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Assessment of the patency of the proximal and distal radial artery access after percutaneous coronary intervention

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Abstract
Background: Compared to trans-femoral access (TFA), trans-radial access (TRA) decreased mortality in the 1990s. It became common practice to use proximal radial access (PRA), which is 2-3 cm above the styloid: Radial artery occlusion (RAO) (no pulse + no Doppler), hematoma, and spasm. Although RAO is frequently asymptomatic, it poses a risk of ischemia and restricts future access. Patency is frequently not evaluated after the surgery. Usability of the ulnar artery is impacted by RAO. Due to fewer difficulties than PRA, distal radial artery access (DRA) is increasingly preferred. Assessing the proximal and DRA patency following percutaneous coronary intervention was the goal of this study.
Methods: 200 patients who were referred for coronary angiography with potential percutaneous coronary intervention (PCI) via radial artery access were the subjects of this prospective study. Additionally, patients were split into two equal groups: Group I received PCI or coronary angiography (CAG) by proximal radial artery access, and Group II received PCI or CAG via DRA.
Results: Overall complication rates, procedural success, and baseline characteristics did not significantly differ between the two groups. However, Group I suffered more radial artery spasm, RAO, and access-site pain, and their first-attempt puncture success was higher, but their hemostasis duration was longer. Group II needed more second tries but had quicker cannulation and hemostasis times. In both groups, patient satisfaction was excellent and comparable.
Conclusions: Distal radial access offers a promising alternative to proximal access in coronary procedures, with notable benefits, though wider adoption requires overcoming technical challenges and further validation through large-scale studies.

Keywords: Assessment, patency, proximal radial artery, distal radial artery

Introduction
For decades, researchers have focused on the location of arterial access for coronary angiography (CAG) and intervention since it is the cause of serious problems, particularly bleeding [1].
Developed in the early 1990s, the trans-radial access (TRA) has demonstrated lower mortality over time in comparison to the trans-femoral access (TFA) [2]. The radial artery is often punctured on the lower forearm 2-3 cm from the styloid process of the radius proximal radial access (PRA). However, the proximal or conventional TRA has numerous drawbacks, such as radial artery blockage, hemorrhage, and radial artery spasm [3].
Radial artery occlusion (RAO) is characterized by the loss of palpable radial pulsations along with the absence of forward blood flow on Doppler evaluation [4]. In some cases, RAO can progress to a permanent blockage of the vessel [5]. Despite this, the condition often remains unnoticed due to the hand's dual arterial circulation, which usually preserves perfusion [5]. Consequently, more than half of operators using the trans-radial approach fail to check radial artery patency before patient discharge. Nevertheless, RAO should not be underestimated, as cases of hand ischemia secondary to this complication have been reported. Moreover, once the artery becomes obstructed, it can no longer serve as an entry site for future catheterization or as a graft for coronary bypass surgery [5]. Importantly, RAO also eliminates the option of using the ipsilateral ulnar artery, since attempting cannulation there could jeopardize hand viability [6].

More recently, distal radial artery access (DRA) has gained attention as an alternative. This method offers multiple advantages over proximal radial access (PRA), particularly in lowering the risk of local vascular complications [7].

Patients and Methods

200 patients who were referred for coronary angiography with the possibility of percutaneous coronary intervention (PCI) via radial artery access were the subjects of this prospective study.

After receiving approval from the Tanta University Faculty of Medicine's Ethical Committee, this study was conducted between April 2024 and April 2025 in Tanta, Egypt. Every patient gave their signed, informed consent.

Patients who had previously undergone radial access angiography, acute coronary syndrome, cardiogenic shock, CABG with radial grafts, chronic renal failure, arteriovenous fistula, peripheral vascular disease (such as Raynaud disease), or any arm or forearm bone deformity were excluded.

Additionally, the patients were split into two equal groups: Group I received CAG or PCI by proximal radial artery access, and Group II received PCI or CAG via DRA.

A complete history, a comprehensive clinical examination, a general examination (including measuring arterial blood pressure and heart rate with particular attention to signs suggestive of coronary artery disease (CAD), a local cardiac examination, a local examination of the radial artery, and laboratory testing (including a complete blood count, kidney function tests (serum urea and creatinine), an international normalized ratio (INR), and post-procedural hemoglobin testing in patients with post-procedural bleeding) were all performed on each patient. Following the surgery, CAG was performed with potential PCI and good vascular access site hemostasis.

Full clinical examination

[Arterial blood pressure, heart rate, local cardiac examination, local examination of the radial artery, with particular attention to indications suggestive of CAD, such as xanthelasma or congestive heart failure]. The patient should have their pulses closely examined, and their bilateral radial arteries should be palpated.

