.

Figure 6



Receiver operating characteristics curve (ROC) in prediction of intervention success.

studied cases, 54.2% smoker, 16.7% CKD, 37.5% hypertensive, 29.2% cardiac and 4.2% hypothyroidism.

The previously mentioned data came in agreement with Moustafa and colleagues who included 20 adult patients who had critical lower limb ischemia (Rutherford 4 and 5) were admitted to the vascular surgery unit of Alexandria main university hospital. They reported that 85% of the study patients had DM, whereas 80% were smokers [12].

The highest percentage of the cases of CLI were diabetic patients, and the most pattern of complications they suffered is infected nonhealing ulcers. This may be explained as diabetic patients are significantly less able to develop arterial collaterals [13].

In the current study, Japanese score system describing the lesion is distributed as following: it illustrates that 56.4% blunt proximal stump, 65.5% positive calcification, median RVD is 1.81 ranging from 0.9 to 3.56 mm and median CTO length is 140 ranging from 21.8 to 320 mm .Outflow of the studied lesions is distributed as the following: 69.1% present outflow and 30.9% absent outflow, 18.2% score 4, score 1, 16.4% score 2, 14.5% score 3, 12.7% score 0 and 9.1% score 6.

According to Tan and colleagues, choosing the best model as the Japanese-BTK (J-BTK) CTO score by comparing the optimism adjusted area under receiver-operating characteristic curves, it was decided to assign one point to 'Blunt type at the proximal entry point', one point to 'Calcification at the proximal entry point', one point to 'Reference vessel diameter less than 2.0 mm','one point to 'CTO length 200 mm" and two points to 'No outflow of the target vessel'. This rule was then used to categorize BTK CTOs into four grades with varying probabilities of S-GC: grade A (J-BTK CTO score of 0 and 1), grade B (scores of 2 and 3), grade C (scores of 4 and 5) and grade D (score of 6). Rates of S-GC in each grade (grades A, B, C and D) were 97.3%, 76.8%, 19.3% and 0%, respectively [14].

In the current study, the incidence of technical success was 54.5% (30 out of 55 CTO lesions). Among the 30 lesions with technical success, there were 28 lesions with antegrade success (93.3%) and 2 lesions (6.7%) with failure of antegrade technique and success achieved with retrograde approach. The overall failure rate of the antegrade technique was (2 lesions out of 30 in the successful group and 25 lesions out of 25 in the failed group).

This was close to the study of Tan and colleagues who conducted a retrospective, multicenter, nonrandomized study of 448 consecutive BTK CTOs in 299 patients (with 484 CTO lesions) treated with endovascular therapy in seven Japanese medical centres from April 2012 to April 2020. The cohort was classified into two groups: an S-GC group and a failed guidewire crossing group. The authors showed that failure of antegrade crossings occurred in 38.6% of lesions (79 of 354 lesions in the S-GC group and 94 of 94 lesions in the F-GC group), which was within the previously reported range [14].

Walker *et al.* [15] showed that retrograde pedal access after a failed antegrade approach was successful in 96% of patients (Rutherford 4-6 with occlusive disease) and those with vessel diameters greater than 1.5 mm.

However, the incidence was much lower: Graziani *et al.* [16] showed in his series of 20 consecutive cases using extended angioplasty of a single tibial and foot artery, was able to achieve a technical success rate of 95%. Amputation-free survival at 2 years was 84.2%.

The difference could be explained due to the associated comorbidities among the included cases in the current study. For example, rates of major lower extremity amputations in the dialysis population have been estimated to be 4.3% after 1 year and 13% among the dialysis patients with [17]. Technical success for endovascular revascularization in this group of patients with tibial disease has been reported as high as 42% [18].

Another reason could be due to more advanced Rutherford category of our patients as our patients were categories 4, 5 and 6, whereas their categories 3, 4, and 5 (part of their patients were claudicant and no patients with gangrene).

The technical success of antegrade or retrograde approach angioplasty for revascularizing lower limb vessels is determined by factors such as lesion length, calcification, distal vessel run-off and operator experience [17,19,20].

