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ORIGINAL RESEARCH

Transradial and Transfemoral Access for Retrograde Chronic Total Occlusion Percutaneous Coronary Interventions: A Comparison of the Clinical Features and Prognostic Implications

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Objective: The research was carried out to determine and compare the efficiency of completely transradial access (cTRA) and transfemoral access (TFA) in retrograde chronic total occlusion (CTO) percutaneous coronary intervention (PCI).

Background: The cases of retrograde chronic total occlusion (CTO) percutaneous coronary intervention usually need the dual access. The transradial method is now used more frequently in CTO PCI, and improves the safety of CTO PCI.

Methods: This retrospective, observational study was carried out in a single center. Participants were patients who underwent dual-access retrograde CTO PCI from January 2017 to October 2023, categorized into two groups: cTRA (biradial access) and TFA (bifemoral, or combined radial and femoral access). All patients in the cTRA group received conventional radial access. All punctures of the femoral artery were performed without fluoroscopic or ultrasound guidance. None of the patients in the TFA group accepted any arterial closure devices. Clinical, angiographic and procedural characteristics and the occurrence of in-hospital major adverse cardiovascular events (MACE) of the cTRA and TFA procedures were recorded.

Results: This research involved 187 CTO PCI procedures with dual access, of which 88 were done using cTRA and the rest (99) were carried out through TFA. The J-CTO (Multicenter Chronic Total Occlusion Registry of Japan) score was lower in the cTRA group than TFA group (2.1± 0.6 vs 3.0± 0.8; P <0.001). The technical success (84.1% vs 82.8%; P= 0.817), procedural success (80.7% vs 79.8%; P= 0.906) and in-hospital MACE rates (5.7% vs 4.0%; P= 0.510) were the same for both groups. For a J-CTO score of 3 or higher, technical success rate was significantly lower in the cTRA group than the TFA group (58.1% vs 74.2%; P < 0.001).

Conclusion: In the retrograde CTO PCI, the percentages of success and in-hospital MACE were similar for both cTRA and TFA. Meanwhile, cTRA may be used for simpler lesions (J-CTO score < 3) as compared to TFA.

Keywords: transradial approach, transfemoral approach, chronic total occlusion, retrograde, percutaneous coronary intervention

Introduction

The application of transradial approach (TRA) for cardiac catheterization and percutaneous coronary intervention (PCI) has led to positive outcomes as opposed to transfemoral approach (TFA) because there is a decrease in complications at the access site, better patient comfort, early mobilization, and a cut in expenses.[1,2] The TFA is the worldwide known method for dealing with chronic total occlusion (CTO) by using a bigger guiding catheter to give more support and create a wider working space.[3] Nevertheless, there is a higher likelihood of bleeding pseudoaneurysm and arteriovenous fistula with TFA, and there is also an increased chance of cardiac events and death after PCI.[2] The increasing usage of the retrograde approach, especially in CTO PCI, has greatly helped to increase the rates of success in revascularization.[4–6] The retrograde technique for CTO PCI is usually performed through transfemoral access and with the use of bigger sheath sizes. This method gives the best support, allows for the use of various combinations of equipment, and does not restrict the use of trapping techniques.[7] Many research has proved that the TRA for CTO PCI is possible and has shown good clinical

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outcomes;[8,9] Nevertheless, the data on TRA for retrograde CTO PCI is not reliable. The aim of this study was to evaluate the clinical and angiographic baseline characteristics, procedural details, and outcomes of retrograde CTO PCI using completely TRA (cTRA) (biradial access) in contrast with TFA (bifemoral or combined radial and femoral access).

