

# Comparison of the transradial and transfemoral approach in treatment of chronic total occlusions with similar lesion characteristics

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## ABSTRACT

**Objective:** There is limited data on the efficacy and the safety of the transradial approach (TRA) for percutaneous coronary intervention (PCI) of chronic total occlusion (CTO), particularly in comparison with the transfemoral approach (TFA) in lesions with similar complexity.

**Methods:** We included 358 patients, who underwent elective CTO PCI between January 2012 and August 2017 and compared the radial (179 patients) and femoral (179 patients) approaches. The J-CTO score was similar in both groups (TRA,  $2.5 \pm 1.3$  vs. TFA,  $2.8 \pm 1.4$ , n.s.). The endpoints analyzed included (i) the composite of all-cause death and nonfatal myocardial infarction (MI) and (ii) the composite safety endpoint of major adverse cardiovascular and cerebrovascular events (MACCEs), including death, MI, coronary perforation, contrast-induced nephropathy (CIN), bleeding at the vascular access site requiring transfusion, cardiac tamponade requiring pericardiocentesis, and periprocedural stroke.

**Results:** Patients' demographics, lesion location, lesion characteristics, and the proportion of antegrade vs. retrograde approach were similar in both groups. The procedural success rate of 96.4% in the radial group and 92.9% in the femoral group was comparable. The total fluoroscopy time (TRA,  $42.4 \pm 15.7$  min vs. TFA,  $40.5 \pm 15.3$  min, n.s.) and contrast medium use (TRA,  $532.2 \pm 21.7$  mL vs. TFA,  $528.2 \pm 24.6$  mL, n.s.) was similar in both groups. There was no in-hospital death or periprocedural MI in both groups. There were three coronary perforations in the TFA group, among them one with tamponade, and one coronary perforation the TRA group. Vascular access site complications (TRA, 0.01% vs. TFA, 0.02%) and CIN (TRA, 0.006% vs. TFA, 0.006%) were rare. One stroke as a result of the procedure was observed in the TFA group. No death was registered.

**Conclusion:** The radial approach in CTO PCI was as fast and successful as the femoral approach, even in a complex lesion subset. (*Anatol J Cardiol* 2018; 19: 319-25)

**Keywords:** transradial approach, chronic total occlusion, J-CTO score, fluoroscopy time, MACCEs

## Introduction

The transfemoral approach (TFA) represents the most extensively used access route for chronic total occlusion (CTO) treatment. However, recently there has been growing interest in using the transradial approach (TRA) to perform percutaneous coronary intervention (PCI) for CTO (1, 2).

It is standard practice for the majority of CTO-dedicated centers and operators to adopt a large guide catheter (GC) in the femoral artery as the preferred strategy to start a PCI on a CTO lesion. However, it is well-known that the use of femoral artery access is associated with higher rates of hemorrhagic and vascular entry-site complications compared with TRA (3). Moreover, TRA allows patients to be mobilized earlier and reduces hospital costs compared with TFA (4), and as demonstrated in recent observational reports, it may also result in a more favorable clinical outcome (5-7). For these reasons, there is a growing

interest worldwide regarding the replacement of TFA with TRA for coronary and peripheral interventions (8-12). However, there are some essential technical challenges of TRA such as limitation of the GC size, making TRA not accessible for all cases.

In this study, we compared the radial vs. femoral approach in the treatment of CTOs with similar lesion complexity.

## Methods

We included 358 patients who underwent elective CTO PCI between January 2012 and August 2017 (179 patients via the radial approach and 179 patients via the femoral approach) in the Department of Cardiology, Bezmialem Vakıf University. This study had a retrospective design as the included cases were collected from our CTO database. We matched patients with similar lesion characteristics: if we included a LAD CTO for the femoral arm, we searched for a radial case with similar or equal lesion

