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Safety and feasibility of carotid artery stenting using a 6F guiding catheter via right distal radial artery access

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Abstract

Objective This study aimed to evaluate the safety and feasibility of carotid artery stenting (CAS) using a 6 F guiding catheter via right distal radial artery access.

Methods The clinical data of 32 patients who underwent internal carotid artery C1 stenting via right distal transradial artery access (rdTRA) at the Department of Cerebrovascular Diseases, Beijing Anzhen Hospital, between January 2022 and December 2023, were retrospectively analyzed. Parameters including puncture time, X-ray irradiation time, exposure dose, surgical success rate, surgery-related cardiovascular and cerebrovascular complications, puncture site complications, and postoperative radial artery patency were recorded and assessed.

Results The procedural success rate of CAS through rdTRA was 100% (32/32). The time from operating room entry to successful puncture ranged from 3 to 36 min, with an average time of 18.56 ± 7.63 min. X-ray exposure time ranged from 12 to 27 min, with an average time of 19.18 ± 4.77 min. One patient experienced a procedure-related transient ischemic attack postoperatively, while another developed bruising along the radial artery course on the third postoperative day. During an out-of-hospital follow-up period averaging 1 to 29 months (median: 5.4 ± 3.6 months), no cardiovascular or cerebrovascular events were reported. The radial pulse was palpable in all patients postoperatively and during the follow-up, with radial artery patency confirmed through patency testing.

Conclusion Carotid artery stenting through rdTRA using a 6 F guiding catheter is a safe and feasible approach, demonstrating high procedural success and minimal complications.

Keywords Carotid artery stenting, Distal radial artery access, Feasibility, 6F guiding catheter, Safety

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Introduction

The conventional approach for carotid artery stenting (CAS) typically involves the femoral artery, utilizing a 6–8 F guiding catheter [1]. In recent years, transradial access (TRA) has gained prominence in interventional procedures and has been associated with significant advancements in clinical practice [2, 3]. The application of TRA in neurointerventional diagnostics and treatment is also increasing [4–6], with CAS through TRA being recommended by relevant guidelines and consensus documents [1, 7]. However, conventional TRA (cTRA) has been associated with a relatively high incidence of radial artery occlusion [4, 7]. Consequently, distal radial artery access (dTRA) has emerged as a novel alternative and has garnered growing clinical attention, though studies on this technique remain limited both domestically and internationally [1].

In the past, a small-scale investigation on neurointerventional diagnosis and treatment via dTRA was conducted at this center [8]. On this basis, the sample size was further expanded in the past two years. This study aims to evaluate the feasibility and safety of performing CAS using a 6 F guiding catheter via right distal radial artery access (rdTRA). Key parameters, including puncture time, surgical success rate, X-ray irradiation time, puncture-related complications, and perioperative cardiovascular and cerebrovascular events, were systematically assessed.

Materials and methods

Research participants

This single-center retrospective study included patients diagnosed with severe stenosis at the beginning of the internal carotid artery, confirmed through cerebral angiography, who underwent CAS via rdTRA between January 2022 and December 2023 at the Department of Cerebrovascular Diseases, Beijing Anzhen Hospital, Capital Medical University. The surgeries were performed by an experienced neurointerventional physician with substantial expertise in TRA, completing no fewer than 100 cases annually, over the preceding two years.

All enrolled patients underwent rdTRA puncture followed by stenting at the beginning of the internal carotid artery. The study cohort comprised 32 patients, including 27 males and 5 females. Prior to the procedure, the diagnosis and treatment plan were exhaustively communicated to patients and their families, and written informed consent was obtained.

Inclusion and exclusion criteria

Inclusion criteria: (1) A negative result on the modified Allen test before surgery, or radial artery ultrasound indicating a radial artery diameter ≥ 2 mm.

(2) Preoperative ultrasound through ultrasound or carotid artery computed tomography angiography (CTA) confirming stenosis exceeding 70% at the origin of the internal carotid artery.

(3) Provision of preoperative informed consent with patients and their families being made completely aware of the interventional diagnostic and treatment procedures and their explicit request for CAS.

(4) Completion of preoperative carotid artery CTA or cerebral angiography.

Exclusion criteria: (1) A history of hand trauma or previous hand surgery.

(2) Documented anatomical variations of the arm.

(3) Use of the radial artery as a conduit for bypass grafting or dialysis.

(4) Patient preference for carotid endarterectomy.

(5) Inability to palpate distal radial artery or proximal radial artery.

(6) Cases where successful puncture through rdTRA was achieved, but establishing access was unsuccessful, necessitating a switch to the femoral artery approach for treatment.

