Original Article

Outcomes of Percutaneous Coronary Intervention in Chronic Total Occlusion among Women

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ABSTRACT

Objective: To determine the outcomes in female patients who underwent percutaneous coronary intervention (PCI) for chronic total occlusion.

Methodology: This longitudinal descriptive study was conducted at the Department of Cardiology, Fauji Foundation Hospital, Rawalpindi from July 2024 to March 2025 after taking approval from the ethical committee. A total of 56 female patients with a diagnosed chronic total occlusion (CTO) who had persistent angina symptoms despite optimal medical therapy were included using non-probability convenience sampling. All these patients were eligible to undergo CTO-PCI with normal kidney function and gave informed consent. The patients underwent CTO-PCI by interventional cardiologists. All the patients had a monthly follow-up for 3 months post-procedure. The outcomes assessed were rate of procedural success, in-hospital major adverse cardiovascular events (MACE) and cardiac mortality & symptom-free at 3 months. Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.

Results: The procedural success rate was found in 37(66.1%) patients. In-hospital MACE occurred in 5(8.9%) patients. Two (3.6%) patients died whereas, 40(71.4%) patients were symptom-free at 3 months. In-hospital MACE was significantly less in the successful CTO-PCI group (p-value=0.04) and the majority [34(94.4%)] of the patients in the successful CTO-PCI group were symptom-free at 3 months (p-value=0.001). However, there was no significant difference in mortality at 3 months between the two groups with a p-value of 0.53. The procedural failure was significantly associated with the elderly age group >60 years (p-value=0.02) and diabetes mellitus (p-value=0.004).

Conclusion: The CTO-PCI has a procedural success rate of 66.1% and the majority of the patients were symptom-free after the procedure. The statistically significant outcomes were reduction in the frequency of in-hospital MACE and symptom-free at 3 months in the successful CTO-PCI group. The procedural failure was significantly associated with the elderly age group and diabetes mellitus.

Keywords: *Chronic total occlusion. Percutaneous coronary intervention. Myocardial infarction.*

INTRODUCTION

Coronary chronic total occlusion is a severe form of coronary artery disease (CAD) that manifests as complete blockage of a coronary artery for >3 months and thrombolysis in myocardial infarction (TIMI) grade 0 flow. It is one of the most challenging situations for interventional cardiologists due to the complexity of the lesions.[1,2] Around 15-35% of the patients with significant CAD who undergo diagnostic intervention have CTO. It is one of the major reasons for referring patients for coronary artery bypass grafting (CABG). Literature has reported that around 30% of the chronic total occlusions cannot even be bypassed by CABG. Percutaneous coronary intervention is still performed for CTO lesions. However, the success rate of CTO-PCI is low with complex procedures and a high rate of complications. The success rate is mainly determined by the complexity of the lesion, the technical expertise of the cardiologist and the co-morbidities of the patients.[3,4] The procedure-related complications of CTO-PCI are coronary dissection, cardiac tamponade, perforation of the coronary artery, myocardial infarction, stroke, major bleeding, side branch occlusion and referral for urgent CABG.[5] The procedural complications if not recognized, prevented or managed properly can lead to drastic effects.[4]

Fortunately, due to the recent advancements in PCI equipment and techniques, the success rates of PCI have increased. Previously, the success rate of PCI for CTO was 60% but now the success rate of 80-90% has been reported in dedicated CTO-PCI centers.[4] In addition to improvement in the success rate, there has been a marked decrease in the complications related to the procedure in recent years owing to higher clinical expertise and dedicated devices.[6] The benefit of successful PCI in CTO lesions is the relief of patient symptoms such as angina, shortness of breath and improvement in the exercise capacity owing to decrease in the extent of ischemia.[7] Lower frequency of major adverse cardiovascular events (MACE) with the successful procedure has also been reported but the role of the procedure in improving long-term outcomes such as increased survival has not been well established.[8]