Material and Methods

Study Design and Patients

The single-center retrospective study was performed by the authors from January 1, 2017 to October 31, 2023, and we concentrated on the patients who were referred to Xiangtan Central Hospital for CTO PCI. From our CTO database, a total of 187 dual-access retrograde CTO PCI procedures were brought into this study (Figure 1). The main exclusion criteria were: retrograde technique was not used, myocardial infarction (MI) within 30 days in the territory of the target CTO or within 3 days in another territory, renal failure with serum creatinine level >3 mg/dL, life expectancy less than 2 years, and contraindications to aspirin or clopidogrel therapy. Participants met specific criteria for CTO PCI, including myocardial viability and at least one of the following: induced ischemia, symptomatic angina, and occlusion of a proximal coronary vessel with left ventricular systolic dysfunction are the signs of serious heart problems. The research was done to know the exact data on vascular access, and then it compared two groups depending on whether they had a femoral puncture or not. Hence, the cTRA cohort (88/187) resulted in 2 procedures with radial access, while the TFA cohort (99/187) included either 2 procedures using femoral access or 1 procedure using femoral access and another one with radial access. The research was approved by the Ethics Committee of Xiangtan Central Hospital and respected all the rules specified in the Declaration of Helsinki (revised in 2013). Every patient was given informed consent before they started (X20182214-5).

Arterial Access

The decision to use a specific arterial access site was determined depending on the case, which reflects the operational approach used by the experienced operators. The method of arterial access was divided as the cTRA (biradial) and TFA (bifemoral and combined radial and femoral). The radial or femoral approach was to be avoided if the patient had

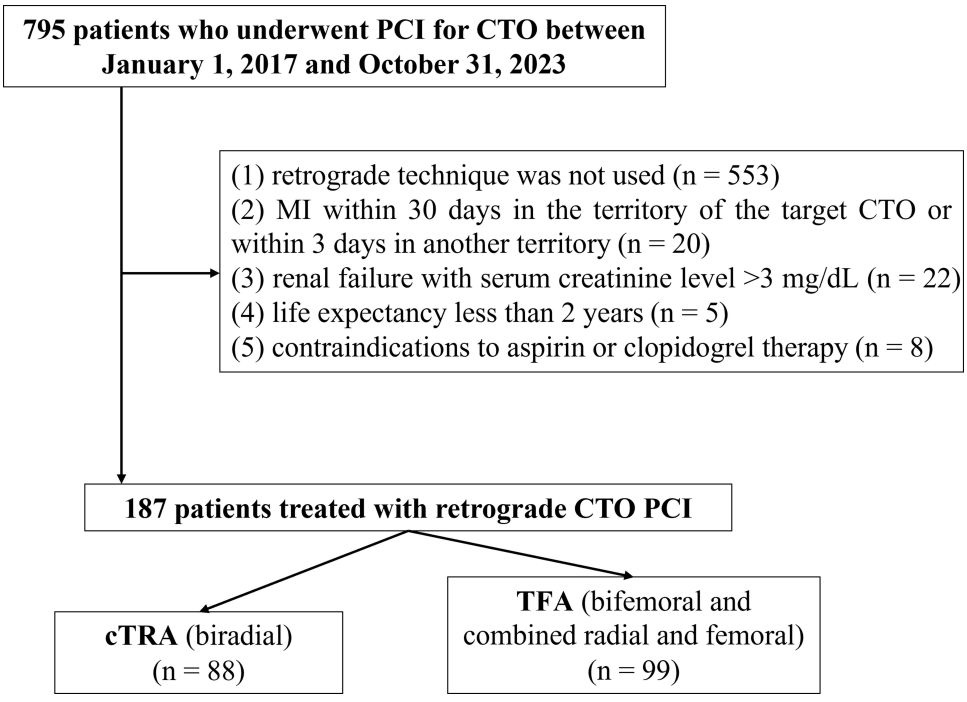

Figure 1 Study flow chart.
Abbreviations: PCI, percutaneous coronary intervention; CTO, chronic total occlusion; MI, myocardial infarction; TFA, transfemoral approach; cTRA, completely transradial approach.

a narrowed or curving artery. Particularly, all patients in the cTRA group received conventional radial access. All punctures of the femoral artery were performed without fluoroscopic or ultrasound guidance. None of the patients in the TFA group accepted any arterial closure devices.