In the current study, there was no statistically significant difference between the cases with successful or failed reperfusion regarding the presence of DM, CKD, hypertension, cardiac disease and hypothyroidism. Failure of the studied lesions is distributed as following: 84% DM, 60% smoker, 36% hypertensive and 32% cardiac.

This disagreed with Tan *et al.* [14] who showed that the S-GC group had a lower prevalence of hemodialysis (53.4% vs. 69.1%; $P = 0.006$) and a higher prevalence of hypertension (74.0% vs. 62.8%; $P = 0.04$), dyslipidemia (43.5% vs. 30.9%; $P = 0.04$), and cerebrovascular disease (44.1% vs. 28.7%; $P = 0.007$).

The variation could be explained due to small sample size included in the current study.

In our prospective study, there is a statistically significant difference between success and failure as regards RVD and CTO length. The median RVD is lower among failed than succeeded cases (1.8 and 2.29), respectively. Higher median CTO length among failed than succeeded cases (225 vs. 95.25).

This agreed with Tan *et al.* [14] who showed that the F-GC group had a longer CTO length (201.6 ±71.1 mm vs. 108.6±85.5 mm; $P < 0.001$), a smaller RVD (2.00±0.37 mm vs. 2.32±0.41 mm; $P < 0.001$).

In the current study, higher Japanese score is detected among failed than succeeded cases (4 vs. 1), respectively. Also, by ROC curve analysis, the area under the curve for Japanese score in differentiating failure from success among the studied lesions is excellent with the best-detected cut-off point 3, yielding sensitivity of 96%, specificity of 96% and total accuracy 89.1% and cut-off point 4 yielding sensitivity of 80%, specificity of 85.3% and total accuracy 89.1%.

This agreed with Tan and colleagues who categorized BTK CTOs into four grades with varying probability of successful overall guidewire crossing: (1) grade A (J-BTK CTO score 0 and 1 point), (2) grade B (score 2 and 3 points), (3) grade C (score 4 and 5 points) and (4) grade D (score 6 points). They demonstrated the relationship between the grading of the J-BTK CTO score and rates of successful overall guidewire crossing. Rates of S-GC in each grade (grades A, B, C and D) were 97.3%, 76.8%, 19.3% and 0%, respectively [14].

In the current study, there is a statistically significant difference between failed and succeeded lesions as regards complications. None of the succeeded cases have complications, whereas for failed cases, 11 lesions have perforation, 3 lesions have dissection. All the failed cases were exposed to the complications of excess unnecessary radiation exposure, long operation time and high contrast dose.

Perforation was the most commonly reported complication in the cases of the study. Perforation is a serious complication that any CLI operator working in the tibial region must be willing to recognize and treat immediately. The location of perforation within the tibial anatomy has important implications. Due to their location in the calf, proximal tibial perforations are more serious and are likely to increase the risk of compartment syndrome [21].

In addition to the previously mentioned benefits, multivariate analysis of predictors of success demonstrated that decreased CTO length, presence of outflow and use of single wire; either wire 0.035 or wire 0.018, increases the chance for success with the overall percent predicted 85.5%.

In the study conducted by Tan *et al.* [14], the following factors were associated with failure of revascularization: 'No outflow of the target vessel' (odds ratio [OR]: 0.11,

95% confidence interval [CI]: 0.06–0.23), 'CTO length greater than or equal to 200 mm' (OR: 0.25, 95% CI: 0.12–0.50), 'RVD less than 2.0 mm' (OR: 0.18, 95% CI: 0.08-0.40), 'Calcification at the proximal entry point' (OR: 0.15, 95% CI: 0.08–0.30) and 'Blunt type at entry point' (OR: 0.33, 95% CI: 0.17–0.64) were retained in the final logistic regression model.

The study has some limitations such as the small included sample size, being a single-center study.

Conclusion

The failure of guide wire crossing in patients with chronic total occlusion below the knee is common and may be associated with other serious complications.

J BTK-CTO demonstrated a high diagnostic accuracy for the prediction of failure in these cases, and this could provide a helpful prognostic score for the careful management of limb ischemia and selection of the target vessel with hopeful reopening.

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Conflicts of interest

There are no conflicts of interest.

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