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Being present in one-third of the patients with CAD, it is mandatory for cardiologists to know the optimal evaluation and management of CTO lesions. The decision to perform PCI for CTO lesions depends on whether the anticipated benefits exceed the risks of the procedure. Although the PCI of CTO lesions is complex, the dramatic improvement in the success rate of the procedure in dedicated CTO centers has drawn significant attention and interest of interventional cardiologists. The number of CTO-PCI procedures in Pakistan is limited owing to expensive PCI equipment and a lack of dedicated CTO operators. Due to this, the data is limited in our setup and our results may vary from the studies conducted in developed countries. This study was designed to determine the outcomes of patients who underwent CTO-PCI in our setup. As most of the patients presenting in Fauji Foundation Hospital are females, this study was conducted specifically in the female population.

METHODOLOGY

This longitudinal descriptive study was conducted at the Department of Cardiology, Fauji Foundation Hospital, Rawalpindi over a 9 months period from July 2024 to March 2025 after taking approval from the ethical committee (Letter No. 857/RC/FFH/RWP, 28-06-2024). Coronary chronic total occlusion was defined as total occlusion with grade 0 TIMI flow for more than 3 months. A sample size of 50 was calculated at 90% confidence interval, 7% margin of error and proportion of successful PCI at 90.1% using the WHO sample size calculator.[9] A total of 56 female patients with diagnosed CTO who had persistent angina symptoms despite optimal medical therapy were included in the study using a non-probability convenience sampling technique. All these patients were eligible to undergo CTO-PCI with normal kidney function. The exclusion criteria were patients with non-CTO lesions and patients with complex CTO lesions managed either conservatively or referred for CABG. Informed written consent was obtained from all the patients or their attendants.

The percutaneous coronary intervention was performed in patients with chronic total occlusion by interventional cardiologists. The procedure was performed through femoral access. The demographic & clinical data of the patients and their baseline angiograms were reviewed to assess the feasibility of the procedure. The procedural details and outcomes were recorded by two other experienced operators. All the patients had a monthly follow-up for 3 months post-procedure. The outcomes assessed were rate of procedural success, in-hospital MACE and cardiac mortality & symptom-free at 3 months. Based on procedural success, patients were divided into two groups: successful and unsuccessful CTO-PCI groups. In-hospital MACE, cardiac mortality & symptom-free at 3 months were compared between the two groups. Procedural success was labeled as recanalization of a CTO lesion with <50% stenosis and grade 3 TIMI flow. The in-hospital MACE included cardiovascular mortality, myocardial infarction (MI), coronary artery perforation, cardiac tamponade, cardiogenic shock, major bleeding and stroke. All deaths due to cardiac causes such as myocardial infarction (MI), heart failure, arrhythmia, or deaths that were unwitnessed or procedure-related were defined as cardiac mortality.[10]

STATISTICAL ANALYSIS

Data entry and analysis were carried out using the Statistical Package for the Social Sciences (SPSS) version 25. The numerical and categorical variables were expressed using mean±standard deviation and frequency & percentage, respectively. The association between categorical variables was determined using the Chi-square test. Fisher's exact test was applied where the expected frequency was less than 5 in any of the cells. The significant p-value was taken as ≤0.05.

RESULTS

The mean age of the female patients with coronary chronic total occlusion was 59±2.5 years. Out of 56 patients, 16(28.6%) were diabetic, 14(25%) were hypertensive, 22(39.3%) had dyslipidemia, and 40(71.4%) had a history of CAD.

The procedural success was found in 37(66.1%) patients achieving successful revascularization, whereas, it was unsuccessful in 19(33.9%) patients. In-hospital MACE occurred in 5(8.9%) of the total patients. Forty (71.4%) were symptom-free while 2(3.6%) patients died at 3 months follow-up.

The outcomes were compared between patients with successful and unsuccessful CTO-PCI groups. In-hospital MACE was significantly less in the successful CTO-PCI group (p-value=0.04) and the majority [34(94.4%)] of the patients in the successful CTO-PCI group were symptom-free at 3 months with statistical significance (p-value=0.001). Six (15%) symptom-free patients belonged to the unsuccessful CTO-PCI group and this was attributed to partial restoration equivalent to TIMI grade 2 flow. However, there was no significant difference in mortality at 3 months between the two groups with a p-value of 0.53 (Table 1).