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characteristics. According to this screening method, cross-over cases were not considered for our study from the beginning. Multiple experienced operators were involved in this study, and most of the coronary procedures were done through the radial approach (>90%). Every patient's intervention was conducted by an experienced operator who had at least 3 years of experience using the radial approach. Operators generally used the right radial artery for intervention and the left radial artery for bilateral injection (90%). Similarly, in the femoral group, operators most often used the right femoral artery for intervention and the left femoral artery for bilateral injection (91%). CTO was defined as thrombolysis in myocardial infarction (TIMI) grade 0 flow with an estimated duration of occlusion of >3 months. Indications for revascularization were angina or equivalent and/or evidence of myocardial ischemia. Patients were anticoagulated with unfractionated heparin with an initial bolus of 70-100 U/kg, with subsequent boluses targeted to an activated clotting time of >300s throughout the intervention. There was no restriction with respect to the lesion or occlusion length.

Postdilatation was mandatory to ensure optimal stent expansion and strut apposition. Dual antiplatelet therapy with acetylsalicylic acid 100 mg per day and clopidogrel 75 mg per day or ticagrelor 90 mg twice daily was prescribed for at least 12 months.

Every patient signed an informed consent for the procedure and subsequent anonymous follow-up data analysis for clinical research purposes.

### Patient selection

Patients from 18 to 80 years with one or more CTOs presenting with angina symptoms or equivalent and/or reversible ischemia were included.

The main exclusion criteria were 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, other comorbid conditions with life expectancy <2 years, contraindications to aspirin or clopidogrel therapy, and women with child bearing potential. Angiographic success was defined as a visual estimated residual in-stent diameter stenosis <30%, with TIMI flow grade 3 without occlusion of a significant side branch, flow limiting dissection, distal embolization, or angiographic evidence of thrombus. Procedural success was defined as the composite endpoint of angiographic success without associated in-hospital major clinical complications [e.g., death, MI, stroke, coronary perforation with tamponade, bleeding requiring transfusion emergency coronary artery bypass graft surgery (CABG)]. Periprocedural MI was defined as an elevation of cardiac biomarkers (creatinine kinase-myocardial band  $\times 5$  times the upper limits of normal, Troponin  $\times 5$  times the upper limit of normal).

### Clinical endpoint parameters

Clinical endpoints that were analyzed included the composite of all-cause death, cardiac death, and major adverse cardiovascular and cerebrovascular events (MACCEs) including non-

fatal target vessel MI, coronary perforation, contrast-induced nephropathy (CIN), bleeding at the vascular access site requiring transfusion, cardiac tamponade requiring pericardiocentesis, and stroke as a result of the procedure.

Follow-up MI was diagnosed based on the rise of cardiac troponins above the 99<sup>th</sup> percentile upper reference limit with at least one of the following observations: symptoms of ischemia; changes in electrocardiogram, i.e., new or presumed new significant ST-T changes or new left bundle branch block or development of pathological Q-waves; imaging evidence of new loss of viable myocardium or new regional wall motion abnormality; or identification of an intracoronary thrombus by angiography.

### Statistical analysis

All continuous variables were tested for normality using Kolmogorov-Smirnov test. Data are presented as percentages, mean $\pm$ standard deviation (SD), or median (interquartile range). Chi-square analysis was used for comparing categorical variables between the groups. Differences in continuous variables were tested with a student t-test or Mann-Whitney U test for parametric and nonmetric variables respectively. Statistical analysis was performed using SPSS version 2.0 (SPSS Inc., Chicago, IL, USA).

## Results

### Population characteristics

The baseline characteristics of the patients are shown in Tables 1 and 2.

In total, 179 patients underwent CTO PCI via the radial approach and 179 via the femoral approach. There was no significant difference in age (TRA, 58.8 $\pm$ 10.6 vs. TFA, 59.1 $\pm$ 9.6;  $p=0.177$ ) and sex (male sex: TRA, 88.8% vs. TFA, 90.5%;  $p=0.626$ ) distribution between both groups. Most of the patients in both groups had a single vessel disease (TRA, 58.7% vs. TFA, 54.7%;  $p=0.532$ ). The cardiovascular risk factor constellation of the study groups was comparable. The left ventricular ejection fraction (LVEF) was measured in the TRA (59.3 $\pm$ 8.8%) and TFA (54.3 $\pm$ 13.2%) groups, without a marked difference ( $p=0.525$ ).