Definitions and Outcomes

When angiographic evidence reveals a thrombolysis in myocardial infarction (TIMI) flow grade of 0 in an occluded artery segment that has been present for more than three months, it diagnoses a CTO.[10] The occlusion time was determined by the initial appearance of angina pectoris, the patient's previous history of MI in the region supplied by that blood vessel, or it could be compared with a previous angiogram.[10] The technical success of CTO PCI was measured by the attainment of successful revascularization of the CTO with less than 30% residual narrowing and the restoration of optimal blood flow with TIMI grade 3 antegrade flow. The J-CTO (Multicenter CTO Registry in Japan), PROGRESS CTO (Prospective Global Registry for the Study of Chronic Total Occlusion Intervention), and PROGRESS CTO complication scores were calculated with methods that had already been used.[11–13] The primary outcome of the research was procedural success, which meant that the procedure was technically successful without any in-hospital major adverse cardiovascular events (MACE). In-hospital MACE was all-cause death, MI, repeat PCI or coronary artery bypass graft (CABG) for the target vessel, pericardial tamp requiring pericardiocentesis or surgery, or stroke. A stroke was described as a sudden neurological event that lasted at least 24 hours. Type 4a MI has been applied as a characteristic of MI in this study as per the Third Universal Definition of MI.[14] The secondary outcome was the major access-site complications, which were considered severe bleeding, vascular problems that needed medical treatment, or big hematomas with a diameter of 10 cm or more. The type of bleeding was identified as either type 3 or more, as per the Bleeding Academic Research Consortium.[15] Interventional collateral vessels are the ones that can be easily crossed with a guidewire and microcatheter. A retrograde approach was considered when a reattempt to pass a collateral vessel or aorto-bypass graft that was supplying the target vessel beyond the lesion and that was involved with the blocked areas was conducted.

A comprehensive analysis of the medical charts or hospital databases by the principal investigator and collaborators was conducted to gather patients' demographic characteristics, cardiovascular risk factors, baseline comorbidities, biology, characteristics of CTO lesions, procedural techniques and procedural complications. Follow-up was performed from the end of PCI to hospital discharge. In-hospital MACE and access-site bleeding or vascular complications were documented. Adverse events were monitored assessed by an independent data and safety monitoring board, composed of two experienced cardiologists and one statistician, reviewing patient safety and study integrity.

Intervention Procedure

Each patient got the best intravenous fluid treatment in the days before and after PCI. Additional doses of unfractionated heparin (100 IU/kg) were added to keep the ACT above 250 seconds every 30 minutes. Operators with more than 50 CTO-PCI cases per year performed all the procedures. The selection of access site and CTO revascularization strategy was up to the operator's decision. There were various types of guidewire techniques used, including single wire, parallel wire, intravascular ultrasound (IVUS)-guided wiring, and retrograde wiring from collateral vessels through simple wiring, kissing wires, the knuckle technique, and the controlled antegrade retrograde tracking (CART) and reverse CART.[16,17] All CTO PCI implanted drug-eluting stents. Offline analysis of digital coronary angiography was conducted using the QAngio software system (v2.1.9, Medis, Leiden, the Netherlands). The agreement between two trained interventional cardiologists (XW and LW) in assessing the coronary anatomic features of coronary angiograms, without knowledge of the patients' clinical presentation and laboratory data, showed good intra-observer and inter-observer variability (κ=0.93 and 0.90, respectively).

Statistical Analysis

Based on the circumstances, the analysis of categorical variables was conducted employing either the Chi-square or Fisher's exact testing, with results presented as frequencies and percentages. Continuous variables were expressed as means ± standard deviation. They were compared between cohorts employing the Student's *t*-test. A statistically significant result was defined as a two-sided P-value of below 0.05. SPSS 28.0 tool (IBM Corp., Armonk, NY, US) was used for the analyses.