To ensure that the palm had sufficient collateral circulation, an Allen's test [8] was performed to confirm adequate collateral circulation. The palm was blanched by compressing both arteries, and after releasing the ulnar artery, normal color returning within 10 seconds indicated sufficient ulnar and palmar arch blood flow.

To eliminate the contribution of subjectivity to the Allen's test, the Barbeau's test [8] was used to minimize subjectivity in assessing collateral circulation. A pulse oximeter was placed on the ipsilateral thumb, and waveform changes were observed during simultaneous radial and ulnar compression. Upon release of the ulnar artery, the tracing was evaluated. Normal results required waveform recovery to baseline within 10 seconds. The finger oximeter, which gives information on the health of the hand's blood flow, can be worn by the patient during the process. Standard transthoracic echocardiography and a 12-lead ECG.

Echocardiographic assessment was performed using a GE Vivid Seven system with a 4-MHz phased array transducer and tissue Doppler imaging. Patients were examined in the partial left lateral decubitus position using both M-mode and modified Simpson's technique. Left ventricular systolic function was evaluated in parasternal long- and short-axis views. M-mode measurements of LV diameters, septal and posterior wall thickness were obtained, and ejection fraction was calculated using the Teichholz formula.

Teichholz EF = (LV end-diastolic dimension - LV end-systolic dimension) / LV end-diastolic dimension [9].

Radial artery ultrasound and Doppler evaluation

In all participants, the radial artery of the forearm and wrist was examined using ultrasound and Doppler techniques to determine blood flow, luminal diameter, and cross-sectional area. Assessments were carried out immediately before catheter insertion, as well as one day and one month following the procedure. These measurements were obtained with a Siemens® Acuson S2000 ultrasound system equipped with an 11-MHz linear probe.

Laboratory investigations

Baseline and follow-up laboratory tests included a complete blood count, renal function profile (serum urea and creatinine), and coagulation status using the international normalized ratio (INR). For patients who experienced bleeding after the intervention, hemoglobin levels were also re-evaluated.

Patient preparation

Before the procedure, patients were provided with full explanations of each step. The hand and forearm up to mid-length were thoroughly disinfected. In addition, the groin region was prepared in case femoral access became necessary, either because radial cannulation failed or mechanical circulatory support was required. The arm was then positioned in a way that was both comfortable for the patient and ergonomically suitable for the operator, facilitating a successful puncture and allowing the intervention to be extended if needed.

Puncture and cannulation: [10]

Group A PRA Protocol

- **Team Preparation:** Catheterization laboratory personnel received instruction on correct patient positioning and optimal setup for radial access procedures.
- **Right Radial Approach:** The patient's arm was kept alongside the body and stabilized on an adjustable arm board or splint. The operator positioned on the right side of the patient, with monitors arranged on the opposite side.
- **Left Radial Approach:** Chosen when the right subclavian artery was markedly tortuous or when angiography of the Left Internal Mammary Artery (LIMA) was required. The patient's arm was placed across the chest in a "Napoleonic" posture, and in some instances, the operator initially worked from the left side.
- **Patient Comfort:** Towels were used beneath the arm to enhance stability and comfort.
- **Sterile Preparation & Imaging Field:** The operative field extended from the radial styloid to approximately 4 cm proximally. Fluoroscopic imaging was arranged from the wrist to about 5 cm above the elbow, with

table height adjusted for ergonomic advantage to the operator.

- **Arterial Puncture:** Vascular access was achieved using a 20-gauge needle inserted 2-3 cm proximal to the styloid process at the site of maximum palpable pulse, followed by the insertion of a 6F sheath employing the Seldinger technique [10].

Group B (DRA)

Right DRA: The patient's right arm was arranged in a semi-pronated position to facilitate access.

Left DTRA: For the left side, the hand was placed across the torso in the direction of the right groin.

Hand Positioning: After proper sterilization and draping, the patient was asked to fold the thumb beneath the fingers while keeping the hand slightly abducted, thereby providing clear exposure of the distal radial artery.

Arterial Access: The artery was punctured at the anatomical snuffbox, proximal to the point of maximal pulsation, using a 20-gauge open needle inserted at a 45° angle until arterial backflow was observed. A small skin incision was then made, after which a 6F radial sheath was advanced into the vessel over a guidewire following the Seldinger technique [10].

Adjunctive pharmacological therapy

A "radial cocktail" should be administered expeditiously through the sidearm of the sheath to prevent vasospasm and thrombosis [11].