### CTO target lesion characteristics

The majority of the lesions involved the right coronary artery (TRA, 41.9% vs. TFA, 41.9%), followed by the left anterior descending artery (TRA, 41.3% vs. TFA, 41.3%) and the left circumflex coronary artery (TRA, 16.8% vs. TFA, 16.8%).

A blunt stump was found in 69.8% of the TRA cases and 74.9% of the TFA cases without statistical difference between both groups ( $p=0.288$ ). Moderate to severe calcification was similarly distributed between both groups (TRA, 71.5% vs. TFA, 78.8%;  $p=0.141$ ).

An occlusion length >20 mm was observed in the majority of cases (TRA, 63.1% vs. TFA, 67.6%;  $p=0.454$ ); there was no re-try among the groups. The J-CTO score was 2.5 $\pm$ 1.3 in the TRA

**Table 1. General characteristics of the study groups**

	TRA (n=179)	TFA (n=179)	P
Age	58.8±10.6 (57; 30-89)	59.1±9.6 (59; 34-82)	0.177
Male sex (%)	159 (88.8)	162 (90.5)	0.626
History of smoking (%)	100 (55.9)	102 (56.9)	0.571
Positive family history for CAD (%)	27 (15.1)	31 (17.3)	0.278
Arterial hypertension (%)	119 (66.5)	130 (72.6)	0.018*
Diabetes mellitus (%)	72 (40.2)	84 (46.9)	0.241
Dyslipidemia (%)	84 (46.9)	100 (55.9)	0.072
BMI (kg/m <sup>2</sup> )	28.5±4.7 (28; 21-42)	29.3±4.3 (29; 21-47)	0.313
History of MI (%)	63 (35.2)	65 (36.3)	0.825
History of Stroke (%)	2 (1.1)	4 (2.2)	0.410
No of diseased vessels			
1	105 (58.7)	98 (54.7)	
2	57 (31.8)	60 (33.5)	
3	17 (9.5)	21 (11.7)	0.532
Previous CABG	29 (16.2)	42 (23.4)	0.027*
Previous PCI	106 (59.2)	120 (67.0)	0.125
Chronic heart failure (%)	6 (3.4)	8 (4.5)	0.586
CKD (%)	4 (2.2)	6 (3.4)	0.521
LVEF (%)	59.3±8.8 (55; 20- 68)	54.3±13.2 (50; 20-66)	0.525
Creatinine (mg/dL)	1.0±0.1 (0.9; 0.6-7)	0.9±0.2 (0.9; 0.6-4.3)	0.509

n, number of individuals. Statistical evaluation by Mann-Whitney U test (continuous variables) or chi-square test (categorical variables). The results are shown as mean±standard deviation (SD). \*P<0.05. Median, minimal, and maximal values of continuous variables are shown in parenthesis under the mean values

group with slightly higher values in the TFA group (2.8±1.4) without significant difference (p=0.473).

### Procedural characteristics

The procedural characteristics of the lesions are shown in Table 3. The procedural success rate was similar in both groups (TRA, 96.4% vs. TFA, 92.9%; p=0.347). No MIs occurred after the procedures.

The antegrade approach was applied in 134 CTOs via TRA and in 125 CTOs via TFA, while the retrograde approach was applied in 45 CTOs via TRA and in 54 CTOs via TFA (p=0.288).

In total, 294 stents were implanted in the TRA group, whereas the stent number was higher with 350 in the TFA group (p=0.039). Predilation was performed with an average balloon diameter of 2.2 mm in both groups.