Surgical methods

The puncture procedure was performed without ultrasound guidance. Preoperative evaluation included palpation of the bilateral proximal and distal radial arteries to assess pulse strength, arterial course, and thickness. Bilateral upper extremities vascular ultrasound was performed to evaluate the diameter of the radial artery.

The patient was positioned supine with the distal forearm slightly supinated (approximately 45°) and stabilized against the hip joint. The wrist was elevated using a sterile single pad to expose the puncture point. Local anesthesia was performed on the puncture site with 1 to 2 ml of 1% lidocaine. The radial artery needle was used to puncture the radial artery using the Seldinger technique, with access obtained via the Hoku or anatomical snuff box approach. Patients were informed about potential pain and provided with psychological preparation prior to puncture.

After the puncture needle entered the blood vessels, a 0.014 guidewire was inserted into the distal end, and a 6 F radial artery sheath (Terumo, USA, or APT, China) was inserted with constant rotational speed and the patient was instructed to breathe deeply. After the arterial sheath was successfully placed, 2000 IU of heparin was administered via the artery, and continuous positive pressure heparin saline was maintained throughout the procedure to prevent intraluminal thrombosis.

Under roadmap, a loach guidewire navigated the 5 F SIM catheter smoothly through the radial artery into the brachial artery. Whole-brain angiography was performed after the SIM catheter formed a loop in the descending

aorta. Subsequently, a V-18/V-14 × 300 cm guidewire, or a loach guidewire was introduced into the external carotid artery through the SIM catheter. After the SIM catheter was withdrawn, a 6 F guiding catheter was inserted through an exchange guidewire, and an embolic protection device was deployed through the 6 F guiding catheter.

A balloon of the corresponding size was inflated to achieve full expansion, followed by precise positioning and deployment of the stent. After the operation, the sheath was removed slowly and evenly, and the radial artery puncture site was continuously pressed. When no bleeding was observed, the gauze was used for compression, and an elastic bandage was applied in the shape of an "8". The elastic bandage was loosened hourly to monitor for hemostasis. If bleeding was controlled, the elastic bandage was removed 4–6 h following the procedure.

Table 1 Baseline characteristics

Item	Results
Demographics	47–77(66.34 ± 6.77)
Age (average age)	27(84.4%)
Male	5(15.6%)
Female	21.11–30.41(25.77 ± 2.71)
Clinical History	24(75.0%)
Smoking	16(50.0%)
Alcohol consumption	6(18.8%)
Cerebral infarction	25(78.1%)
Hypertension	15(46.9%)
Coronary heart disease	11(34.4%)
Diabetes mellitus	21(65.6%)
Hyperlipidemia	0(0.0%)
Atrial fibrillation	1(3.1%)
Peripheral vascular disease	
Laboratory examination	
Total protein (g/l)	7.14 ± 1.70
Albumin (g/L)	6.86 ± 12.88
WBC (10^9/L)	143.5 ± 14.76
RBC (10^{12}/L)	228.34 ± 72.24
Hb (g/L)	21.47 ± 10.42
PLT (10^9/L)	19.44 ± 6.00
AST (U/L)	66.72 ± 9.92
ALT (U/L)	46.85 ± 10.10
Creatinine (μmol/L)	78.86 ± 14.50
Uric acid (μmol/L)	340.43 ± 110.71
Glucose (mmol/L)	6.02 ± 2.03
Triacylglycerol (mmol/L)	1.70 ± 1.08
Total cholesterol (mmol/L)	3.70 ± 1.06
HDL-C (mmol/L)	0.95 ± 0.25
LDL-C (mmol/L)	2.08 ± 0.96
Homocysteine (μmol/L)	15.15 ± 4.68

WBC: white blood cells;
RBC: red blood cells;
Hb: hemoglobin;
PLT: platelets;
AST: aspartate aminotransferase;
ALT: alanine aminotransferase;
HDL-C: high-density lipoprotein cholesterol;
LDL-C: low-density lipoprotein cholesterol

Data collection

Data collected included demographic information (age, sex, and risk factors such as smoking, alcohol consumption, hypertension, diabetes mellitus, coronary heart disease, and hyperlipidemia) and clinical parameters. Clinical data encompassed puncture time, operation time, X-ray exposure time, total radiation dose, success rate of diagnostic vascular selection, surgical success rate, puncture complications, surgery-related ischemic complications, and radial artery patency assessments.

