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Vascular Access Site and Outcomes Among 26,807 Chronic Total Coronary Occlusion Angioplasty Cases From the British Cardiovascular Interventions Society National Database

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ABSTRACT

OBJECTIVES The aim of this study was to assess, using a national percutaneous coronary intervention (PCI) database, access-site choice and outcomes after chronic total occlusion (CTO) PCI.

BACKGROUND Given the influence of access site on outcomes, the use of radial access in CTO PCI warrants further investigation.

METHODS Data were analyzed from the British Cardiovascular Intervention Society dataset of 26,807 elective CTO PCI procedures performed in England and Wales between 2006 and 2013. Multivariate logistic regression was used to identify predictors of access-site choice and its association with outcomes.

RESULTS There was a significant decrease in femoral artery (FA) access from 84.6% in 2006 to 57.9% in 2013. Procedural factors associated with FA access included dual access (odds ratio [OR]: 3.89; 95% confidence interval [CI]: 3.45 to 4.32), CrossBoss/Stingray (OR: 1.87; 95% CI: 1.43 to 2.12), intravascular ultrasound (OR: 1.32; 95% CI: 1.21 to 1.53), and micro-catheter use (OR: 1.18; 95% CI: 1.03 to 1.39). There was an association between FA access and the number of CTO devices used ($p = 0.001$ for trend). Access-site complications (1.5% vs. 0.5%; $p < 0.001$), periprocedural myocardial infarction (0.5% vs. 0.2%; $p = 0.037$), major bleeding (0.8% vs. 0.2%, $p < 0.001$), transfusion (0.4% vs. 0%; $p < 0.001$), and 30-day death (0.6% vs. 0.1%; $p = 0.002$) were more frequent in patients undergoing CTO PCI using FA access. An access-site complication during CTO PCI was associated with significant increases in transfusion (8.0% vs. 0.1%; $p < 0.001$), procedural coronary complication (17.3% vs. 5.8%; $p < 0.0001$), major bleeding (8.4% vs. 0.3%; $p < 0.001$), and mortality at all time points.

CONCLUSIONS FA access remains predominant during CTO PCI, with case complexity and device size associated with its use. Access-site complications were more frequent with FA use and strongly correlated with adverse outcomes. (J Am Coll Cardiol Intv 2017;10:635–44) © 2017 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

BCIS = British Cardiovascular Intervention Society

CABG = coronary artery bypass graft

CTO = chronic total occlusion

MI = myocardial infarction

NICOR = National Institute of Cardiovascular Outcomes Research

PCI = percutaneous coronary intervention

Radial arterial access is increasingly the preferred choice for percutaneous coronary intervention (PCI) among interventional cardiologists worldwide (1,2). Factors influencing this major change in practice over the past decade include an improvement in patients' experience; a reduction in hospital costs through facilitation of day-case PCI; the avoidance of major bleeding, transfusion, and access-site complications; and reductions in short- and long-term mortality (3-10). Although there remains significant variation in radial rates by country, center, and operator, many default radial centers now perform more than 90% of procedures without the need to puncture the femoral artery. Indeed, the most recent British Cardiovascular Intervention Society (BCIS) National Angioplasty Audit revealed that in 2014, 75.3% of all PCI procedures in the United Kingdom were performed using the radial artery (11).

Access-site choice is defined by a number of factors, including physician practice and preference, anatomic variation (such as radial loops), radial occlusion, and arterial spasm (12,13). However, particularly complex case subgroups such as patients with histories of coronary artery bypass graft (CABG) surgery and those with chronic occlusive disease may still be undertaken using femoral arterial access (14). In particular, chronic total occlusion (CTO) PCI presents several access-site challenges, including the need for dual arterial access and large-caliber guide catheters to facilitate CTO techniques (15,16). Therefore, moving to routine radial arterial access remains a technical challenge for many CTO PCI procedures despite advances in the technology and experience that have facilitated the almost exclusive use of radial artery access in non-CTO PCI procedures at many centers.

CTO outcomes from the BCIS dataset have previously been analyzed but without a specific focus on access site (17). There are many sources of data, both randomized and registry-based, on non-CTO PCI procedures and access site but no clinical trials of access-site practice in CTO PCI and its associated outcomes and only limited observational registry data from small single-center series (18-20). Therefore, the aim of the present study was to examine, using the BCIS National PCI Audit, the baseline demographics, procedural characteristics, and predictors and the outcomes of patients undergoing CTO PCI from the femoral artery compared with the radial artery.