Our results showed that procedural success was associated with age and diabetes mellitus. The procedure was unsuccessful in most of the elderly above 60 years (p-value=0.02) and diabetic patients (p-value=0.004) (Table 2).

DISCUSSION

One of the most challenging interventions in the field of interventional cardiology is CTO-PCI. In CTO-PCI, there is prolonged procedural time that leads to increased exposure to radiation. It requires complex interventional tools and is much more complicated as compared to non-CTO-PCI.[11] There has been a significant improvement in the success rate of CTO-PCI in recent years resulting from better operative expertise and advanced equipment. The procedural success improves the function of the left ventricle, hence improving the patient's symptoms, increasing their physical activity and satisfaction.[12]

Table 1: Comparison of Outcomes of the Patients between Successful and Unsuccessful CTO-PCI Groups

Outcomes		Successful CTO-PCI Group Frequency & Percentage	Unsuccessful CTO-PCI Group Frequency & Percentage	Total	p-value
In-Hospital MACE	**No**	36(97.3%)	15(78.9%)	51(91.1%)	0.04*
	Yes	1(2.7%)	4(21.1%)	5(8.9%)	
	Total	37(66.1%)	19(33.9%)	56(100%)	
Cardiovascular Mortality		0(0%)	2(10.5%)	2(3.6%)	
Myocardial Infarction		1(2.7%)	0(0%)	1(1.8%)	
Perforation		0(0%)	1 (5.3%)	1(1.8%)	
Cardiogenic Shock		0(0%)	1(5.3%)	1(1.8%)	
Cardiovascular Mortality at 3 Months	**Yes**	1(2.7%)	1(5.9%)	2(3.6)	0.53
	No	36(97.3%)	16(94.1%)	52(92.9%)	
	Total	37(66.1%)	17(30.4%)	54(96.4%)	
Symptom-Free at 3 Months	**Yes**	34(94.4%)	6(37.5%)	40(71.4%)	0.001*
	No	2(5.6%)	10(62.5%)	12(21.5%)	
	Total	36(64.3%)	16(28.6%)	52(92.9%)	

**Significant p-value*

Table 2: Association of Procedural Success with Age and Co-Morbidities

Parameters		Successful CTO-PCI Group (n=37)	Unsuccessful CTO-PCI Group (n=19)	Total	p-value
Age Groups (Years)	**≤50**	4(10.8%)	1(5.3%)	5(8.9%)	0.02*
	51-60	19(51.4%)	4(21.1%)	23(41.1%)	
	61-70	10(27%)	6(31.5%)	16(28.6%)	
	>70	4(10.8%)	8(42.1%)	12(21.4%)	
	Total	37(66.1%)	19(33.9%)	56(100%)	
Diabetes Mellitus	**Diabetic**	6(16.2%)	10(52.6%)	16(28.6%)	0.004*
	Non-Diabetic	31(83.8%)	9(47.4%)	40(71.4%)	
	Total	37(66.1%)	19(33.9%)	56(100%)	
Hypertension	**Hypertensive**	10(27%)	4(21.1%)	14(25%)	0.75
	Non-Hypertensive	27(73%)	15(78.9%)	42(75%)	
	Total	37(66.1%)	19(33.9%)	56(100%)	
Lipid Profile	**Deranged (Dyslipidemia)**	14(37.8%)	8(42.1%)	22(39.3%)	0.75
	Normal	23(62.2%)	11(57.9%)	34(60.7%)	
	Total	37(66.1%)	19(33.9%)	56(100%)	
History of CAD	**Present**	29(78.4%)	11(57.9%)	40(71.4%)	0.108
	Absent	8(21.6%)	8(42.1%)	16(28.6%)	
	Total	37(66.1%)	19(33.9%)	56(100%)	