Results

Baseline Characteristics

From January 1, 2017, to October 31, 2023, a consecutive cohort of patients who had undergone retrograde CTO interventions were included in the study. The research involved 187 people with an average age of 62.6±11.5 years. In a group of 152 males, the average age was around 60.2±11.8 years, and in another one consisting of 35 females, it was about 72.5±8.3 years. The clinical features of the participants in both study cohorts are presented in Table 1, and they were similar. The angiographic characteristics are presented in Table 2. The J-CTO score was significantly lower in the cTRA group compared to the TFA group (2.1± 0.6 vs 3.0± 0.8; P <0.001).

Procedural Characteristics

The TFA cohort had a greater probability of getting 7-F guide catheters as opposed to the cTRA group (73.9% vs 93.9%; P <0.001) (Table 3). Only 1.0% of TFA patients receiving 8-F guide catheters. The main way for the final retrograde

Table 1 Clinical Characteristics

	cTRA (n=88)	TFA (n=99)	P value
Age, y	62.1±11.0	63.1±12.2	0.541
Male	70 (79.5)	82 (82.8)	0.556
Female	18 (20.5)	17 (17.2)	0.503
BMI, kg/m^2	27.1±3.7	26.6±2.3	0.704
Diabetes mellitus	34 (38.6)	42 (42.4)	0.621
Hypertension	61 (69.3)	77 (77.8)	0.189
Hypercholesterolemia	20 (22.7)	26 (26.3)	0.575
Smoker	44 (50.0)	50 (50.5)	0.945
Family history of CAD	35 (39.8)	32 (32.3)	0.125
Peripheral arterial disease	20 (22.7)	18 (18.2)	0.441
Previous MI	17 (19.3)	24 (24.2)	0.309
Previous PCI	40 (45.5)	49 (49.5)	0.379
Previous CABG	5 (5.7)	4 (4.0)	0.737
Previous atrial fibrillation	6 (6.8)	7 (7.1)	0.799
Previous TIA or stroke	7 (8.0)	6 (6.1)	0.611
History of CHF	11 (12.5)	10 (10.1)	0.604
Hgb, mg/dL	13.8 ±3.4	13.5 ± 1.8	0.287
Creatinine, μmol/L	73.8±18.6	80.2±28.0	0.569
LVEF, %	60.9±10.4	57.8±12.4	0.926
GFR, mL/min/1.73 m^2	83.2±25.3	86.9±25.7	0.311
Total cholesterol, mmol/L	4.0±1.3	4.1±1.2	0.557
Triglycerides, mmol/L	1.8±0.7	2.2±2.0	0.212
HDL-c, mmol/L	0.8±0.3	0.9±0.2	0.400
LDL-c, mmol/L	2.5±0.9	2.5±1.1	0.997
Medications			
Aspirin	88 (100)	99 (100)	1.000
$P2Y_{12}$ receptor inhibitor	87 (98.7)	96 (98.0)	0.904
Oral anticoagulation	4 (4.5)	5 (5.1)	0.862
Warfarin	2 (2.3)	2 (2.0)	0.943
NOAC	2 (2.3)	3 (3.0)	0.912

Note: Values are mean ± SD or n (%).

Abbreviations: BMI, body mass index; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CHF, congestive heart failure; GFR, glomerular filtration rate calculated by the Cockcroft-Gault formula; Hgb, hemoglobin; LVEF, left ventricular ejection fraction; MI, myocardial infarction; PCI, percutaneous coronary intervention; TIA, transient ischemic attack; TFA, transfemoral approach; cTRA, completely transradial approach; HDL-c, high density lipoprotein cholesterol; LDL-c, low density lipoprotein cholesterol; NOAC, new oral anticoagulants.