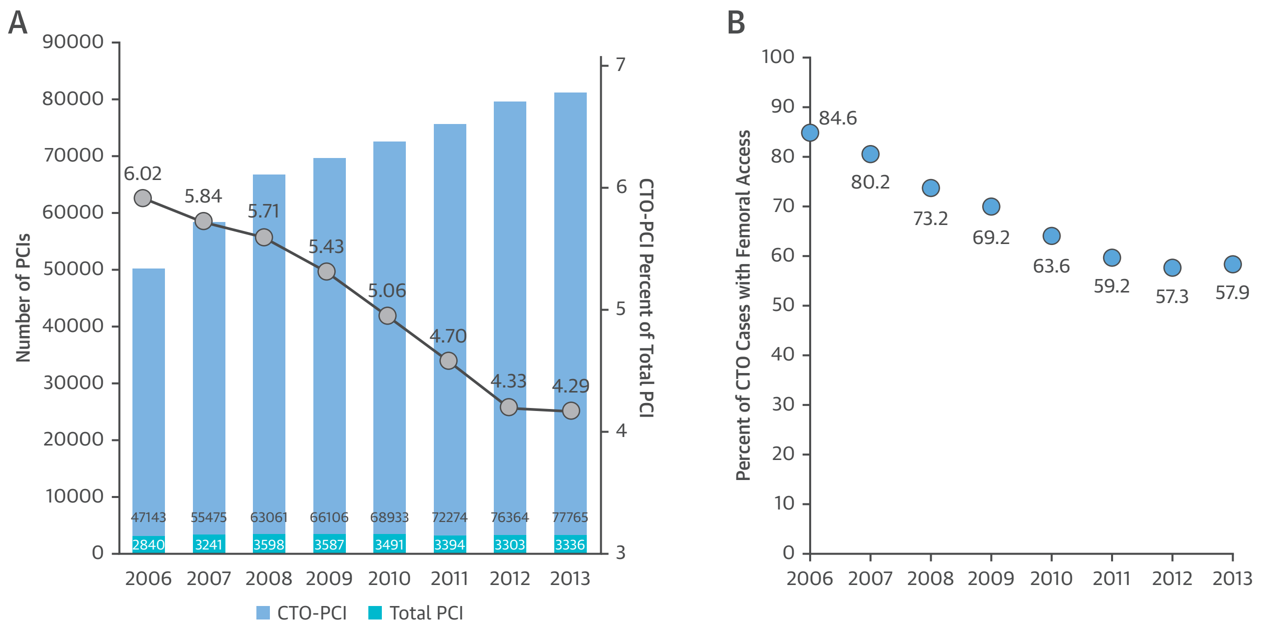
METHODS

STUDY DESIGN, SETTING, AND PARTICIPANTS. We analyzed national data from all patients with stable angina who underwent elective PCI for CTO in England and Wales between January 2006 and December 2013.

SETTING, DATA SOURCE, AND STUDY SIZE. Data on PCI practice in the United Kingdom were obtained from the BCIS dataset, which records this information prospectively and publishes it in the public domain as part of the national transparency agenda (21). The data collection process is overseen by the National Institute of Cardiovascular Outcomes Research (NICOR) (http://www.ucl.ac.uk/nicor/) with high levels of case ascertainment. In 2013, 98.6% of all PCI procedures performed in the National Health Service hospitals in England and Wales (http://www.bcis.org.uk) were recorded in the database. The BCIS-NICOR database contains 113 clinical, procedural, and outcomes variables, with approximately 80,000 new records added each year. The participants of the database are tracked by the Medical Research Information Services for subsequent mortality using the patients' National Health Service number (a unique identifier for any person registered within the National Health Service in England and Wales). Although the BCIS dataset covers the entire United Kingdom, only patients from England and Wales have mortality tracked by the Office of National Statistics, so the present analysis is restricted to patients from these 2 countries.

STUDY DEFINITIONS. We analyzed all recorded elective CTO PCI procedures that were undertaken for stable angina in England and Wales between January 1, 2006, and December 31, 2013. Patients were categorized according to access-site choice during CTO PCI. Participants with missing information on access site and CTO status were excluded. In cases in which more than 1 arterial access site was used, any femoral artery puncture was defined as a femoral case. For example, a dual-access case with left radial and right radial access was considered a radial case. However, a dual-access case with right radial and right femoral access was considered a femoral case. Study definitions were used as in the BCIS-NICOR database. Specifically, pre-procedural renal failure was defined as any 1 of the following: creatinine >200 μmol/l, renal transplantation history, or dialysis. Penetration catheters most commonly used during the study period were the Tornus and Gopher catheters. Microcatheters most commonly used during the study period were

FIGURE 1 **Chronic Total Occlusion Volumes and Access by Years 2006 to 2013**



(A) Annual number of percutaneous coronary intervention (PCI), annual number of chronic total occlusion (CTO) PCI, and percentage of total PCI represented by CTO PCI in England and Wales ($p < 0.0001$ for all annual trends). **(B)** Annual rate of femoral puncture during CTO PCI in England and Wales, 2006 to 2013 ($p < 0.0001$ for trend).

the Corsair and Finecross catheters. An access-site complication was defined as a false aneurysm, a hemorrhage (without hematoma), a hemorrhage with delayed discharge, a retroperitoneal hematoma, an arterial dissection, or any access-site complication requiring surgical repair. For the purposes of the present study, we defined in-hospital major bleeding as either gastrointestinal bleeding, intracerebral bleeding, retroperitoneal hematoma, blood or platelet transfusion, or an arterial access-site complication requiring surgery.

