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DETERMINANTS OF SUCCESSFUL PARALLEL WIRE TECHNIQUE IN PERCUTANEOUS CORONARY INTERVENTION TO CORONARY CHRONIC TOTAL OCCULSION

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Abstract

Introduction: Chronic total occlusions (CTOs) of coronary arteries have been considered as one of the most challenging issues in the scope of interventional cardiology. PWT is a useful strategy in the process of percutaneous coronary intervention (PCI) as an additional technique to overcome blockages when the initial guidewire does not pass through them. The factors leading to successful results of PWT are poorly identified.

Objective: The proposed study aims to evaluate the factors contributing to the anatomical, procedural, and clinical success of the parallel wire technique in CTO PCI.

Material and Methods: A prospective study was conducted among 92 patients at the Armed Forces Institute of Cardiology & National Institute of Heart Disease Rawalpindi, from July, 2024 to December, 2024, who underwent CTO PCI using PWT. The findings comprised the type of lesions, findings, and results of the procedure.

Results: A 77.2 percent cumulative PWT was achieved. Severe calcification (63.9%) and proximal cap ambiguity (58.2%) significantly reduced success rates in patients. In most lesions, the right coronary artery was involved, and the average length of the lesion was 31.8 × 10.7 mm. In-hospital deaths and complications were missing; however, complications were reported in 6.5 percent of the cases.

Conclusion: The complexity matters in terms of PWT success in CTO PCI. Accurate preprocedural assessment and proper planning of action are essential for achieving optimal outcomes.

Keywords: Chronic Total Occlusion, Parallel Wire Technique, Percutaneous Coronary Intervention, Coronary Artery Disease, Lesion Complexity.

INTRODUCTION

Chronic total occlusions (CTOs) of the coronary arteries are one of the most complex groups in interventional cardiology, typically characterized by complicated characteristics and a lengthy procedure time. PCI methods and equipment are continually improving, although executing CTO interventions remains heavily reliant on the technical methodologies used, physicians' experience, and patient-related factors (1). The PWT has become a commonly employed approach into a mandatory strategy in contemporary CTO PCI, particularly in situations where the guidewire is incapable of crossing the lesion. Appropriate handling of the wire, visualization of the vessel, and understanding of the lesion's morphology are usually the primary determining factors in the process (2). The factors contributing to the success of the PWT are still not fully comprehended, with most current literature lacking specifics on how to better plan the procedure and its results, despite its immense popularity (3). The Global CTO crossing algorithm has highlighted the importance of hybrid strategies in CTO PCI, where PWT has proven influential in facilitating a transition from a primary strategy to a reentry strategy following the failure of the initial strategy (4). One advantage of the hybrid strategy is that it allows for flexibility and algorithmic decision-making, and recommends PWT as a viable bailout strategy when antegrade wiring in the first approach fails.

In addition to this, the enhanced availability of advanced and sophisticated microcatheters and guidewires has improved the utility and efficiency of PWT (5). At present, CTO lesions are complex (because of great calcification, blurred proximal caps, and long-lasting segment closure), and some tactical approaches can improve procedural success, including PWT (6). With the technologies to generate PCI ongoing maturity, the exact choices and application of the parallel wire solution provide the chance to show a substantial improvement in patient care, reduced procedural complications, and less fluoroscopy time. Several clinical trials and registries have compared the relative outcomes of PCI with conservative or surgical approaches to CTO management. Cardiac rehabilitation alone is the exercise-based rehabilitation that has significant benefit in chronic coronary syndrome, but PCI as an alternative revascularisation method is a favourite choice in anatomical candidates, especially when the symptoms are persistent even after adopting medical treatment (7). Successful CTO PCI, when compared to medical therapy alone, has been repeatedly shown to be associated with symptomatic relief, quality of life, and possible long-term survival in systematic reviews and meta-analyses (8).