- **Puncture time**: Time elapsed from entry into the operating room to the commencement of X-ray exposure.
- **Surgical success**: The smooth passage of the embolic protection device through the stenosis and accurate placement of the stent.
- **X-ray exposure time and total radiation dose**: Obtained from the hospital information system (HIS).
- **Evaluation of radial artery patency**: Palpation of radial artery pulse 24 h after surgery and during the follow-up. Additionally, a finger oxygen saturation test was conducted by compressing both the radial and ulnar arteries until the oxygen saturation signal disappeared. Then, the radial artery is released as the ulnar artery continues to be compressed. Recovered oxygen saturation signal indicates radial artery patency (positive result).

Statistical analysis

Statistical analysis was performed using SPSS version 22.0 software (SPSS Inc., Chicago, IL, USA). Measurement data are expressed as mean ± standard deviation ($\overline{x} \pm s$). $P < 0.05$ was considered statistically significant.

Results

Demographic and clinical characteristics

The study included 32 participants, comprising 27 males (84.4%) and 5 females (15.6%), with an age range of 47 to 77 years (average age: 66.34 ± 6.77 years). The most prevalent risk factors were male sex (84.4%), hypertension (78.1%), smoking (75.0%), hyperlipidemia (65.6%), alcohol consumption (50.0%), coronary heart disease (46.9%), and a history of cerebral infarction (44.8%). Detailed demographic and clinical data are presented in Table 1.

Laboratory tests

The laboratory test results of the study cohort are summarized in Table 1.

Surgical data

All 32 patients underwent successful puncture through the right distal radial artery without the aid of ultrasound guidance. Cerebral angiography was performed in all cases before CAS, and the success rate was 100%.

Concurrent procedures performed included:

- Internal CAS combined with vertebral artery stenting in one patient.
- Internal CAS combined with intracranial segment CAS in one patient.
- Right internal CAS combined with left internal carotid artery balloon dilation in one patient.

A 6 F guiding catheter was used for all patients during the interventional procedures. Upon successful placement of the guiding catheter, an embolic protection device was inserted, followed by pre-dilation and subsequent stent placement. All patients underwent successful stent implantation. Among them, 3 cases (8.6%) were open-loop stents, and 29 (87.9%) were closed-loop stents. The surgical success rate was 100%.

The duration from operating room entry to successful puncture was (18.56 ± 7.63 min) (range: 3–36 min). The procedural time was (52.28 ± 12.85) minutes (range: 35–89 min). X-ray exposure time averaged 19.18 ± 4.77 min (range: 12–27 min), and the cumulative radiation dose was 585.00 ± 209.84 mGy (range: 121–1075 mGy). Details regarding the completion of interventional therapy are presented in Table 2.

Complication data

Among the cohort, one individual experienced bruising along the radial artery course on the third postoperative day. This condition resolved without specific treatment, and a follow-up clinical evaluation one month later confirmed a palpable radial artery pulse. Another individual developed a localized visual field defect within 24 h of the procedure, which improved following administration of neuroprotective therapy.

All 32 patients were followed up through telephone consultations, outpatient visits, and online communication, with a follow-up duration ranging from 1 to 29 months (mean: 5.4 ± 3.6 months). No cases of radial artery occlusion, puncture site ischemic events, or cardiovascular and cerebrovascular events were reported during the follow-up.

Table 2 Interventional therapy outcomes

Treatment completion	*N*(%)
Puncture situation	
RdTRA	32(100%)
Completion rate of imaging technique	*32*(100%)
Guidewire suspension technique:	
• Loach guidewire	3(25.9%)
• V-18 guidewire	20(56.9%)
• V-18 + V-14 double-suspension technology	9(17.2%)
Embolic protection devices:	
• FilterWire	11
• SpiderFX™ embolic protection device	6
• Emboshield NAV® embolic protection device	16
Stent Implantation Success Rate:	*32*(100%)
• RC1	24(75%)
• LC1	8(25%)
Stent diameter	
• 7 mm	29(87.9%)
• 8 mm	3(10.3%)
Interventional treatments	
• Open-loop stent	3(8.6%)
• Closed-loop stent	29(91.4%)

Discussion

At present, CAS via TRA has been recommended by relevant national and international guidelines and consensus. Previous studies have shown that radial artery puncture has a higher rate of radial artery occlusion [1, 7]. However, dTRA has shown promise in mitigating this complication compared to cTRA. Since dTRA is associated with shorter postoperative hemostasis time and a lower incidence of ischemic events, it is a promising new alternative [9–11]. At present, dTRA is mostly used in cerebral angiography in the neurointerventional field, and research on CAS via dTRA remains limited [12–14].