The clinical outcomes of interest were in-hospital death, 30-day mortality, 1-year mortality, in-hospital bleeding, periprocedural infarction, emergency surgery, stroke, cardiac tamponade, side-branch occlusion, slow flow, and coronary dissection, for which we initially calculated the crude rates by access-site choice.

DATA ANALYSES. The rates of access-site choice by year of PCI were analyzed using linear regression. All study years (2006 to 2013) are presented in this analysis. However, for the purposes of examining the predictors and outcomes of access-site choice for CTO PCI, analysis was restricted to the final 2 years of data (2012 and 2013) to encompass mature interventional practice and when changes in access-site choice rates were minimal. For these years, we examined the baseline characteristics of participants by access site. These variables included age, sex, smoking status, body mass index, family history of coronary heart disease, hypertension, hyperlipidemia, diabetes, previous myocardial infarction (MI), previous stroke, peripheral vascular disease, valvular heart disease, renal disease, previous PCI, previous CABG, left ventricular function, antiplatelet therapy, warfarin use, bivalirudin use, glycoprotein IIb/IIIa inhibitors use, vessel attempted for PCI (graft, left main, left anterior descending, circumflex, right coronary), radial access, stent implanted, rotational atherectomy use, laser angioplasty use, cutting balloon use, presence of a chronic occlusion, surgical cover, and year of PCI. We tested for associations between each categorical variable and access site using a chi-square test, and for continuous variables, we used 1-way analysis of variance. We then performed a multivariate analysis of the predictors of access site in 2012 and 2013 using multivariate logistic regression to investigate the influence of variables that have the potential for being included in the linear component of a proportional hazards model. Variables included in the model were sex, Canadian Cardiovascular Society class, New York

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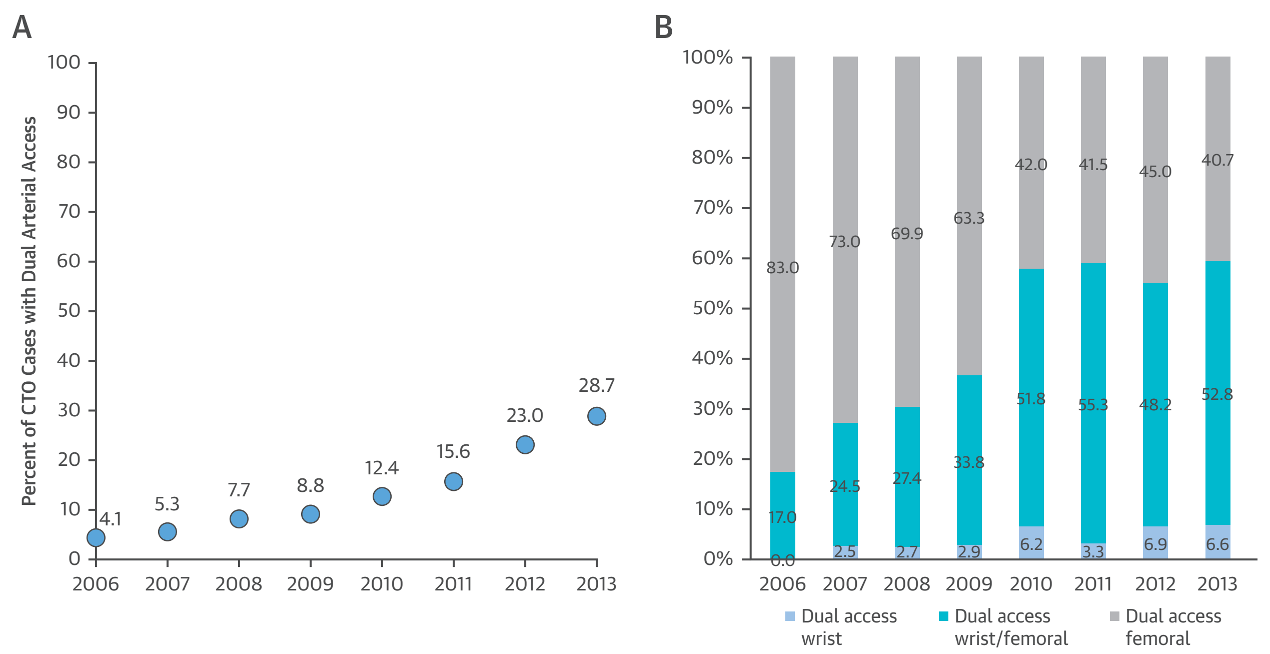
FIGURE 2 Dual Access Use by Years 2006 to 2013



(A) Annual rates of dual arterial access use during chronic total occlusion (CTO) percutaneous coronary intervention (PCI) in England and Wales, 2006 to 2013 ($p < 0.0001$ for trend). **(B)** Annual rates of use of dual radial access ($p = 0.0045$ for trend), dual radial and femoral access ($p = 0.0012$ for trend), and dual femoral access ($p = 0.0007$) during CTO PCI in England and Wales, 2006 to 2013.