The anatomical peculiarities of the CTO lesion, in particular its calcification, tortuosity, and the length of the lesion, have a significant impact on the success of the procedure. Methods such as PWT can be instrumental in accomplishing these conditions (9). The clinical value of success in CTO PCI extends beyond the angiographic success in the short term. Observational trials conducted over long periods have shown that patients who undergo PCI have a survival advantage over those who are subjected to medical therapy alone, indicating that more advantageous and repeatable methods, such as PWT, are necessary in the field (10). Additionally, PCI proved to be equally effective in treating diabetic patients, just as coronary artery grafting surgery (CABG) in cases where the patients had a favourable anatomy and their risk during the procedure is low (11). Therefore, the improvement of PCI procedures, such as PWT, can bring greater application and utility to various classes of patients. The use of CTO PCI has come to be considered a treatment option in carefully selected patients, primarily in high-volume centres and with well-trained operators (12). With the rise in the number of CTO cases due to the ageing and comorbidities of populations, bleeding avoidance strategies and thoughtful preprocedural planning have become essential for procedural success and safety (13). Fewer frailty-related factors have been shown to predict lower outcomes with CTO PCI and, hence, be an indication to avoid an aggressive interventional approach, collectively including nutritional status, morbid obesity, and frailty, although these are deemed to be sub-optimally documented (14). The reasoning behind these multidimensional determinants is crucial when it comes to maximising the efficiency of PWT use in PCI. Modern issues in CTO PCI include prolonged procedure time, increased radiation exposure, and extensive resource utilisation (15). The PWT is technically challenging but offers an efficient way to cross lesions that can, theoretically, be performed with fewer complications when done accurately. Notably, PROGRESS-CTO complication scores and

other similar validated tools can help assess the risk of various procedures, thereby helping operators select candidates who are most likely to benefit from methods such as PWT (16). Furthermore, the development of coronary imaging, particularly coronary computer tomography angiography (CTA), has enabled more efficient planning of complex procedures, such as PWT, by ensuring improved visualisation of CTO lesions before PCI (17).

Efforts are particularly focused on the elderly population who receive complex PCI or experience CTOs and other issues, as they are susceptible to hemodynamic instability and procedural complications (18). Additionally, the circumspect execution of PWT based on anatomical and clinical manifestations can significantly enhance the safety and efficiency of procedures for these high-risk populations. Moreover, the prognostic implications of CTO in PCI during acute and periprocedural myocardial infarction also underscore the significance of successful revascularisation without delay, which, in turn, confirms the validity of established techniques such as PWT in clinical practice (19).

Considering the above, one can say that the parallel wire technique plays a significant niche in the CTO PCI armamentarium. PWT can enhance the efficiency of a procedure and improve patient outcomes through successful guidewire delivery in the most challenging situations, thereby decreasing the need for retrograde or subintimal staging. Nonetheless, the factors of success and achievements in PWT have not been identified correctly in the literature. These factors, including anatomical and technical concerns, operator experience, patient selection, and other issues, can be used to inform the best approach to training, planning procedures, and designing devices that lead to improved patient care outcomes in patients with coronary CTOs. The present research aims to fill this knowledge gap by critically evaluating the factors contributing to the success of the parallel wire technique in CTO PCI.

Objective: To evaluate the most crucial anatomical (keying), technical, and procedural conditions of percutaneous coronary interventions in patients with a coronary chronic total occlusion, where the parallel wire technique can be discussed as successful.

MATERIALS AND METHODS

Study Design: Observational study designed

Study Setting: Armed Forces Institute of Cardiology & National Institute of Heart Disease Rawalpindi, Punjab, Pakistan

Duration of the Study: From July, 2024 to December, 2024.

Inclusion Criteria: Patients diagnosed with chronic total occlusion of the coronary arteries proven by angiography (the definition of TIMI 0 flow resulting in over 3 months of stasis) and prescribed percutaneous vessel intervention with the help of the parallel wire technique at the age of 18 years and older were placed. All the patients were made aware (consented). The interventional cardiologist recruited patients with single or multivessel disease related to CTO, and they were deemed capable of undergoing PCI.

Exclusion Criteria: Patients were excluded if CABG had been performed previously on the target vessel and it remained patent, when patients presented with acute coronary syndrome on admission, or if they were contraindicated from having contrast media used. They were also excluded if they had an end-stage kidney disease, hemodynamic instability, or severe left ventricular dysfunction (LVEF <30). Only patients who did not perform the parallel wire technique were excluded.