Table 2 Angiographic Characteristics

	cTRA (n=88)	TFA (n=99)	P value
CTO target vessel			0.792
LAD	30 (34.1)	32 (32.3)	
LCX	17 (19.3)	19 (19.2)	
RCA	41 (46.6)	48 (48.5)	
In-stent CTO	5 (5.7)	6 (6.1)	0.813
Previous failed CTO-PCI	6 (6.8)	10 (10.1)	0.203
Calcification at CTO	19 (21.6)	23 (23.2)	0.895
CTO length ≥20 mm	34 (38.6)	44 (44.4)	0.690
Blunt entry shape	48 (50.0)	55 (55.6)	0.806
Bending >45° within segment	22 (25.0)	29 (29.3)	0.631
Interventional collaterals	84 (95.4)	92 (92.9)	0.551
J-CTO score	2.1± 0.6	3.0± 0.8	<0.001
0	0 (0)	0 (0)	1.000
1	7 (8.0)	7 (7.1)	0.901
2	50 (56.8)	26 (26.3)	<0.001
3	21 (23.9)	40 (40.4)	<0.001
4	10 (11.4)	23 (23.2)	<0.001
5	0 0)	3 (3.0)	0.251
PROGRESS CTO score	1.3± 0.9	1.4± 1.0	0.128
PROGRESS CTO complication score	2.4± 1.8	2.3± 1.8	0.501

Note: Values are mean ± SD or n (%).
Abbreviations: CTO, chronic total occlusion; LCX, left circumflex coronary artery; J-CTO, Multicenter Chronic Total Occlusion Registry in Japan; LAD, left anterior descending coronary artery; PROGRESS CTO, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention; RCA, right coronary artery; PCI, percutaneous coronary intervention; TFA, transfemoral approach; cTRA, completely transradial approach.

Table 3 Procedural Characteristics and Technical Aspects

	CTRA (n=88)	TFA (n=99)	P value
Technical success	74 (84.1)	82 (82.8)	0.817
Stent use	85 (96.6)	94 (94.9)	0.580
Total length of stent used, mm	53.9± 10.4	57.8± 12.4	0.620
Procedural time, min	132± 76	118± 71	0.195
Fluoroscopy time, min	54± 23	49± 25	0.313
Contrast use, mL	293± 69	313± 51	0.131
Technical aspects			
6-F guiding catheter size (target)	23 (26.1)	5 (5.1)	<0.001
7-F guiding catheter size (target)	65 (73.9)	93 (93.9)	<0.001
8-F guiding catheter size (target)	0 (0)	1 (1.0)	NA
6-F guiding catheter size (donor)	45 (51.1)	54 (54.5)	0.353
7-F guiding catheter size (donor)	43 (48.9)	45 (45.5)	0.381
Final retrograde crossing technique			0.859
CART	1 (1.4)	1 (1.2)	
Reverse CART	54 (73.0)	62 (75.6)	
Kissing wire	7 (9.5)	8 (9.8)	
Retrograde wire crossing	10 (13.5)	9 (11.0)	
Knuckle technique	2 (2.7)	2 (2.4)	
Coronary dissection (donor vessel)	5 (5.7)	4 (4.0)	0.737
No/slow flow	0 (0.0)	2 (2.0)	0.819
Coronary perforation	7 (8.0)	6 (7.1)	0.882

Note: Values are mean ± SD or n (%).
Abbreviations: NA, not available; CART, controlled antegrade retrograde tracking; TFA, transfemoral approach; cTRA, completely transradial approach.

crossing was reverse CART, as revealed in Table 3. The time of the procedure, contrast volume, and radiation dose were not different between cTFA and TRA. Out of 206 cases where a radial artery sheath was successfully inserted, Doppler ultrasound detected that 3 patients (0.97%) had radial occlusion.