In the TRA group, the mean stent length was 32.4±1.8 mm with a mean of 1.77±0.1 stents per lesion and a diameter of 2.9±0.05

**Table 2. CTO and lesion characteristics of the study groups**

	TRA (n=179)	TFA (n=179)	P
Target lesions, n (%)			
LAD	74 (41.3)	74 (41.3)	
LCX	30 (16.8)	30 (16.8)	
RCA	75 (41.9)	75 (41.9)	1
Blunt stump	125 (69.8)	134 (74.9)	0.288
Moderate to severe calcification	128 (71.5)	141 (78.8)	0.141
Bending	68 (38.0)	102 (57.0)	0.001*
Length > 20 mm	113 (63.1)	121 (67.6)	0.454
Retry	0	0	1
J-CTO score	2.5±1.3	2.8±1.4	0.473
Collateral vessel			
Bridge	84 (46.9)	90 (50.3)	
Epicardial	27 (15.1)	27 (15.1)	
Septal	68 (38.0)	62 (34.6)	0.144

n, number of individuals. Statistical evaluation by Mann-Whitney U test (continuous variables) or chi-square test (categorical variables). The results are shown as mean±standard deviation (SD). \*P<0.05. Median, minimal, and maximal values of continuous variables are shown in parenthesis under the mean values

mm. Postdilation was performed in all pa-tients with a mean balloon diameter of 3.3±0.05 mm.

In the TFA group, the mean stent length was 30.1±1.4 mm with a mean of 2.05±0.1 stents per lesion and a diameter of 2.9±0.1 mm. Postdilation was performed in all pa-tients with a mean balloon diameter of 3.4±0.05 mm.

In 15.1% of the cases of the TRA group, a 6F GC was used, whereas the majority of CTOs were treated using a sheathless 7F GC (84.9%).

In the TFA group, 86.6% of the cases were conducted with a 7F GC, whereas the minority of CTOs were treated with a 6F (7.8%) or 8F (5.6%) GC. Bilateral injection was performed in similar rates with comparable use of microcatheters and stiff guide-wires between both groups.

The majority of these lesions were treated with a single wire crossing in both groups. The parallel-wire technique was conducted 32 times in the TRA group and 30 times in the TFA group. In 23.5% of the cases treated via TFA, the reverse controlled antegrade and retrograde subintimal tracking (CART) technique was applied. The number of reverse CART significantly decreased in the TRA group (7.8% vs. 23.5% in the TFA group, p<0.001).

Fluoroscopy time was similar in both groups, without reaching statistical significant difference (TRA, 42.4±15.7 min vs. TFA, 40.5±15.3 min; p=0.332). Contrast medium use was comparable in both groups (TRA, 532.2±21.7 vs. TFA, 528.2±24.6; p=0.547).

### Clinical outcome parameters

An overall analysis of all patients revealed four in-hospital MACEs in the TRA group and eight in the TFA group. Among

**Table 3. Procedural characteristics of the study groups**

	TRA (n=179)	TFA (n=179)	P
<b>Procedural success rate (%)</b>	96.4	92.9	0.347
<b>Approach type (%)</b>			
Antegrade	134 (74.9)	125 (69.8)	
Retrograde	45 (25.1)	54 (30.2)	0.288
Bilateral injection, n	144 (80.4)	152 (84.9)	0.331
<b>Guide catheter (%)</b>			
6F	27 (15.1)	14 (7.8)	
7F	152 (84.9)	155 (86.6)	
8F	0	10 (5.6)	
7F Sheathless	74 (41.3)	0 (0)	<0.001
Microcatheter (%)	177 (98.9)	179 (100)	0.156
Stiff guidewires, n	153 (85.5)	140 (78.2)	0.098
<b>Special technique (%)</b>			
Parallel wire	32 (17.9)	30 (16.7)	0.890
Reverse CART	14 (7.8)	42 (23.5)	<0.001
Parallel+CART	4 (2.2)	0 (0)	0.054
Parallel+Reverse CART	6 (3.4)	14 (7.8)	0.066
Anchoring balloon	61 (34.1)	72 (40.2)	0.190
Fluoroscopy time (min)	42.4±15.7 (40, 24-78.3)	40.5±15.3 (39, 29-75.5)	0.332
Contrast medium (ml)	532.2±21.7 (520, 370-950)	528.2±24.6 (520, 350-1200)	0.547

n, number of individuals. Statistical evaluation by Mann-Whitney U test (continuous variables) or chi-square test (categorical variables). The results are shown as mean±standard deviation (SD). \*P<0.05. Median, minimal and maximal values of continuous variables are shown in paranthesis under the mean values

them, there were three coronary perforations in the TFA group, one with tamponade requiring pericardiocentesis, and one coronary perforation the TRA group.