Radial Sheaths

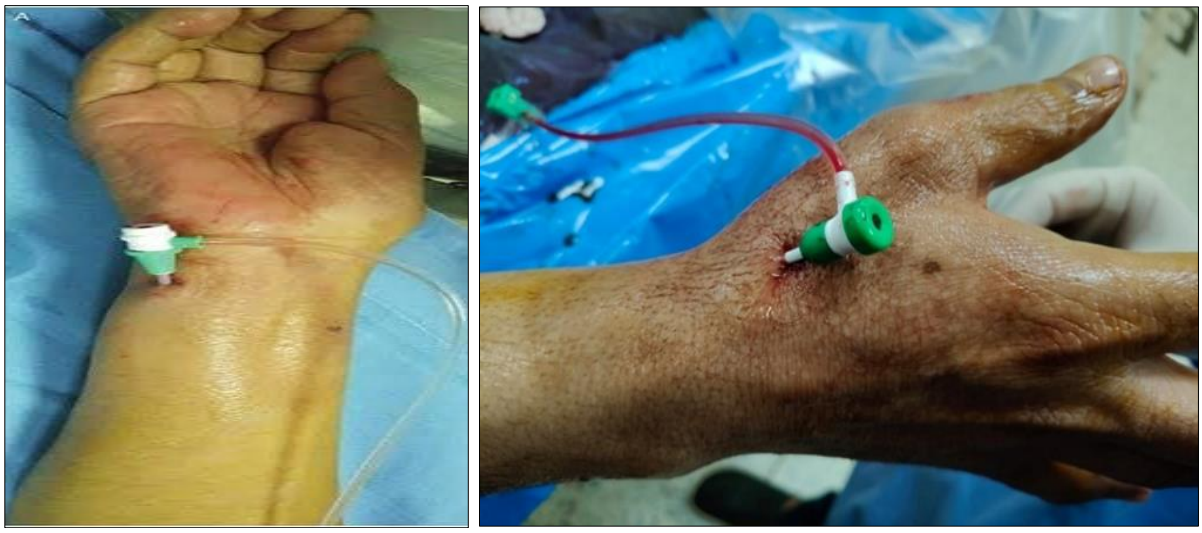
Sheath Characteristics

Commonly 5F/6F, 10-11 cm long. Hydrophilic coating, tapered tip, smooth dilator transition Size Selection: Chosen based on equipment needs.7F-8F radial-specific sheaths unavailable in Ultrasound (U.S).

For larger support, sheathless technique considered.

Insertion Technique: Sheath inserted over guidewire after needle/Angiocath removal. Aspirated and flushed with heparinized saline immediately.

After needle or Angiocath removal, sheath over the guidewire was inserted gently. Once in place, the sheath was aspirated and flushed with heparinized saline immediately. Figure 1.



(A) (B)

Fig 1: (A) Proximal radial artery sheath and (B) Distal radial artery sheath

TRA Wire and Catheter Manipulation

Appropriate guidewires and catheters were utilized to traverse the radial artery into the ascending aorta, followed by selective cannulation of both the right and left coronary arteries to carry out the intended intervention.

Wire Choice

For radial sheath placement, a micro-puncture guidewire (0.018-0.021 inch, 30-50 cm in length, floppy tip with a stiff shaft) was commonly employed.

Procedure

Once entry into the arterial lumen was confirmed, the needle angle was slightly lowered, and the wire was advanced carefully through the Angiocath or needle. The guidewire was gently advanced up to the elbow, ensuring unobstructed and smooth passage.

- **Warning sign:** Any resistance suggested possible diversion into a side branch or subintimal track.
- **Action:** If resistance occurred, advancement was stopped immediately, and the wire was withdrawn and redirected under fluoroscopic guidance.

Vascular Closure

At the end of the procedure, the radial sheath was withdrawn, and direct pressure was applied to the puncture site to secure haemostasis.

Haemostasis was maintained by manual compression, a compression band, or a tourniquet for approximately two hours.

Group A (PRA): The primary objective was to control bleeding while maintaining antegrade radial blood flow, achieving what is known as *patent haemostasis*.

Technique

A haemostatic device was applied (e.g., wrist compression band) then inflated just enough to stop surface bleeding.