Methods

The patients who fulfilled the inclusion criteria were assessed pre-procedurally, depending on the specific criteria, through coronary angiography and non-invasive imaging. Skilled interventional cardiologists performed CTO PCI through a hybrid approach, and the choice between the parallel wire approach and standard practice was based on angiographic characteristics, including an ambiguous proximal cap, lesion length, and wire deflection. The standard methods of PCI were employed, including dual antiplatelet medication, anticoagulation with unfractionated heparin, guide catheters, microcatheters, and speciality guidewires. The first wire was used to enter the proximal cap, and in case that fails, the second or third wire was inserted with the first to start the PWT. Intra-procedural outcome documentation was performed, which included the success rate of wire crossing,

the need for alternative methods, and the incidence of complications. Data were examined, focusing on anatomical, methodological, and patient factors related to a successful procedure outcome. All participants had their procedure time, movements recorded under a fluoroscope, contrast administered, and interventions documented in hospital records.

RESULTS

In the final analysis, 92 patients were included in the research using the parallel wire technique in CTO PCI. The average age of the patients was 61.3 ± 9.2 years, and 76.1% were male. The most prevalent comorbidities were hypertension (68.5%), diabetes mellitus (41.3%) and previous MI (36.9 %). Successful CTO crossing using the parallel wire method with TIMI 3 flow and <30 residual stenosis was defined as procedural success and was found in 71 cases (77.2%).
Table 1 displays baseline clinical and demographic characteristics.

Table 1: Baseline Characteristics of the Study Population (n = 92)

Variable	Value
Mean Age (years)	61.3 ± 9.2
Male Gender (%)	76.1%
Hypertension (%)	68.5%
Diabetes Mellitus (%)	41.3%
Prior Myocardial Infarction (%)	36.9%
Smoking History (%)	28.3%
Mean LVEF (%)	49.6 ± 6.7

Angiographic properties revealed that the majority of CTO lesions were in the right coronary artery (52.2%), followed by the left anterior descending artery (33.7%). The average lesion length was 31.8 mm ± 10.7 mm. There was severe calcification in 39.1 %, and proximal cap ambiguity in 23.9 %.

Table 2: Angiographic and Lesion Characteristics

Parameter	Value
CTO in RCA (%)	52.2%
CTO in LAD (%)	33.7%
CTO in LCx (%)	14.1%
Mean Lesion Length (mm)	31.8 ± 10.7
Severe Calcification (%)	39.1%
Proximal Cap Ambiguity (%)	23.9%

The median fluoroscopy time was 39 minutes (IQR: 2852), and the mean contrast volume was 238.4 44.1 mL based on the procedural metrics. The second wire in parallel technique was successful in 77.2 per cent of the cases, with only 14 patients (15.2 per cent) needing conversion to dissection/reentry techniques. Hospital deaths were not found, and minor complications (dissection, but not in perforation or MI) manifested in 6.5 % of cases.