Vascular access site complications (TRA, 2 vs. TFA, 3) and CIN (TRA, 1 vs. TFA, 1) were rare. One stroke as a result of the procedure was observed in the TFA group. No death was registered.

## Discussion

In the last 20 years, the procedural success rates for CTO interventions have significantly increased as a result of improved guide wires and devices, as well as operator technique and experience. Success rates for PCI of CTOs now range from 65% to 80% and have steadily improved over time (13). Due to prolonged procedural time required to establish vessel patency in CTOs, local complications associated with femoral artery access may lead to serious clinical complications. TRA has been shown to reduce vascular and bleeding complications at the access site,

improve patient comfort, and decrease the length of hospitalization compared with TFA (14).

The radial approach is gaining ground as interest grows all over the world. A review of the literature found that the proportion of radial access was 3% in 2007, with a sharp rise to 5%–7% between 2010–2011 (1, 15). Successful attempts have been made to treat CTOs via TRA in China, Japan, and Europe (16-19).

In this study, we have demonstrated that the radial approach for CTO PCI is not inferior in procedural success compared with the femoral approach, although the lesion complexity was similar in both groups (Tables 2, 3). Further, fluoroscopy times and contrast volume were similar in both groups (Table 3).

Previous studies, investigating the feasibility of CTO PCI via the radial approach, partially in comparison to the femoral approach, show similar outcome results among each other (16-19).

Rathore et al. (19) reported comparable angiographic success rates as TRA for CTO (82% in the radial group vs. 86% in the femoral group), and access site vascular complications were significantly less in the radial group, whereas Liu et al. (17) reported that the success rate of TRA for CTO was 80%, minimizing vascular complications without increasing procedural time and contrast use.

In a recent study, Alaswad et al. (20) compared the technique and outcomes of transradial versus transfemoral access among 650 CTO PCI cases performed between January 2012 and March 2014 at six centers in the United States. The investigators concluded that transradial CTO PCI can be performed with similar rates of procedural success and complications as transfemoral CTO PCI, but it is associated with longer procedure and fluoroscopy times. Moreover, transradial access was only used in 110 (17%) cases and associated with a number of crossing approach changes. In most of the studies, the vascular access route was chosen according to the complexity of CTO, implying that cases treated via TRA were characterized by less degree of difficulty. Conversely, although the J-CTO score was higher in cases treated via the radial approach in the Alaswad study, the TRA number was small and the cases of both approach types were not matched with each other (20).

In contrast, in our study, the CTO complexity, determined by the J-CTO score, was similar between both groups, whereas bending was more frequently found in the TFA group. We suppose that this is based on a selection bias, as most of femoral cases were performed at the beginning of the study period, while the radial cases were performed later.

In another recent study, TFA with antegrade or antegrade plus retrograde approach was mainly performed for blunt-type entry in CTO lesions because large guiding catheters could then be used, thus facilitating techniques such as parallel wiring and intravascular ultrasound guided wiring.

On the other hand, the J-CTO score was sequentially increasing from TRA, TFA, TRA/TFA to TFA/TFA, although the success rates were not significantly different among the four groups according to approach site. The operators carefully selected the

**Table 4. In-hospital MACCE of the study groups**

	TRA (n=179)	TFA (n=179)	P
MACCE, in hospital	4	8	0.240
Bleeding at the access site	2	3	0.652
Required transfusion	0	1	
Vascular repaired operation	0	1	
Coronary perforation	1	3	0.316
Pericardial effusion	1	2	0.536
Pericardial tamponade	0	1	0.317
Myocardial infarction	0	0	1
Stroke	0	1	0.317
Contrast-induced nephropathy	1	1	1
Death, all cause	0	0	1

n, number of individuals. Statistical evaluation chi-square test (categorical variables). The results are shown as mean±standard deviation (SD). \*P<0.05

approach site based on CTO difficulty; moreover, they concluded that in particular, a low J-CTO score may be one of the favorable factors in TRA (21).