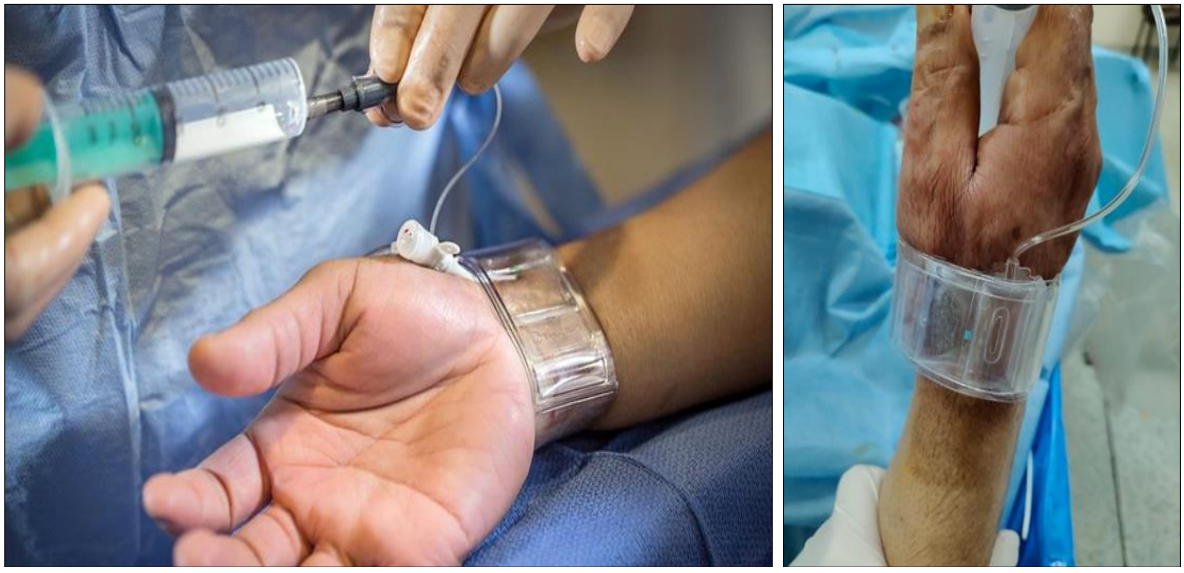
Gradually a haemostatic device was deflated until antegrade flow was confirmed, using plethysmography (pulse oximetry on ipsilateral thumb).

- **Aftercare:** Once the sheath was removed and the device was in place, the patient could sit up and ambulate immediately.
- **Compression duration:** Typically, 60-120 minutes, up to 4 hours if GP IIb/IIIa inhibitors are used and
- **Device removal:** Only after visual confirmation of haemostasis

Group B (DRA)

The preferred strategy after vascular access was patent haemostasis, in which bleeding was controlled without completely obstructing arterial circulation. Several techniques could be used to achieve this, including the application of gauze with an elastic bandage, TR-Band, pneumatic compression bands, or specialized devices tailored for distal radial access, such as the Prelude SYNC DISTAL. In most cases, haemostasis at the distal radial puncture site was accomplished within three hours. During compression, patients were able to move their wrists freely, which enhanced overall comfort.

Following sheath removal and application of the haemostatic device, patients were allowed to sit upright and walk immediately. The emphasis remained on maintaining patent haemostasis managing bleeding effectively while preserving antegrade blood flow. Different compression tools, ranging from simple bandages to purpose-designed distal radial devices, could be utilized. Generally, the process required only a few hours, during which mobility of the wrist was preserved, contributing to patient satisfaction and convenience. Figure 2.



(A) (B)

Fig 2: (A) Proximal radial artery haemostasis using a transparent wrist compression device and distal radial artery haemostasis using a transparent wrist compression device

Clinical Outcomes

Major adverse cardiac events (MACEs) were monitored, including death, recurrent myocardial infarction, and stroke. Bleeding complications were evaluated using the Bleeding Academic Research Consortium (BARC) criteria, while access site-related events such as radial artery occlusion, perforation, dissection, pseudoaneurysm, arteriovenous fistula, and persistent pain were carefully recorded. Hematomas were graded according to the modified EASY classification. Procedural success was defined as obtaining arterial access with successful puncture and completing the planned intervention, whereas procedural failure referred to the need for crossover to another access site due to unsuccessful puncture or cannulation, abandonment of the procedure because of complications, or inability to achieve revascularization of the target vessel. Total procedural time was measured from arterial puncture until the end of the procedure, including sheath removal in diagnostic angiography but excluding it in PCI cases. Radiation exposure was assessed by the dose area product (DAP), expressed in Gy·cm² as the product of radiation dose and the irradiated area. Cannulation performance was further evaluated by recording the time from wire advancement to sheath insertion, excluding the duration of local anesthesia, as well as the number of attempts required.

Follow-Up

Timing: Immediate and at 1-month post-procedure. Patency Assessment: Manual palpation, finger pulse oximetry, and arterial duplex for all patients.

The incidence of MACEs was reported: (Death, Recurrent myocardial infarction, Stroke,) Bleeding: Bleeding was valuated according to BARC scale [12], Vascular access site complication was noted: Radial artery occlusion, Hematoma was evaluated according to modified easy classification [13]. Perforation, Dissection. Pseudo-aneurysm, Persistent pain and A-V fistula.

Overall procedural success

Procedural success was described as achieving arterial puncture and completing the intended intervention. In contrast, procedural failure was defined as a composite outcome that included the requirement to switch to an alternative access site, either because the artery at the initial

entry site could not be punctured, the coronary artery could not be cannulated, or the planned percutaneous transluminal coronary angioplasty (PTCA) and stent deployment could not be carried out. Failure also encompassed major access site complications or an inability to complete the diagnostic coronary angiography.