Outcomes

Table 4 presents the procedural and in-hospital results. The technical success rate (84.1% vs 82.8%; P = 0.817) and the procedural success rate (80.7% vs 79.8%; P = 0.906) were comparable in both cohorts. The average MACE occurrence during hospitalization was 4.8% (9 out of 187 cases). The MACE rate was the same for both cTRA and TFA interventions (5.7% vs 4.0%; P = 0.510). The in-hospital mortality rate was 0.53%, with one patient out of 187 experiencing death. The frequency of both successful and failed cases in the Figure 2 corresponds to the J-CTO score. There was no significant difference in the technical success of the three groups with J-CTO scores of 0, 1, and 2. Despite this, for JCTO scores ≥3, cTRA resulted in a lower technical success rate as compared to TFA (58.1% vs 74.2%, SPSS P<0.001).

Discussion

The present research firstly assess the clinical and angiographic features, procedural techniques, and outcomes of cTRA and TFA in retrograde CTO PCI. The main findings are (1) cTRA and TFA have almost the same rates of technical and procedural success, as well as an in-hospital MACE rate for retrograde CTO PCI; (2) cTRA may be more suitable for cases with J-CTO scores less than 3, but it is challenging to use this technique on cases with J-CTO scores of 3 or higher in retrograde CTO PCI.

Many observational studies[18–23] and meta-analysises[24,25] have shown that TRA for CTO PCI is as technically successful and has equal procedural success rates as TFA, but the number of vascular access complications is lower. In a recent randomized trial carried out by Meijers et al[26] the same procedural success rates were reported for TRA and TFA in treating complex coronary lesions (86.0% for TRA vs 89.2% for TFA). Nevertheless, the TRA cohort had much fewer access-site vascular complications or bleeding incidents.

On the other hand, Gorgulu et al[27] performed a randomized study to compare the clinical, angiographic, and procedural characteristics as well as outcomes of TRA versus TFA in 610 cases of PCI for CTO. The investigators concluded that TRA was as successful in the procedure as TFA (84% vs 86%; P = 0.563), but it was connected to fewer complications at the access site (2.0% vs 5.6%; P = 0.019). Tajti et al[20] analyzed cases of radial-only approach (n = 747), radial femoral approach (n = 844), and femoral-only approach (n = 2199) from 23 centers for CTO PCI between 2012

Table 4 Primary and Secondary Endpoints

	cTRA (n=88)	TFA (n=99)	P value
Procedural success	71 (80.7)	79 (79.8)	0.906
MACE	5 (5.7)	4 (4.0)	0.510
MI	1 (1.1)	1 (1.0)	0.998
RTVR	0 (0)	0 (0)	1.000
Tamponade (requiring surgical or percutaneous intervention)	4 (4.5)	2 (2.0)	0.189
TIA	0 (0)	0 (0)	1.000
Stroke	0 (0)	0 (0)	1.000
Death	0 (0)	1(1.1)	0.969
Secondary endpoint			
Major bleeding	3 (3.4)	6 (6.1)	0.198
Vascular complications requiring intervention	0 (0)	2 (2.0)	0.890
Major bleeding + vascular complications requiring intervention	3 (3.4)	8 (8.1)	0.061
Hematoma	1 (1.1)	5 (5.1)	0.091
Total	4 (4.5)	13 (13.1)	<0.001

Note: Values are n (%).
Abbreviations: MACE, major adverse cardiovascular event(s); MI, myocardial infarction; RTVR, repeat target vessel revascularization; TIA, transient ischemic attack; TFA, transfemoral approach; cTRA, completely transradial approach.