Heart Association functional class, previous MI, previous CABG, previous PCI, diabetes, lesion location, imaging use, rotational atherectomy use, penetration catheter use, microcatheter use, CrossBoss use, and dual access. To correct for missing values, we first imputed missing data on baseline covariates using multiple imputations with chained equations to adjust for missing data (missing data points are presented in Online Table 1). We then ran a stepwise forward selection with a proportional hazards model with $p < 0.10$ as the entry criterion. To correct for a possible error during imputation that might be introduced by missing values being distributed in a nonrandom fashion, we used a pattern mixture model during sensitivity analysis. Finally, an individual logistic regression analysis was performed to investigate the impact of an arterial complication in 2012 and 2013 on clinical outcomes.

RESULTS

TEMPORAL TRENDS AND BASELINE DEMOGRAPHICS BY ACCESS-SITE CHOICE FOR CTO PCI. Between 2006 and 2013, 26,807 stable angina CTO interventions were performed in the United Kingdom, with significant increases in overall PCI and CTO PCI numbers, although the number of cases performed for CTO PCI as a percentage of total PCI dropped significantly (Figure 1A). During the study period, there was a significant decrease in femoral artery access from 84.6% in 2006 to 57.9% in 2013 ($p < 0.0001$) (Figure 1B), and although changes plateaued from 2011 onward, femoral use remained dominant. Between 2006 and 2013, there was a significant increase in dual arterial access use ($p < 0.0001$) (Figure 2B). Within dual-access cases, although there was a significant increase in dual access via radial use (from 0% to 6.6% during the study period; $p = 0.0045$), 93.4% of dual-access cases were undertaken using at least 1 femoral puncture (Figure 2B). The baseline demographics by access site for patients undergoing CTO PCI in 2012 and 2013 are presented in Table 1. In general, baseline clinical characteristics did not differ significantly by access-site choice for CTO PCI, although a history of PCI and a history of CABG were the strongest associates.

PROCEDURAL VARIABLES BY ACCESS-SITE CHOICE FOR CTO PCI. The procedural variables for patients by access site are presented in Table 2. In contrast to

TABLE 1 Baseline Participant Characteristics by Access Site for Chronic Total Occlusion Percutaneous Coronary Intervention

	Femoral (n = 3,732)	Radial (n = 2,748)	p Value
Age (yrs)	64.0 ± 10.8	63.8 ± 10.8	0.329
Female	710 (19.0)	474 (17.3)	0.074
Smoking status			
Never smoked	1,129 (33.0)	911 (36.6)	0.004
Ex-smoker	1,799 (52.5)	1,238 (49.7)	0.033
Current smoker	498 (14.5)	343 (13.7)	0.407
BMI (kg/m^2)	29.6 ± 6.1	29.6 ± 6.6	0.462
Hypertension	2,444 (69.2)	1,745 (66.3)	0.014
Diabetes	956 (27.0)	614 (23.4)	0.001
Previous MI	1,535 (43.4)	1,057 (40.2)	0.013
Q wave on ECG	326 (9.7)	260 (10.5)	0.333
Previous stroke	131 (3.7)	108 (4.1)	0.463
Peripheral vascular disease	248 (7.0)	177 (6.7)	0.648
Valvular heart disease	61 (1.7)	49 (1.9)	0.699
Renal disease	95 (2.7)	61 (2.3)	0.368
Creatinine (μmol/l)	93.5 ± 43.1	92.8 ± 44.4	0.322
Previous PCI	1,589 (43.5)	952 (35.1)	<0.001
Previous CABG	660 (18.0)	282 (10.4)	<0.001
Ejection fraction (%)	52.4 ± 13.3	52.2 ± 11.5	0.462
CCS class ≥3	1,659 (46.9)	1,140 (44.0)	0.029
NYHA functional class ≥3	844 (24.5)	543 (21.6)	0.010
Antiplatelet therapy			
Clopidogrel	3,002 (83.3)	2,242 (85.6)	0.012
Prasugrel	54 (1.5)	49 (1.9)	0.269
Ticagrelor	47 (1.3)	40 (1.5)	0.522
Warfarin	50 (1.4)	42 (1.6)	0.524

Values are mean ± SD or n (%).