Statistical analysis: Data were analyzed using SPSS v21. Continuous variables are reported as mean±SD and compared with Student's t-test or Mann-Whitney test; categorical variables are given as frequencies/percentages and compared with chi-square, Yates' correction, Fisher's exact test, or ORs. Significance was set at $p \leq 0.05$.

Results

In group I, 51.0% were females and 49.0% were males. While in group II, 30.0% were females and 70.0% were males with a significant difference regarding gender (p-value =0.0025). However, there was no significant difference between the two groups regarding age an in group I, 48.0% had DM, 70.0% had HTN, 60.0% had dyslipidaemia and 48.0% were smokers. While in group II, 58.0% had DM, 50.0%had HTN, 54.0%had dyslipidaemia and 57.0%were smokers. There was a significant difference between two groups regarding HTN (p. value =0.006) while there was no significant difference regarding; DM, dyslipidaemia and smoking. Table 1.

Table 1: Comparison between two groups according to demographic data and the risk factors of the studied groups

Variable		Group I (n=100) p I (n=100)	Group II (n=100) (n=100)	P e
Sex	Male	49 (49%)	70 (70%)	0.0025*
	Female	51(51%)	30(30%)	
Age (years)		55.15± 9.488	53.42± 8.644	0.179
Risk Factors				
Smoking		48(48%)	57(57%)	0.257
DM		48(48%)	58(58%)	0.202
HTN		70(70%)	50(50%)	0.006*
Dyslipidemia		60(60%)	54(54%)	0.475

In group I, 10.0% underwent prior PCI, 3.0% underwent prior CABG. Meanwhile in group II, 20.0% underwent prior PCI, 7.0% underwent prior CABG. There was no significant difference regarding prior PCI and prior CABG. **Table 2**

Table 2: Distribution of the studied groups according to history of cardiac disease

Variable	Gr Group I Group I (n=100) I (n=100)	Group II Group II (n=100) (=100)	P P value
Prior PCI	10(10%)	20(20%)	0.089
Prior CABG	3(3%)	7(7%)	0.193

There was no significant difference regarding INR, Creatinine, HB and EF. Table 3

Table 3: Descriptive analysis of the studied groups according to laboratory data and ejection fraction

G Group I (n=100) I (n=100)	(n Group I (n=100) (n=100)			Group II (n=100)			P P
	Min. -Max.	Mean±SD.	Median (IQR)	Min. - Max.	Mean±SD.	Median (IQR)	
EF (%)	39.0- 72.0	54.8±7.61	56.0 (49.0-59.0)	37.0- 84.0	54.5±7.36	55.0 (49.0-59.0)	0.777
INR	0.70-1.4	1.1±0.15	1.1 (1.0-1.2)	0.80-1.3	1.1±0.12	1.1 (1.0-1.2)	1.000
Creatinine (mg/dl)	0.80-2.90	1.20±0.441	1.10 (1.00-1.48)	0.700-1.60	1.14±0.163	1.10 (1.00-1.20)	0.204
Hb (gm/dl)	8.60-15.2	11.7±1.27	11.9 (10.9-12.6)	7.50-14.7	11.6±1.45	11.7 (10.7-12.5)	0.604

There was a significant difference between the two studied groups regarding cannulation time (p- value =0.0038) while there was no significant difference regarding; procedure time, amount of dye and DAP, In group I, A successful procedure was reported in 97.0% of cases and three cases had to cross over to right femoral access meanwhile in group II, A successful procedure was reported in 93.0% of cases and four cases had to cross over to right conventional access and three cases had to cross over to right femoral access with no significant difference as regarding cross over required for both groups. Group I had a higher first-attempt puncture success (92% vs. 72%, $P = 0.0003$), while second attempts were more common in Group II (15% vs. 4%, $P = 0.012$). Third attempts were slightly higher in Group II (6% vs. 1%), but not significant. Coronary angiography rates (6% vs. 4%), simple PCI (89% vs. 90%), and complex PCI (5% vs. 6%) showed no significant differences. Hemostasis time was significantly longer in Group I (124.6±27.51 min vs. 107.9±13.85 min, $P = 0.0001$).Table4

Table 4: Comparison between the two groups studied according to procedure time, cannulation time, amount of dye and total DAP, successful procedure, number of attempts and crossover required, procedure outcome and haemostasis