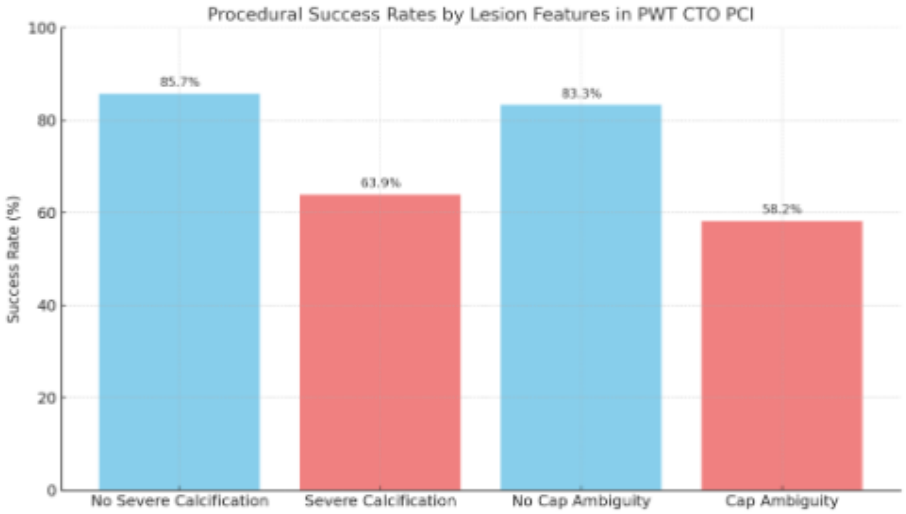
Table 3: Procedural Outcomes

Outcome	Value
PWT Success Rate (%)	77.2%
Median Fluoroscopy Time (min)	39 (IQR: 28–52)
Mean Contrast Volume (mL)	238.4 ± 44.1
Conversion to Retrograde (%)	7.6%

Outcome	Value
Procedural Complications (%)	6.5%
In-hospital Mortality (%)	0%

To be able to visualise how the key factors of lesion influence procedure success, a bar graph was created presenting the success rates stratified by the severity of calcification and proximal ambiguity of the cap.

Graph 1: Procedural Success by Lesion Complexity



The graph of the Procedural Success Rates of the Lesion Features. It demonstrates that the occurrence of extreme calcification and proximal cap ambiguity is associated with a reduced success rate of the parallel wire technique in CTO PCI.

DISCUSSION

The study's outcomes emphasise that the success of the parallel wire technique (PWT) in treating chronic total occlusion (CTO) through percutaneous coronary intervention (PCI) procedures is heavily reliant on the morphology and lesion status, specifically heavy calcification and uncertainty regarding the proximal cap position. Our findings and the outcomes of numerous other large-scale registry studies match, as we attain a procedure success rate of 77.2% (1,2). It would be wise to indicate that PWT is an effective and efficient bailout or front-line procedure, especially in hard CTOs. The first studies of Taniguchi et al. (1) identified some determinants of PWT success, namely noting that the lesion morphology and that of the operator strategy were the most critical variables. This is consistent with the fact that the success rate was significantly higher in patients with no proximal cap ambiguity or heavy calcification, indicating that good visualisation and simplified manipulation of the wire play a significant role in augmenting a positive outcome.

Similarly, in their multicenter registry, Werner et al. (2) also discovered that PWT success correlates with the length of a lesion, the course of the vessel, and the use of escalation during wire procedures that were included in our procedural planning. According to Rathore and Suzuki (3), the concept behind the PWT is based on inserting an additional guidewire to examine other microchannels or subintimal tracks in case the leading one encounters trouble. This technique is most useful in the hands of experienced practitioners, and when the characteristics of the lesion allow it to be tracked in parallel without causing excessive injury to the vessel. Within the concept of the global hybrid algorithm proposed by Wu et al. (4), our study's results support the patterned shift to the application

of PWT in situations of resistance or ambiguity at the proximal cap, utilising single-wire techniques. On a grander scale of interventional cardiology. According to (5), the PWT has been described as one of the cornerstones of antegrade CTO techniques, as well as for limited or high-risk retrograde options. This is what we have found, and the retrograde conversions were necessary in only 7.6 % of cases. Khan and Ludman (6) also note the role of personalised approaches to PCI, and our model of personalised decision-making, which would involve taking the individual lesion data into account when deciding on the use of PWT, is thus strengthened. These findings should also be considered in the context of general CTO management. Although medical and conservative treatments are beneficial, as outlined by Buckley et al. (7) and van Veelen et al. (8), PCI can still have a dramatic effect on symptoms and medium-term outcomes in a few well-selected patients with CTOs. According to the opinion of experts regarding the European CTO Club (9), the case presented in our study demonstrates the clinical practicability and utility of the PWT, even in high-complexity cases. Notably, Park et al. (10) have also emphasised the long-term results achieved by the CTO PCI, stating that patients with successful recanalisation experience better survival. Although the present study does not directly apply to these long-term achievements, it is indirectly beneficial to these objectives by facilitating strategies that maximise positive outcomes during crossings. Additionally, the impact of PWT on diabetics, who comprised the majority of our sample (41.3%), is of particular interest, considering the evidence provided by Xie et al., which favoured PCI as a viable alternative to CABG in a specific category of diabetics (11). Additionally, Galassi et al. (12) emphasised that procedural planning and subsequent imaging, lesion evaluation, and bail-out planning should be standardised. Although not comprehensive, the capability of some of our cases to include CTA imaging and lesion mapping played a positive role in indexing wires and selecting appropriate angles. It is based on studies, such as the one presented by Hong et al. (17), which demonstrated that CTA-guided PCI significantly enhances procedural accuracy.