BMI = body mass index; CABG = coronary artery bypass grafting; CCS = Canadian Cardiovascular Society; ECG = electrocardiography; MI = myocardial infarction; NYHA = New York Heart Association; PCI = percutaneous coronary intervention.

TABLE 2 Procedural Variables by Femoral Versus Radial Access Site for Chronic Total Occlusion Percutaneous Coronary Intervention

	Femoral (n = 3,732)	Radial (n = 2,748)	p Value
Off-site surgical cover	1,367 (38.5)	1,099 (42.5)	0.002
Single arterial access	2,168 (58.1)	2,636 (95.9)	<0.001
Dual arterial access	1,564 (41.9)	112 (4.1)	<0.001
Dual radial	–	112 (4.1)	
Dual femoral	713 (19.1)	–	
Radial/femoral	851 (22.8)	–	
Number of CTOs attempted	1.05 ± 0.26	1.06 ± 0.29	0.061
Vessel attempted			
Graft	86 (2.3)	72 (2.6)	0.549
Left main	157 (4.3)	72 (2.6)	<0.001
Left anterior descending	1,251 (33.9)	1,082 (39.6)	<0.001
Circumflex	693 (18.8)	752 (27.5)	<0.001
Right coronary	2,079 (56.4)	1,316 (48.2)	<0.001
Trainee first operator	415 (11.7)	514 (19.6)	<0.001
Intravascular ultrasound	384 (11.5)	180 (7.4)	<0.001
Rotational atherectomy	141 (3.9)	64 (2.4)	0.002
Penetration catheter	109 (3.0)	50 (1.9)	0.007
Microcatheter	790 (21.8)	360 (13.8)	<0.001
CrossBoss/Stingray	140 (3.9)	15 (0.6)	<0.001
Glycoprotein inhibitor	144 (4.1)	152 (6.0)	0.001
Number of DES used	1.72 ± 1.51	1.64 ± 1.43	0.023
Procedural success	2,770 (75.0)	2,146 (79.1)	0.002
Number of successful lesions	1.09 ± 0.92	1.22 ± 0.99	<0.001
Final TIMI flow grade			
0	269 (19.0)	136 (14.9)	0.012
1	46 (3.3)	50 (5.5)	0.010
2	49 (3.5)	39 (4.3)	0.319
3	1,042 (74.1)	682 (75.2)	0.591

Values are n (%) or mean ± SD.

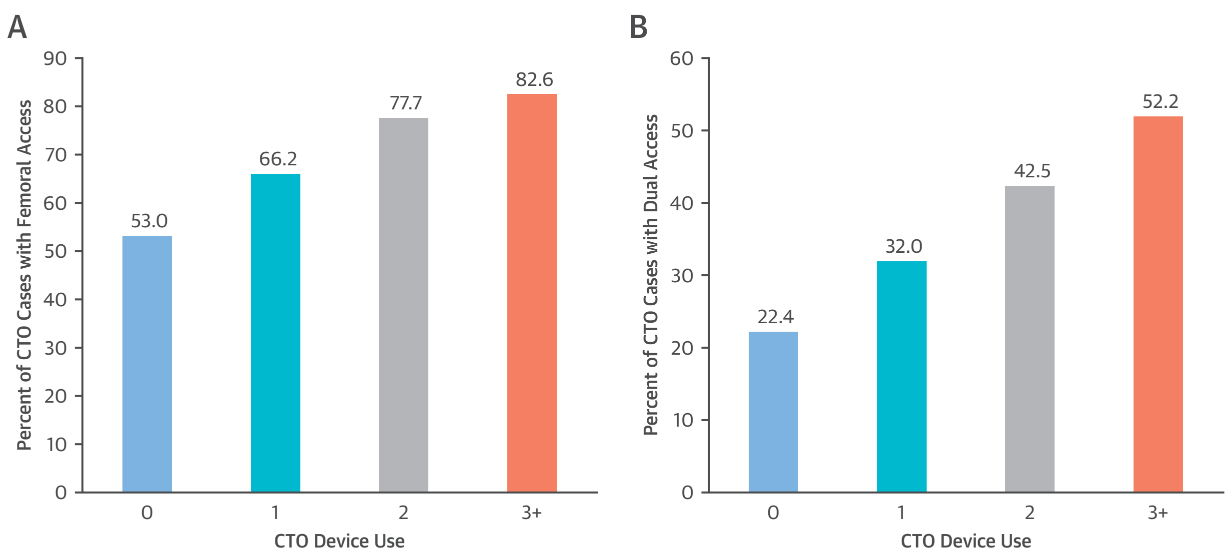
CTO = chronic total occlusion; DES = drug-eluting stent(s); TIMI = Thrombolysis In Myocardial Infarction.