Variable		Group I (n=100)100)	Group II (n=100) II (n=100)	l P
Cannulation time (seconds)	Min. - Max.	13.0- 256	14.0- 307	0.0038*
	Mean±SD.	106± 51.1	130± 59.5	
Procedure time (minutes)	Min. - Max.	12.0-91.5	14.0-78.0	0.925
	Mean±SD.	36.8±17.2	36.6±12.6	
Amount of dye (ml)	Min. - Max.	30-280	45-230	0.42
	Mean±SD.	107±49	112±39	

Total DAP (Gy.cm²)	Min. - Max.	35.0-220	30.0-190	0.3064
	Mean±SD.	109±36.7	113±33.7	
Successful procedure		97(97%)	93(93%)	0.34
Number of attempts	1 attempt	92(92%)	72(72%)	0.0003*
	2 attempts	4(4%)	15(15%)	0.012*
	3 attempts	1(1%)	6(6%)	0.12
Cross over required		3(3%)	7(7%)	0.34
Procedure outcome				
Coronary angiography		6(6%)	4(4%)	0.75
Simple PCI		89(89%)	90(90%)	1.00
Complex PCI		5(5%)	6(6%)	1.00
Time for haemostasis (min)	Min. - Max.	89.0-190.0	80.0-150.0	0.0001*
	Mean±SD.	124.6±27.51	107.9±13.85	

No significant differences were found between the two groups regarding overall hematoma, bleeding, vascular, or non-vascular complications. However, RAO occurred significantly more often in group I (p=0.05). Radial artery spasm was also higher in group I (12% vs. 1%, p=0.05), as was persistent access-site pain (p=0.05). Patient satisfaction was similar between groups (88% vs. 92%, not significant). Table5

Table 5: Comparison between the two studied groups according to hematoma, bleeding incidence, vascular complication, radial artery spasm, persistent pain and patient satisfaction

		Group I (n=100) n=100) 100	**Group II (n=100) I (n=100)**	**v l P**
Haematoma		10(%)	8(8%)	
Haematoma I a	G1	0(0%)	3(3%)	
	G2	0(0%)	2(2%)	
	G3	0(0%)	1(1%)	
	G4	0(0%)	1(1%)	0.8048
Haematoma IB		4(4%)	1(1%)	
Haematoma II		3(3%)	0(0%)	
Haematoma III		2(2%)	0(0%)	
Haematoma IV		1(1%)	0(0%)	
Bleeding incidence				
BARC type I bleeding		3(3%)	3(3%)	0.999
BARC type II bleeding		2(2%)	0(0%)	0.4975
BARC type III bleeding		0(0%)	0(%)	0.999
BARC type IV bleeding		0(%)	0(0%)	0.999
Vascular complication				
Major vascular complications		1(1%)	0(0%)	0.9999
Minor vascular complications		2(2%)	1(1%)	0.9999
Major access-related non-vascular complications		0(0%)	0(0%)	0.9999
Minor access-related non-vascular complications		0(0%)	0(0%)	0.9999
Radial artery occlusion		13(13%)	3(%)	0.05*
Radial artery spasm		12(12%)	1(1%)	0.05*
Persistent pain		12(12%)	3(3%)	0.05*
Patient Satisfaction		88(88%)	92(92%)	0.4795

Discussion

Cardiac catheterization has undergone significant advancements since its first application in [14]. CAG procedures have been improved by advances in technology and anatomical knowledge of the circulatory system. Finding the best arterial access site for various patient characteristics and clinical circumstances has been the subject of extensive research. Despite providing comparatively easy access, the femoral artery has been linked to greater rates of bleeding and vascular problems, especially when used in conjunction with antiplatelet and anticoagulant medication, which raises morbidity, mortality, and lengthens hospital admissions [15].

Prior PCI was more common in group II of the current investigation than in group I, while the difference was not statistically significant (p-value=0.089). Similarly, 7% of patients in Group II reported having had CABG previously, compared to 3% in Group I (p-value=0.193). These results indicated a tendency for patients undergoing distal radial access to have a greater prevalence of prior cardiac procedures, which may be due to operator preference or patient selection factors that favor distal access in patients with complicated cardiac histories.

This observation aligns with the findings of the dipra study. They reported comparable rates of prior PCI and CABG between distal and PRA groups, indicating that distal radial access is a viable option even in patients with a history of significant cardiac interventions [10].

In the present study, the mean cannulation time was significantly shorter in group I compared to in group II. This may suggest that cannulation via the proximal radial artery may be more time efficient.

This finding came in accordance with the study conducted by Kiemeneij *et al.* [16] who stated that the distal radial artery might be more difficult to cannulate because of its smaller diameter and more tortuosity, which could result in lengthier access times.

Regarding the total procedure time, the current study found no significant difference between the two groups. The mean procedure time was 36.8±17.2 minutes for group I and 36.6±12.6 minutes for group II. This may indicate that, despite the longer cannulation time observed in the distal radial group, the overall procedure duration remains comparable between the two access sites.