Safety was also a determining factor in our results. According to Capodanno et al. (13), in CTO PCI, CTO avoidance and minimisation of complications should be given top priority. No in-hospital deaths and only 6.5 minutes of minor complications were observed in our study, indicating the relative safety of PWT when used appropriately. Similar to Cheng et al. (14), who appreciate the significance of patient nutritional and frailty evaluation, these themes will not be central to the current research, they will be considered in further procedural risk evaluation. In addition to the burden of the lesion, Kodeboina et al. (15) emphasise the system-wide burden of PCI in CTOs. Our results can potentially decrease the cost and radiation exposure, thanks to our success with PWT and the overall reduction in the required changes in strategies.

Future risk stratification of PWT candidates may also be further streamlined through the use of the PROGRESS-CTO complication scoring method, as discussed by Simsek et al. (16). The relevance of patient age and frailty cannot be overstated. Reduced success rates were observed in our aged patients (>70 years) in line with findings by Hanna et al. (18), who reported that patients who undergo complex PCI and are older fare worse. Lastly, a zero in-hospital mortality rate and few complications are also in line with the observations of Kim et al. (19), who have demonstrated that CTO PCI, even in the setting of myocardial infarction, can be performed safely when appropriately performed with support. Lastly, the effectiveness of the parallel wire technique in CTO PCI is complicated and can be attributed to a multifactorial interplay of lesion anatomy, operator experience, procedural approach, and patient-related factors. The study makes PWT a more legitimate technique in the modern use of CTO management, insofar as it can be approached anatomically predictively and performed accurately. Although identifying the features remains difficult in patients with heavily calcified lesions and ambiguous entry points, early identification of these features can guide procedural strategy, minimise complications, and maximise outcomes.

CONCLUSION

This paper highlights the key elements that contribute to the effectiveness of the parallel wire technique (PWT) in percutaneous coronary intervention (PCI) for treating chronic total occlusion (CTO). The results of our study show that the nature of lesions is a significant determinant of the success rates of the procedures, especially severe calcification and proximal cap ambiguity. Overall

(comprising only 51.7% individuals whose responses were recorded as the use of PWT), PWT showed itself as a highly efficient and safe measure in the hands of highly-experienced operators, when used wisely. The methodology reduced the requirement of retrograde or dissection/reentry methods and kept the levels of complications low. These findings underscore the importance of a thorough plan before the procedure, including anatomical evaluation and individualised approaches that utilise interventional procedures. Since CTO PCI is still an unfixed field, it is critical to incorporate lesion-specific aspects into the procedural algorithms to enhance outcomes. Further research, involving larger numbers of patients and substantive follow-up, is needed to substantiate these findings and facilitate the streamlining of technique choice in complex CTO cases.

REFERENCES

[1] Taniguchi Y, Sakakura K, Jinnouchi H, Tsukui T, Hatori M, Tamanaha Y, et al. Determinants of successful parallel wire technique in percutaneous coronary intervention to coronary chronic total occlusion. Cardiovasc Revasc Med. 2024;59:48-52.

[2] Werner GS, Rathore S, Avran A, Garbo R, Galassi AR, Lauer B, et al. Parallel Wire Approach for Recanalisation of Chronic Total Coronary Occlusions in a Large Contemporary Multi-Center Registry. Catheter Cardiovasc Interv. 2024;105(1):32-42.

[3] Rathore S, Suzuki T. Parallel-wire techniques. In: Chronic Total Occlusions: A Guide to Recanalization. 2023. p. 109-14.

[4] Wu EB, Brilakis ES, Mashayekhi K, Tsuchikane E, Alaswad K, Araya M, et al. Global chronic total occlusion crossing algorithm: JACC state-of-the-art review. J Am Coll Cardiol. 2021;78(8):840-53.