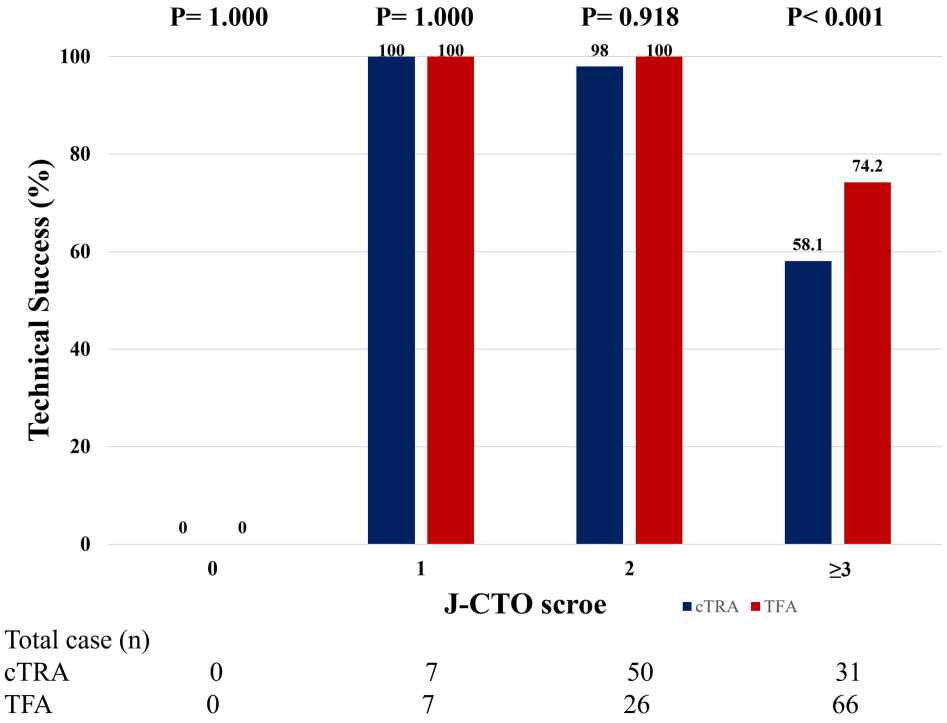

Figure 2 Success rate of transradial and transfemoral procedures and J-CTO score.
Abbreviations: J-CTO, multicenter chronic total occlusion registry of Japan; TFA, transfemoral approach; cTRA, completely transradial approach.

and 2018 and showed that transradial approach CTO PCI is becoming more prevalent, from 11% usage in 2012 to 67% in 2018. The technical and procedural success rate and in-hospital outcomes were also similar in all three groups. Rinfret et al[28] have reported remarkable success in both the technical and procedural aspects of retrograde CTO PCI, with 42 transradial cases showing a high rate of success. Our study goes beyond what other studies have found by showing that both cTRA and TFA methods for retrograde CTO PCI had similar levels of technical success and MACE during hospitalization.

CTO lesions are very complex, and they can be recognized by the large accumulation of atherosclerotic plaque, which is made mainly of fibrocalcific material.[29] Therefore, the key to successful wire crossing and device delivery is having a good backup support system in vessels with high levels of calcification and CTO. Thus, the benefits of using the transradial approach are probably outweighed by the disadvantages of not having any backup when treating complex chronic total occlusions. I Usually, the choice of vascular access route in the studies was determined by the difficulty of the CTO. This implies that the cases treated through TRA had a lower level of difficulty.[18,20,24,30] One of the important findings from this study is that it revealed that TFA produced a significantly higher J-CTO score postintervention when compared to cTRA. This data is important as it highlights TRA as a good alternative for treating noncomplex CTO, though complex CTO remains technically challenging. Therefore, if a patient is screened and gets a high J-CTO score, it would be possible to predict that TRA CTO PCI can be performed successfully, and if a patient gets a low J-CTO score, then TRA CTO PCI may not be suitable for the patient. The good results from the study can be attributed to both the CTO PCI and radial access proficiency of the operators, as well as their tendency to use larger guide catheters (7 F). This may also be due to patient selection that patients with less difficult cases are done through the trans-radial option.

Nowadays, most of the CTO PCI procedures are still done through transfemoral or a combination of both radial and femoral methods. This is mainly because 7 French guiding catheters are widely used, and they offer both good support and flexibility in technique selection.[31] Nevertheless, the application of thin-walled sheaths or sheathless methods cuts down on the requirement for large-bore arterial sheaths, which makes cTRA CTO PCI doable for most patients.[9] Of course, the transradial procedure and the use of a 6-F guiding catheter make it possible to apply different new inventions in devices and techniques for CTO PCI. The TRA in the CTO PCI should not be considered a limitation on the choice of

materials and techniques any more.[31] The generalization that TFA is the best method for CTO PCI seems a bit overstated. If the cTRA is done by skilled operators who are very experienced in radial access management and have a lot of confidence in TRA PCI, then we can say that it works as well as TFA, even for retrograde CTO cases.