The current results align with those of the TENDERA trial, which showed that although distal radial access can prolong puncture time, the overall duration of the procedure remains comparable to that of proximal radial access (PRA) [11].

Regarding the use of contrast dye, this study found a slightly greater average volume in group II than in group I, but the difference did not reach statistical significance. This implies that the selected access route may have little to no effect on the total contrast medium required during PCI.

These observations are consistent with Achim *et al.*, [17] who also found no meaningful variation in contrast volume between distal and proximal radial techniques.

In the same way, radiation exposure, assessed by the dose-area product (DAP), showed no significant disparity between groups. Group I recorded a mean DAP of 109±36.7 Gy·cm², compared to 113±33.7 Gy·cm² in group II, reinforcing that the access site has minimal influence on radiation exposure during the procedure.

The current results align with the outcomes of the DISCO radial trial, which also demonstrated that radiation exposure did not significantly differ between distal and proximal radial access during coronary interventions [18].

In terms of overall procedural success, both groups achieved very high rates: 97% in group I compared to 93% in group II, a difference that did not reach statistical significance (p=0.34).

This observation supports earlier reports that documented excellent success rates for both access strategies. Notably, a large-scale prospective cohort reported a 97.4% success rate with distal radial access, confirming its practicality in daily practice [18].

Furthermore, evidence from a meta-analysis conducted by Biondi-Zoccai *et al.*, [19] which included 3,210 patients, showed that the left radial approach outperformed the right in terms of reducing access site failure that necessitated crossover to femoral access.

In the present study, the spectrum of procedures was evenly distributed between the two groups. Diagnostic coronary angiography was carried out in 6% of group I versus 4% of group II; straightforward PCI in 89% of group I compared with 90% of group II; and complex PCI in 5% of group I against 6% of group II. None of these variations were statistically significant, suggesting that either access site is equally suitable for diverse coronary procedures.

This finding was in agreement with the results of the dipra study. They reported similar procedural success rates between DRA and PRA groups (96.7% and 98%, respectively) (p- value=0.72) [21]. The study concluded that DRA is a safe and effective alternative to PRA for cardiac catheterization and interventions, with no significant differences in procedural outcomes [17].

The present study came in agreement with previous studies suggested that both proximal and DRA routes are equally effective for CAG and PCI procedures, including complex interventions. Therefore the choice of access site can thus be tailored based on patient anatomy, operator experience, and other clinical considerations without compromising procedural success [22].

In the present study, the mean time to achieve haemostasis was significantly shorter in group II compared to group I. This finding may indicate that DRA facilitates quicker haemostasis following PCI.

This observation was in agreement with the results of a comprehensive meta-analysis by Koledinsky *et al.*, [17] which demonstrated that haemostasis occurred on average 66 minutes faster after DRA compared to PRA. The study suggested that the anatomical characteristics of the distal radial artery, such as its smaller diameter and superficial location, contribute to the reduced haemostasis time observed with DRA.

Additionally, a study by Sharma *et al.*, [23] found that DRA is associated with shorter haemostasis times and reduced RAO rates compared to PRA, further emphasizing the advantages of DRA in clinical practice.

In this study, the occurrence of access site hematomas was similar in both groups, with rates of 10% in group I and 8% in group II. Most of these hematomas were minor in nature, and there was no meaningful difference in their severity between the two groups.

These results are in line with earlier reports showing comparable hematoma frequencies between distal and proximal radial access. For example, Garg *et al.*, [24] documented a 10.7% rate of forearm hematoma after transradial coronary procedures, the majority of which were minor and resolved without requiring intervention. Likewise, a meta-analysis comparing distal and proximal radial access confirmed no significant variation in the incidence of hematomas affecting the forearm or hand between the two approaches [18].

Regarding bleeding outcomes based on the BARC classification, both groups demonstrated low and nearly identical complication rates. BARC type I bleeding was observed in 3% of cases in each group (p = 0.999). Type II bleeding occurred in 2% of patients in group I but was absent in group II (p = 0.4975). Importantly, no cases of more severe bleeding, such as BARC type III or V, were recorded in either group [25].

The present findings are consistent with results from the Korean prospective registry for evaluating the safety and efficacy of the distal radial approach (KODRA), a large-scale multicenter prospective trial that assessed the outcomes of DRA in patients undergoing PCI. That registry demonstrated no significant difference in DRA-related bleeding between high bleeding risk (HBR) and non-HBR groups, with no major bleeding events (BARC type III or higher) occurring in either population. Overall, access-site complications were infrequent, further confirming the safety of DRA across diverse patient groups [25].