**Significant p-value*

The mean age of the patients with coronary chronic total occlusion was 59±2.5 years in our study. Out of 56 patients in our study, 16(28.6%) were diabetic, 14(25%) were hypertensive, 22(39.3%) had dyslipidemia and 40(71.4%) had a history of CAD. In line with our results, another study reported a mean age of the patient of 59.49 ± 9.16 years. In that study, 19.61% of the patients were diabetic, 24.18% had hypertension, 43.46% had dyslipidemia, and 66.99% had a history of myocardial infarction (MI).[13] In contrast to our results, the mean age of the patients was 63±10 years in a study conducted by Gilpin et al. in the UK.[9]

Our results revealed a procedural success rate of 66.1%. In-hospital MACE occurred in 8.9% of the patients. At 3 months follow-up, 2(3.6%) patients died due to cardiovascular causes whereas, 71.4% of the patients were symptom-free. In a meta-analysis, outcomes of CTO-PCI compared to medical treatment or CABG were observed. The procedure was successful in 75.4% of the patients and was linked with a decrease in cardiac mortality and MACE at long-term follow-up. It was also revealed that patients who underwent CTO-PCI developed a marked improvement in their left ventricular ejection fraction. However, in contrast to other studies, the procedure did not decrease long-term MACE.[14] According to another meta-analysis, a significant decrease in the frequency of angina with CTO-PCI was observed.[15]

Gilpin et al. reported in-hospital MACE in only one (0.5%) patient. They found that cardiac mortality occurred in 4(2.4%) and MI in 14(8.3%) patients at follow-up.[9] In another study, the procedural success was significantly lower in CTO-PCI as compared to non-CTO-PCI. The CTO-PCI was linked with a higher incidence of cardiac tamponade and coronary artery perforation as compared to non-CTO-PCI. It was also reported that MACE occurred more frequently in CTO-PCI cases than in non-CTO-PCI. However, there was no difference in cardiac mortality between the two groups.[16] Another study compared CTO-PCI with non-CTO-PCI where the procedural success was lower in CTO-PCI (76%) than non-CTO-PCI (95.7%). The incidence of in-hospital MACE was higher in CTO versus non-CTO-PCI with a higher frequency of MI, bleeding, cardiogenic shock and in-hospital mortality. However, there was no difference in long-term MACE between CTO and non-CTO-PCI.[17] Another study reported a success rate of 58.7% with CTO-PCI.[18] In a study conducted in India, the CTO-PCI had a success rate of 74.6%. In-hospital mortality occurred in 0.9% of the patients. Cardiac tamponade occurred in 0.6% and coronary artery perforations in 1.3% of patients.[19] The results of a meta-analysis revealed that MACE was significantly less in patients who underwent PCI for CTO compared to patients managed with medical therapy alone.[20] A study conducted in Pakistan at the Peshawar Institute of Cardiology found that the success rate of CTO-PCI was 77.45% and 13.73% of the patients experienced in-hospital MACE.[13]

Our results showed that the frequency of MACE was significantly less in patients with successful CTO-PCI. Two other studies reported better prognosis in patients with procedural success and a decrease in MACE.[21,22] Our results showed that the procedure was significantly unsuccessful in most of the elderly above 60 (p-value=0.02) and diabetic patients (p-value=0.004). Similar to our findings, a study reported high procedural success in younger patients as compared to older patients.[23] In contrast, a systematic review reported no difference in procedural success between younger and older patients.[24] In a study, diabetes mellitus was related to a high rate of procedural failure while the association with other variables such as age, hypertension, smoking, gender, dyslipidemia and history of CAD was not significant.[13]

CONCLUSION

The CTO-PCI has a procedural success rate of 66.1% and the majority of the patients were symptom-free after the procedure. The statistically significant outcomes were reduction in the frequency of in-hospital MACE and symptom-free at 3 months in the successful CTO-PCI group. The procedural failure was significantly associated with the elderly age group above 60 and diabetes mellitus.