Our research showed that the number of MACEs during hospitalization was the same in both the cTRA and TFA groups. On the other hand, there was a numerical drop in both vascular access and bleeding complications in the cTRA cohort. Previous research has shown that the occurrence of serious complications in connection with the access site was reduced within the TRA cohort.[18,20,22,23,26,27,30] On the contrary, it should be seen especially with consideration that the TFA access technique does not have perfect results, which is why the FORT CTO (Femoral or Radial Approach in the Treatment of Coronary Chronic Total Occlusion)[27] has its own limitations. Up to now, it is not clear if modern TFA techniques, which are based on needles of micropuncture,[32] femoral angiography, and devices of vascular closure[33] could have been used for better safety of the procedure.

The proximal transradial access (pTRA) is commonly used for regular CTO PCI; however, the novel distal transradial access (dTRA) promises benefits in biradial CTO PCI as it offers better ergonomics for both the operator and the patient and faster hemostasis and outpatient discharge times.[34] In a recent study, Achim et al[35] compared the procedural technique, vascular complications and clinical outcomes of dTRA versus pTRA among 337 CTO PCI cases performed between May 2016 and October 2021 in 3 Hungarian hospitals. They found that the dTRA is not inferior compared with the pTRA in procedural success rate for complex CTO PCI and clinical long-term adverse outcomes. Poletti et al[36] reported alternative forearm vascular accesses (dTRA and/or transulnar approach) and pTRA had comparable procedural success rate (92% vs 94.2%, $p = 0.70$) and primary safety end point rate (4.8% vs 6.0%, $p = 0.70$). At the same time, it is safe and feasible to use the distal radial approach for balloon aortic valvuloplasty and transcatheter aortic valve implantation.[37,38]

Limitations

This research has various limitations. Firstly, its retrospective design may introduce selection and information biases. Although propensity score matching might have reduced the effect of selection bias and potential confounding, many cases with complex CTO remained unmatched and were excluded. So, We did not use propensity score matching method for statistical analysis. Secondly, the findings of the research, which was performed at a single center, might not be generalizable to a wider population. It is imperative, therefore, to validate these results through multicentric clinical trials. Furthermore, the limited sample size may impede the research's ability to identify substantial disparities between the cohorts. Third, the current study did not take into account the outcomes in the mid- and long-term. Last, in the TFA cohort, hemostasis was obtained by manual compression, which caused a considerable time delay of 6 hours. No arterial closure devices were used, despite the fact that their efficiency in decreasing the frequency of arterial access complications was not proven.

Conclusions

Upon comparing TFA and cTRA, it was discovered that the latter is used in simpler lesions for retrograde CTO PCI. In addition to this, the cTRA had equal success rates and in-hospital MCAE as TFA for retrograde CTO PCI. The feasibility of cTRA for retrograde CTO PCI may be greater in cases with J-CTO scores < 3, but it will present a technical problem in cases with J-CTO scores of ≥ 3. It is important to carry out prospective, randomized studies in order to clearly prove which approach for retrograde CTO PCI is better. Further works will be required to reduce large-bore transfemoral access site–related complications, for example, with a focus on the use of ultrasound-guided TFA and femoral closure devices. Meanwhile, more study is required to accurately determine the superiority of the distal transradial access and transulnar approach.

Data Sharing Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The present research was carried out in accordance with the tenets mentioned in the Helsinki Declaration and was approved by the Ethical Board of Xiangtan Central Hospital (approval number: X20182214-5). Prior to the commencement of the research, our team obtained written informed consent from each patient.

Consent for Publication

Not applicable. No individual patient data will be reported.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

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