Similarly, evidence from a comprehensive meta-analysis comparing distal and proximal radial access showed no significant difference in bleeding complications between the two techniques. This analysis, which pooled data from 44 studies including 21,081 participants, concluded that both access routes are associated with a low risk of bleeding, thereby supporting the idea that the choice of access can be individualized according to patient characteristics and operator expertise without compromising safety [17].

In the current comparison between group I and group II for PCI, vascular complications were uncommon in both

groups. Major vascular complications occurred in 1% of patients in group I and were absent in group II, while minor vascular complications were noted in 2% of group I and 1% of group II. Importantly, there were no recorded non-vascular access-related complications in either group. These observations highlight that both proximal and distal radial approaches are safe and carry a minimal risk of vascular events during PCI.

These findings align with prior investigations into the safety of distal radial access. Yamada *et al.*, [26] for example, reported a low rate of access-site complications among patients undergoing PCI for acute myocardial infarction via DRA. In that study, minor bleeding (BARC type II) was seen in 1.7% of cases, with no major bleeding complications, an RAO incidence of 1.1%, and only one patient experiencing a grade III hematoma. Their results further underscore the favorable safety profile of distal radial access across different clinical contexts [26].

In the present study we evaluated the patency of proximal versus DRA for PCI, we observed a significantly higher incidence of RAO in the PRA group (13%), compared to (3%) in the distal radial access group, with a p-value of 0.05. This finding underscored the potential advantage of distal radial access in preserving radial artery patency post-procedure.

This result came in agreement with previous studies that reported a lower incidence of RAO with distal radial access. For instance, a study by Didagelos *et al.*, [27] reported an overall RAO incidence of 9.5%, with a lower rate observed in patients undergoing PCI compared to diagnostic angiography alone. Additionally, a meta-analysis by Didagelos *et al.*, [27] found that distal radial access was associated with a reduced risk of RAO compared to proximal access [27].

Furthermore, a study by Al-Azizi *et al.*, [10] highlighted that distal radial access was a safe strategy for cardiac catheterization, with a low complication rate and no increased risk of hand dysfunction at 30 days. This supported the notion that the distal radial access not only reduced the risk of RAO but also maintained hand function, which was crucial for patient quality of life post-procedure.

In the current study comparing group I and group II, radial artery spasm occurred significantly more frequently in group I (12%) compared to group II (1%) with a p-value of 0.05. Similarly, persistent pain at the access site was reported by 12% of patients in group I versus only 3% in group II, also with a statistically significant difference (p-value = 0.05). These findings may suggest that distal radial access may be associated with a more favourable patient comfort profile and a lower incidence of vascular spasm during and after the procedure.

This study came in agreement with the findings reported by Aminian *et al.*, [18] who demonstrated in a multicentre prospective study that distal radial access resulted in significantly lower rates of radial artery spasm compared to proximal access, citing the anatomical advantage of the distal radial artery's smaller caliber and fewer surrounding nerve fibers, which may contribute to reduced spasm and discomfort during cannulation and sheath manipulation [28].

Moreover, another study by Vefali and Saracoglu [29] suggested that patients undergoing PCI via the distal radial artery reported significantly less post-procedural pain, attributing the difference to the less invasive nature of the snuffbox puncture and reduced tissue trauma.

In the present study, patient satisfaction was assessed following PCI via two different radial artery access sites: PRA and distal radial access. The results demonstrated high satisfaction rates in both groups, with 88% in group I and 92% in group II. The difference between the groups was not statistically significant (P- value = 0.4795), indicating comparable patient satisfaction across both access approaches.

This finding agreed well with the outcomes of a recent meta-analysis that evaluated the efficacy and safety of DRA compared to PRA for CAG and PCI. The study found that DRA significantly reduced the incidence of RAO and hematoma, and shortened haemostasis time, without compromising procedural success rates. These advantages may contribute to enhanced patient comfort and satisfaction, supporting the use of DRA as a viable alternative to PRA in PCI procedures [17].

Furthermore, a large prospective multicentre registry study by Lee *et al.*, [30] reported high success rates for CAG and PCI via DRA, with low complication rates. The study concluded that DRA is a safe and effective approach for coronary procedures, which may positively influence patient satisfaction.

This study limit single-centre design and small sample size limit the generalizability and statistical power of the findings. The non-randomized methodology introduces potential selection bias, as operator preferences and patient characteristics may have influenced the choice of access site. Additionally, the short-term follow-up prevents the evaluation of long-term outcomes.

Conclusions

Distal radial access is emerging as a safe and effective alternative to conventional PRA for coronary procedures. Its advantages such as reduced complication rates, preservation of the proximal radial artery, and improved patient outcomes make it an attractive option in modern interventional practice. However, its adoption is tempered by a steeper learning curve and technical challenges. To support its widespread implementation and establish standardized guidelines, further validation through large-scale, multicentre randomized trials is essential.

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