patient baseline characteristics, there were many significant differences among procedural variables patients who underwent CTO PCI using femoral artery access compared with those using radial artery access. Additionally, the complexity of the intervention was closely associated with access choice, with a primary consultant operator, dual arterial access, intravascular ultrasound, rotational atherectomy, penetration catheter, microcatheter, and CrossBoss/Stingray use all more frequently observed when femoral artery access was chosen. There was a highly significant association between femoral artery access and the number of CTO devices used (R^2 = 0.965; p = 0.001 for trend) (**Figure 3A**) and a highly significant association between dual arterial access and the number of CTO devices used (R^2 = 0.996; p = 0.0001 for trend) (**Figure 3B**). Procedural success and the number of successful lesions was lower in the femoral cohort (**Table 2**). Online Table 2 illustrates baseline variables and procedural variables categorized by radial only, radial dual access, femoral only, radial and femoral dual access, and femoral dual access.

PREDICTORS OF ACCESS-SITE CHOICE FOR CTO PCI. Using multivariate analyses, covariates found to be associated with femoral artery access for CTO PCI in 2012 and 2013 were identified and are presented in **Table 3**. The only patient-related factors associated with femoral access were female sex and a history of revascularization. Procedural factors associated with femoral artery access were dual arterial access, CrossBoss/Stingray use, intravascular ultrasound use, rotational or laser atherectomy, and microcatheter use. Circumflex CTO intervention was associated with lower use of femoral artery access.

CLINICAL OUTCOMES BY ACCESS-SITE CHOICE FOR CTO PCI. Acute coronary arterial procedural complications for CTO PCI procedures carried out in 2012

FIGURE 3 CTO Procedure Complexity and Femoral Access



(A) Femoral access use by number of chronic total occlusion (CTO) devices used (a combination of intravascular ultrasound, penetration catheter, atherectomy, microcatheter, or CrossBoss use) during CTO percutaneous coronary intervention (PCI) in England and Wales, 2012 and 2013 (p = 0.001 for trend). **(B)** Dual arterial access use by number of CTO devices used during CTO PCI (p = 0.0001 for trend).

and 2013 were similar between the femoral and radial cohorts (**Table 4**). However, in-hospital complications, including access-site complications (1.5% vs. 0.5%; $p < 0.001$), periprocedural MI (0.5% vs. 0.2%; $p = 0.037$), major bleeding (0.8% vs. 0.2%; $p < 0.001$), blood transfusion (0.4% vs. 0%; $p < 0.001$), and death (0.2% vs. 0.1%; $p = 0.027$), were more frequent in patients undergoing CTO PCI using femoral artery access. Mortality at 30 days (0.6% vs. 0.1%; $p = 0.002$) was greater in the femoral cohort. Online Figure 1 illustrates outcomes categorized by radial only, radial dual access, femoral only, radial and femoral dual access, and femoral dual access.

TABLE 3 Significant Associations Between Covariates and Femoral Access for Chronic Total Occlusion Percutaneous Coronary Intervention

	Odds Ratio	95% CI	p Value
Dual arterial access	3.89	3.45–4.32	<0.001
CrossBoss/Stingray use	1.87	1.43–2.12	<0.001
Intravascular ultrasound	1.32	1.21–1.53	<0.001
Female	1.21	1.10–1.32	0.007
Microcatheter use	1.18	1.03–1.39	<0.001
Previous CABG	1.12	1.04–1.29	<0.001
Previous PCI	1.08	1.02–1.14	0.023
Circumflex CTO	0.94	0.89–1.00	0.050

CABG = coronary artery bypass grafting; CI = confidence interval; CTO = chronic total occlusion; PCI = percutaneous coronary intervention.

CLINICAL OUTCOMES BY ACCESS-SITE COMPLICATION DURING CTO PCI. In an analysis of the full 2006–2013 cohort, a femoral access-site complication during CTO PCI was associated with significant increases in transfusion (8.0% vs. 0.1%; $p < 0.001$), acute procedural coronary complications (17.3% vs. 5.8%; $p < 0.0001$), major bleeding (8.4% vs. 0.3%; $p < 0.001$), and mortality at all time points (**Table 5**). Using individual logistic regression, the adverse association of an arterial complication on clinical events was significant (**Table 6**). **Figure 4** illustrates the Kaplan-Meier plots for mortality by femoral access-site complication status to 12 months, confirming the significant relationship between this event and patient survival ($p = 0.001$).