In our study, blunt stump appeared frequently with 57.8% of the TRA cases vs 68.2% of the TFA cases, without a marked difference between both groups (p=0.288).

Normally, TRA commits the operator to the use of smaller guide catheters (6F GC in more than 70% of cases) and this might be a concern when planning a complex PCI procedure such as CTO recanalization (17, 22). However, experienced transradial operators have learned to overcome such limitations, focusing on the material compatibility and technical plan of CTO PCI (23).

Looking at our data, a sheathless 7F GC was more frequently used than a 6F GC in the TRA group (41.3% vs. 15.1%) (Table 3). There was no significant difference in the frequency of 7F GC use between the TRA and TFA groups (84.9% vs. 86.6%). In 10 cases, where TFA was conducted and where the need of multiple devices in the coronary artery was anticipated, an 8F GC was used (Table 3).

Despite the frequent use of bigger GCs >6F in the radial artery, there was no major vascular complication observed (Table 4).

The sheathless technique has given the operator the possibility to improve the passive support by using larger GCs like 7F, without harming the radial artery (24). In a recent study, 116 patients from four tertiary US centers who underwent TRA using 7F sheathless guiding catheter were recruited. Fifty seven stenoses of the 123 lesions (49%) were complex interventions, which included patients with acute coronary syndromes, CTO, bifurcation stenting, calcified lesions, left main artery, and saphenous venous graft interventions. Overall, the procedural success rate was 95%. At 7 days, there were six patients (5%) with radial artery occlusion (RAO), of which two had severe radial

artery spasm during the procedure. At 30 days, the overall persistent RAO was only detected in three patients (2.5%), as three patients had return of antegrade radial artery flow (24).

If the radial approach was conducted, we commonly used 7F GCs, and when more support was required, anchoring balloon technique was applied (34.1% of all TRA cases).

Another technique to enhance the support is the “five in six technique” (or “mother-and-child technique”) greatly facilitated by dedicated devices (Terumo Heartrail™ catheter, Terumo Corp., Tokyo, Japan; or the novel GuideLiner™, Vascular solutions, MN, USA) (25).

Otherwise, there was no marked difference in the use of microcatheters, guide wires, or special techniques like parallel wiring, whereas reverse CART was more frequently applied in the TFA group (Table 3). The retrograde approach was conducted in nearly 25.1% of the TRA cases and 30.2% of the TFA cases. In other studies mentioned before, CTO treatment via TRA was mainly performed with the antegrade technique.

As improving the retrograde approach has increased the success rate of CTO treatment (26-28), it is inevitable to perform retrograde CTO PCI using the radial access. Here, we have shown that the retrograde technique is also feasible with a high success rate.

On the other hand, TRA is not as easy to adopt because it is associated with some specific technical issues, and as a consequence, with the need of a learning curve for all operators. This concept is evident when looking at the literature data on PCI in CTO lesions treated by the radial approach and expert radialists. Four single-center observational studies on TRA for PCI in CTO lesions provided data regarding the comparison of TRA PCI success rate between the initial and later periods of the study, demonstrating that it significantly improves in the second period of the study with an increased operator experience after a first period of learning curve (18, 22, 28-30).

Thus, we conclude that operators’ experience combined with sufficient technical support and materials’ compatibility might enforce the use of radial approach for CTO treatment, especially if we consider that procedural success is not inferior with similar or even less use of contrast medium and less major vascular complications compared with the femoral approach.

### Study limitations

Although our study population was not very small compared with other studies in the literature, larger studies with larger control groups would offer more valid and reliable results.

Female sex was under-represented in the study.

### Conclusion

In summary, the radial approach in CTO PCI was as fast and successful as the femoral approach, even in a complex lesion subset.

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