[5] Azzalini L, Karmpaliotis D, Santiago R, Mashayekhi K, Di Mario C, Rinfret S, et al. Contemporary issues in chronic total occlusion percutaneous coronary intervention. Cardiovasc Interv. 2022;15(1):1-21.

[6] Khan SQ, Ludman PF. Percutaneous coronary intervention. Medicine. 2022;50(7):437-44.

[7] Buckley BJ, De Koning IA, Harrison SL, Fazio-Eynullayeva E, Underhill P, Kemps HM, et al. Exercise-based cardiac rehabilitation vs. percutaneous coronary intervention for chronic coronary syndrome: impact on morbidity and mortality. Eur J Prev Cardiol. 2022;29(7):1074-80.

[8] van Veelen A, Elias J, van Dongen IM, Hoebers LPC, Claessen BEPM, Henriques JPS. Percutaneous coronary intervention versus medical therapy for chronic total coronary occlusions: a systematic review and meta-analysis of randomised trials. Neth Heart J. 2021;29(1):30-41.

[9] Mashayekhi KA, Pyxaras SA, Werner GS, Galassi AR, Garbo R, Boudou N, et al. Contemporary issues of percutaneous coronary intervention in heavily calcified chronic total occlusions: an expert review from the European CTO Club. EuroIntervention. 2023;19(2):e113.

[10] Park TK, Lee SH, Choi KH, Lee JM, Yang JH, Song YB, et al. Late survival benefit of percutaneous coronary intervention compared with medical therapy in patients with coronary chronic total occlusion: a 10-year follow-up study. J Am Heart Assoc. 2021;10(6):e019022.

[11] Xie Q, Huang J, Zhu K, Chen Q. Percutaneous coronary intervention versus coronary artery bypass grafting in patients with coronary heart disease and type 2 diabetes mellitus: Cumulative meta-analysis. Clin Cardiol. 2021;44(7):899-906.

[12] Galassi AR, Vadalà G, Werner GS, Cosyns B, Sianos G, Hill J, et al. Evaluation and management of patients with coronary chronic total occlusions considered for revascularisation. A clinical consensus statement of the EAPCI of the ESC, EACVI of the ESC, and the ESC Working Group on Cardiovascular Surgery. EuroIntervention. 2024;20(3):e174.

[13] Capodanno D, Bhatt DL, Gibson CM, James S, Kimura T, Mehran R, et al. Bleeding avoidance strategies in percutaneous coronary intervention. Nat Rev Cardiol. 2022;19(2):117-32.

[14] Cheng L, Rong J, Zhuo X, Gao K, Meng Z, Wen X, et al. Prognostic value of malnutrition using geriatric nutritional risk index in patients with coronary chronic total occlusion after percutaneous coronary intervention. Clin Nutr. 2021;40(6):4171-9.

[15] Kodeboina M, Piayda K, Jenniskens I, Vyas P, Chen S, Pesigan RJ, et al. Challenges and burdens in the coronary artery disease care pathway for patients undergoing percutaneous coronary intervention: a contemporary narrative review. Int J Environ Res Public Health. 2023;20(9):5633.

[16] Simsek B, Kostantinis S, Karacsonyi J, Alaswad K, Krestyaninov O, Khelimskii D, et al. Predicting periprocedural complications in chronic total occlusion percutaneous coronary intervention: the PROGRESS-CTO complication scores. Cardiovasc Interv. 2022;15(14):1413-22.

[17] Hong SJ, Kim BK, Cho I, Kim HY, Rha SW, Lee SH, et al. Effect of coronary CTA on chronic total occlusion percutaneous coronary intervention: a randomized trial. Cardiovasc Imaging.

2021;14(10):1993-2004.
[18] Hanna JM, Wang SY, Kochar A, Park DY, Damluji AA, Henry GA, et al. Complex percutaneous coronary intervention outcomes in older adults. J Am Heart Assoc. 2023;12(19):e029057.
[19] Kim SH, Behnes M, Mashayekhi K, Bufe A, Meyer-Gessner M, El-Battrawy I, et al. Prognostic impact of percutaneous coronary intervention of chronic total occlusion in acute and periprocedural myocardial infarction. J Clin Med. 2021;10(2):258.