DISCUSSION

The findings of the present study can be summarized as follows: 1) there was a significant increase during the study period in radial artery access for CTO PCI, although the femoral artery remained the predominant access site; 2) dual arterial access increased significantly during the study period and was driven

TABLE 4 Outcomes by Access Site After Chronic Total Occlusion Percutaneous Coronary Intervention

	Femoral (n = 3,732)	Radial (n = 2,748)	p Value
Immediate procedural outcomes			
Tamponade	15 (0.4)	5 (0.2)	0.172
Emergency surgery	7 (0.2)	4 (0.2)	1.000
Coronary dissection	138 (3.9)	88 (3.4)	0.373
Major side-branch loss	27 (0.8)	17 (0.7)	0.760
Slow flow	11 (0.3)	10 (0.4)	0.660
Access site complication	56 (1.5)	14 (0.5)	<0.001
Clinical outcomes			
Transfusion	15 (0.4)	0 (0)	<0.001
Periprocedural MI	19 (0.5)	5 (0.2)	0.037
In-hospital major bleeding	29 (0.8)	5 (0.2)	<0.001
In-hospital death	8 (0.2)	2 (0.1)	0.027
Mortality at 30 days	22 (0.6)	3 (0.1)	0.002
Mortality at 1 yr	85 (3.0)	55 (2.6)	0.388

Values are n (%).

mainly by femoral artery use; 3) dual arterial access was closely correlated with procedure complexity; 4) the main predictor of femoral use was CTO PCI procedure complexity; 5) access-site complications were significantly more likely in the femoral cohort; and 6) femoral access-site complications were strongly predictive of adverse patient outcomes. The findings of the present study are largely consistent with those of previous studies, although the totality of the evidence is limited to observational studies (largest series 950 cases) and a total of <4,000 cases in a recent meta-analysis (18-20). However, these data, also modest in size, demonstrate an accumulating radial experience in treating CTO disease with higher success rates later in the learning curve. At the present time, no randomized trials are planned or completed.

TABLE 5 Outcomes by Access-Site Complication After Chronic Total Occlusion Percutaneous Coronary Intervention

	Access-Site Complication (n = 255)	No Access-Site Complication (n = 25,574)	p Value
Transfusion	20 (8.0)	28 (0.1)	<0.001
Periprocedural MI	4 (1.6)	125 (0.5)	0.051
Procedural complication	42 (17.3)	1,372 (5.8)	<0.001
In-hospital major bleeding	21 (8.4)	78 (0.3)	<0.001
In-hospital stroke	1 (0.4)	6 (0.02)	0.103
In-hospital death	5 (2.0)	29 (0.1)	<0.001
Mortality at 7 days	4 (1.6)	65 (0.3)	<0.001
Mortality at 30 days	6 (2.4)	103 (0.4)	<0.001
Mortality at 1 yr	11 (4.7)	543 (2.3)	0.001

Values are n (%).
MI = myocardial infarction.

TABLE 6 Adjusted Odds of Adverse Outcomes After Access-Site Complication During Chronic Total Occlusion Percutaneous Coronary Intervention

	Multiple Logistic Regression Adjusted Odds	95% CI	p Value
Transfusion	76.5	42.5–137.7	<0.0001
In-hospital major bleeding	28.9	17.5–47.6	<0.0001
30-day death	17.3	6.7–45.1	<0.0001
Post-procedural CVA	16.5	2.0–137.5	<0.0001
Procedural complication	3.4	2.4–4.8	<0.0001
Periprocedural MI	3.2	1.2–8.7	0.002

CI = confidence interval; CVA = cerebrovascular accident; MI = myocardial infarction.

Despite radial artery access becoming a default strategy in the United Kingdom over the past decade, the present data demonstrate that in CTO PCI, the femoral artery remains predominant. Scrutiny of the predictors of femoral access suggest that a requirement for large-caliber guide catheters, dual arterial access, and procedure complexity are the main drivers of this practice rather than patient-defined characteristics. A particular challenge in CTO PCI is the frequent need for dual arterial access for contralateral visualization and wiring. Bilateral radial artery access would facilitate this technique without necessitating femoral artery puncture, and although there are modest volume case series published with high success rates, this has not been a widely adopted technique (22-24). There are also case reports of novel techniques to allow contralateral injection with a single arterial puncture, and these hold promise in minimizing future femoral arterial use (25,26). Additionally, there is often a necessity in CTO PCI for large-caliber guide catheters to allow the use of bulky devices such as laser atherectomy, to facilitate CTO techniques such as trapping and snaring, and to accommodate the sheer amount of interventional equipment that is often required in contemporary complex procedures (15,16). Although the physical size of the radial artery may be prohibitive for large guide catheters, particularly in women, there are developments in interventional techniques and equipment that allow even 8-F guides to be used radially (27,28). Therefore, although the particular challenges presented by CTO PCI may restrict a more universal use of radial arterial access, technique and equipment developments may facilitate greater use in the future.