LIMITATIONS & RECOMMENDATIONS

It was a single-centered study with a small sample size and included only female patients. The patients did not have long-term follow-up. The study did not find the association of patient outcomes with various CTO scores. Multi-centered trials should be conducted in Pakistan with a large sample size including patients from both genders. Percutaneous coronary intervention can be safely opted for CTO cases and efforts should be put in further improving equipment and technical expertise for the procedure.

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Authors' Contributions:
M.W.H: Conceptualized the study, drafted the manuscript, and coordinated the research.

A.M: Supervised the study and reviewed the manuscript.
A.H.Q: Managed methodology, ethical approval, and patient recruitment.
M.W.A.L: Performed statistical analysis and interpreted results.
W.M: Assisted in data collection and literature review.
M.R: Maintained the database and helped in proofreading.
S.A: Critically reviewed the manuscript and approved the final version.

REFERENCES

1. Vescovo GM, Zivelonghi C, Scott B, Agostoni P. Percutaneous coronary intervention for chronic total occlusion. US Cardiol. 2020; 14:e11. doi:10.15420/usc.2020.10.

2. Niizeki T, Tsuchikane E, Konta T, Kishi K, Okada H, Ito Y, et al. New angiographic difficulty score for first-attempt chronic total occlusion in the 3 major coronary arteries. JACC Cardiovasc Interv. 2023; 16(20):2542-51. doi:10.1016/j.jcin.2023.08.046.

3. Xenogiannis I, Pavlidis AN, Karamasis GV. Contemporary percutaneous interventions for coronary chronic total occlusions. Front Cardiovasc Med. 2024; 11:1495936. doi:10.3389/fcvm.2024.1495936.

4. Cilia L, Megaly M, Davies R, Tehrani BN, Batchelor WB, Truesdell AG. A non-interventional cardiologist's guide to coronary chronic total occlusions. Front Cardiovasc Med. 2024; 11:1350549. doi:10.3389/fcvm.2024.1350549.

5. Karacsonyi J, Vemmou E, Nikolakopoulos ID, Ungi I, Rangan BV, Brilakis ES. Complications of chronic total occlusion percutaneous coronary intervention. Neth Heart J. 2021; 29(1):60-7. doi:10.1007/s12471-020-01502-1.

6. Etriby KAE, Okasha NK, Zahran ME, Mohamed TR. Impact of successful antegrade and retrograde CTO-PCI on short-term prognosis. Egypt Heart J. 2024; 76(1):66. doi:10.1186/s43044-024-00501-6.

7. Zhao S, Chen Y, Wang Q, Zhu B, Wei Z, Wang Z, et al. Benefits of successful percutaneous coronary intervention in chronic total occlusion patients with diabetes. Cardiovasc Diabetol. 2022; 21(1):271. doi:10.1186/s12933-022-01708-0.

8. Jiang Y, Wei ZY, Wu YJ, Dou KF, Yang WX, Yang YJ, et al. The impacts of percutaneous coronary intervention to treat chronic total occlusion of right coronary artery on the 5-year prognosis: a single-centered retrospective study. Int J Cardiol. 2024; 414:132384. doi:10.1016/j.ijcard.2024.132384.

9. Gilpin TR, Maznyczka A, Anantharam B, Dana A. Procedural results and long-term outcome of chronic total occlusion percutaneous coronary intervention in a UK non-surgical centre. Interv Cardiol. 2024; 19:e05. doi:10.15420/icr.2023.23.

10. Simsek B, Rempakos A, Kostantinis S, Karacsonyi J, Gorgulu S, Alaswad K, et al. Periprocedural mortality in chronic total occlusion percutaneous coronary intervention: insights from the PROGRESS-CTO registry. Circ Cardiovasc Interv. 2023; 16(6):e012977. doi:10.1161/CIRCINTERVENTIONS.123.012977.

11. Munirwan H, Kusyanto FA, Zanisa Z, Latief MH. Chronic total occlusion percutaneous coronary intervention (CTO-PCI) in an intractable heart failure patient: Is there any benefit? Narra J. 2023 Aug; 3(2):e140. doi:10.52225/narra.v3i2.140.

12. Synetos A, Koliastasis L, Ktenopoulos N, Katsaros O. Recent advances in coronary chronic total occlusions. J Clin Med. 2025; 14(5):1535. doi:10.3390/jcm14051535.

13. Suleman M, Arif N, Khan MI, Jibran MS, Jamil M, Khan SU, et al. The outcomes and complications of percutaneous interventions in chronic total coronary occlusion. Egypt Heart J. 2024; 76(1):62. doi:10.1186/s43044-024-00490-6.

14. Macherey-Meyer S, Salem K, Heyne S, Meertens MM, Finke K, Mauri V, et al. Percutaneous coronary intervention versus optimal medical therapy in patients with chronic total occlusion: a meta-analysis. J Clin Med. 2024; 13(10):2919. doi:10.3390/jcm13102919.

15. Farag M, Egred M. CTO in contemporary PCI. Curr Cardiol Rev. 2022; 18(1):e310521193720. doi:10.2174/1573403X17666210531143519.

16. Abdelaziz A, Elsayed H, Atta K, Mechi A, Kadhim H, Aboutaleb AM, et al. Short- and long-term outcomes of percutaneous coronary interventions in chronic and non-chronic total occlusions: a meta-analysis of 690,123 patients. Curr Probl Cardiol. 2023; 48(11):101890. doi:10.1016/j.cpcardiol.2023.101890.

17. Almarzooq ZI, Tamez H, Wang Y, Curtis JP, Kirtane AJ, Secemsky EA, et al. Long-term outcomes of chronic total occlusion percutaneous coronary intervention among medicare beneficiaries. J Soc Cardiovasc Angiogr Interv. 2023; 2(2):100584. doi:10.1016/j.jscai.2023.100584.

18. Guan C, Yang W, Song L, Chen J, Qian J, Wu F, et al. Association of acute procedural results with long-term outcomes after CTO-PCI. JACC Cardiovasc Interv. 2021; 14(3):278-88. doi:10.1016/j.jcin.2020.10.003.

19. Vemuri KS, Sihag BK, Sharma Y, Nevali KP, Vijayvergiya R, Kumar RM, et al. Real world perspective of coronary chronic total occlusion in third world countries: a tertiary care centre study from northern India. Indian Heart J. 2021; 73(2):156-60. doi:10.1016/j.ihj.2021.03.001.

20. Khanra D, Mishra V, Jain B, Soni S, Bahurupi Y, Duggal B, et al. Percutaneous coronary intervention provided better long term results than optimal medical therapy alone in patients with chronic total occlusion: a meta-analysis. Indian Heart J. 2020; 72(4):225-31. doi:10.1016/j.ihj.2020.07.013.

21. Zhang D, Nan N, Xue Y, Zhang M, Tian J, Chen C, et al. Comparison of successful versus failed percutaneous coronary intervention in patients with chronic total occlusion: a systematic review and meta-analysis. Cardiol J. 2024; 31(1):15-23. doi:10.5603/CJ.a2022.0010.

22. Megaly M, Khalil M, Basir MB, McEntegart MB, Spratt JC, Yamane M, et al. Outcomes of successful vs. failed contemporary chronic total occlusion percutaneous coronary intervention. Cardiovasc Interv Ther. 2022; 37(3):483-9. doi:10.1007/s12928-021-00819-x.

23. Rempakos T, Mutlu D, Alexandrou M, Carvalho PEP, Strepkos D, Choi JW, et al. Outcomes of chronic total occlusion percutaneous coronary intervention in young patients. JSCAI. 2024; 3(5):101751. doi:10.1016/j.jscai. 2024.101751.

24. Lateef N, Ahsan MJ, Fazeel HM, Haseeb A, Latif A, Kousa O, et al. Percutaneous coronary intervention for chronic total occlusion in patients aged <75 years versus ≥75 years: a systematic review. J Community Hosp Intern Med Perspect. 2020; 10(1):25-31. doi:10.1080/20009666.2020. 1719731.