Although acute coronary complications were similar between the femoral and radial cohorts, there

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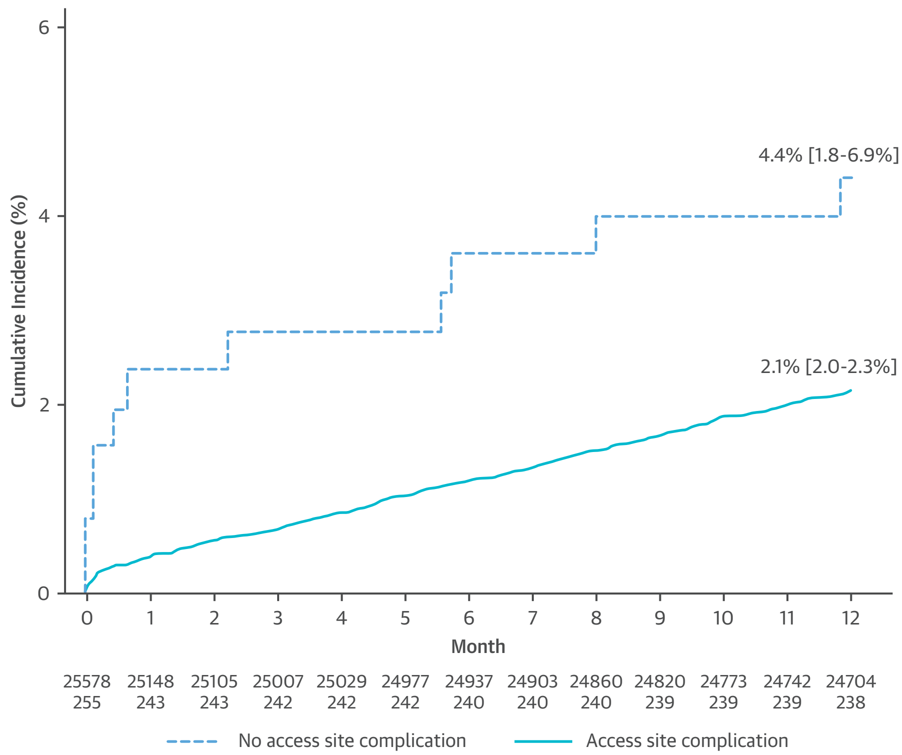
FIGURE 4 **Kaplan-Meier Plots for 12-Month Mortality by Femoral Access-Site Complication Status, Procedure Years 2006 to 2013 (p = 0.001)**



was a significant increase in access-site complications in the femoral cohort. This was associated with increases in transfusion, major bleeding, and short-term mortality. Indeed, a further analysis of outcomes of all patients with and without femoral access-site complications confirms the very significant adverse effect such an event has on outcomes. Patients experiencing access-site complications were 70 times more likely to receive transfusions and 17 times more likely to die in the first 30 days after the procedure than patients without access-site complications. The odds ratios of these relationships were significantly greater than in other studies, such as ACUITY (Acuity Catheterization and Urgent Intervention Triage Strategy) and may be due to the baseline bleeding risk being significantly higher because of an acute presentation and the use of potent anticoagulant agents such as glycoprotein inhibitors (29). Additionally, the mortality expected from any elective procedure without a major complication would be predicted to be extremely low. Therefore, the impact of such an event is especially important in an elective setting, and strategies to minimize access-site complications (aside from radial access), including routine fluoroscopic imaging and vascular ultrasound, may become more widely adopted (30).

STUDY LIMITATIONS. As with any database, the robustness of the conclusions is directly related to the quality of data entered. Although there are high levels of case ascertainment and field completion within the database, the accuracy of field completion for individual centers cannot be validated. Additionally, although the BCIS dataset records 113 variables, it does not record sheath size, anatomic data, and in particular J-CTO (Multicenter CTO Registry in Japan) score. Therefore, conclusions regarding guide catheter size and procedure complexity cannot be directly derived from the available data and can only be inferred from the devices used. Finally, because these data are registry derived, any conclusions are potentially influenced by unmeasured confounders inherent in observational studies of this nature. For example, the higher procedural success and lower MI rates associated with radial use may be a reflection of case selection bias rather than a true reflection of radial superiority over femoral access. Additionally, the lack of a significant increase of access-site complications observed with dual femoral puncture versus single femoral puncture might be explained by confounders such as center or referral bias.

CONCLUSIONS

Femoral artery access remains predominant during CTO PCI, with case complexity and device size associated with its use. Access-site complications were more frequent with femoral artery use and were strongly correlated with adverse outcomes.

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PERSPECTIVES

WHAT IS KNOWN? Access-site choice for PCI is a vital part of procedure planning and completion. Although many operators have switched to radial access, CTO PCI presents several challenges to access-site choice.

WHAT IS NEW? In the present study, we demonstrate that the femoral artery remains the default access site of choice even in the United Kingdom, where the majority of all PCI procedures are undertaken radially.

WHAT IS NEXT? Femoral artery use was associated with more complicated CTO procedures but also associated with more access-site complications. As in other studies, access-site complications were closely associated with adverse outcomes.

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KEY WORDS access choice, chronic total occlusion, complications, national database, percutaneous coronary intervention

APPENDIX For supplemental tables and a figure, please see the online version of this article.