The success rate of puncture at the distal radial artery is lower than that at the proximal radial artery, and the learning curve for performing this procedure is steeper. Furthermore, the smaller diameter of the distal radial artery raises concerns about the suitability of conventional treatment equipment for neurointerventional procedures [15]. A 6 F guiding catheter, typically used for CAS through the proximal radial artery, is appropriate for placing stents with a diameter of 8 mm or less. The diameter of the internal carotid artery ranges from 3 to 6 mm, while the diameter of the common carotid artery is typically around 8 mm. Therefore, a stent with an 8 mm diameter can generally meet the clinical needs for most carotid artery stenosis.

Recent small-scale studies abroad have confirmed the feasibility and safety of using a 5 F guiding catheter for CAS through the distal radial artery [5]. Systematic reviews suggest that a 4- or 5-F catheter is commonly used for cerebral arteriography via dTRA, while a 6 F

catheter is typically used for treatment [6]. However, there are limited reports on the feasibility, safety, and surgical technique of using a 6 F catheter for CAS via dTRA.

The Chinese Expert Consensus on Coronary Interventional Diagnosis and Treatment through the Distal Radial Artery and the Expert Consensus on Neurointerventional Diagnosis and Treatment via the Transradial Access have reported that the diameter of the distal radial artery ranges from 1.7 ± 0.5 mm to 2.4 ± 0.5 mm [7, 16]. These guidelines suggest that the diameter of the distal radial artery can accommodate a 6 F radial artery sheath, a 7 F radial thin-walled sheath, or an 8 F unsheathed catheter for most patients. The pre-measure function of the CTA software was used to predict the distal and proximal diameters of carotid artery stenosis. If the preassessment indicates that a stent with a diameter of 8 mm or smaller is suitable, then dTRA could be considered a viable approach.

In this study, a 6 F radial sheath was used during the conventional operation process in the distal radial artery, and a 6 F guiding catheter was utilized for all cases. All patients underwent successful operations using the 6 F guiding catheter, with satisfactory stent placement, and no post-dilation was performed following stenting. The main advantage of rdTRA is that there is no need for strict braking after the operation, and patients can resume activities immediately, significantly reducing discomforts such as low back pain and urinary retention caused by prolonged bed rest or restricted limb movement. In addition, the puncture point of dTRA is located in the snuffbox area on the dorsal side of the wrist, away from the superficial palmar arch, which can preserve the blood flow of the proximal radial artery, thereby reducing the risk of postoperative radial artery occlusion. It is worth noting that for the radial artery in the snuffbox area with a thinner diameter (1.5–2.5 mm) and complex surrounding bony structures, precise positioning is required during puncture, and the technical requirements for the operator are relatively high. The mechanical characteristics of the reverse path result in a weak supporting force of the catheter, and it may face challenges of insufficient stability in complex interventional treatments (such as stent release or thrombus aspiration). For beginners, the steep learning curve and high failure rate of dTRA (especially in cases of slender or calcified blood vessels) are its main limiting factors.

One patient in this study developed a transient ischemic attack (3%), which is consistent with the incidence reported in other studies [3]. This aligns with the expected complication rates recommended by stroke prevention guidelines, which suggest that the rate should be less than 6% for symptomatic patients and less than 3% for asymptomatic patients. Among the 32 patients in this study, only one experienced bruising along the radial artery course, 24 h postoperatively. The follow-up period ranged from 1 to 29 months, with no occurrence of forearm hematoma, radial pulse weakening, or occlusion.

In this study, no complications of radial artery occlusion were observed after using 6 F Guiding via dTRA. This outcome may be attributed to the small sample size, the negative results of the modified Allen test in patients prior to surgery, or preoperative radial artery ultrasound indicating a radial artery diameter of ≥ 2 mm. Further large-scale studies and meta-analyses are needed to validate these findings and provide additional evidence.

This study employed three modalities for pathway establishment: loach guidewire guidance, 0.018-inch guidewire guidance, and a combination of 0.018-inch guidewire and 0.014-inch guidewire guidance. During the interventional treatment, for 25.9% of the patients, the loach guidewire was used to guide the guiding catheter into the right common carotid artery. Additionally, for 56.9% of the patients, the right common carotid artery was accessed using only the 0.018-inch guidewire. For cases where a sharp angle existed between the right common carotid artery and the subclavian artery, the catheter was advanced successfully using the double guidewire suspension technique, involving both 0.018-inch and 0.014-inch guidewires.

In this cohort, closed-loop stents were utilized in the majority of cases (75%), aligning with findings from previous studies suggesting that closed-loop stents are suitable for most clinical scenarios. These results support existing evidence regarding the applicability and effectiveness of closed-loop stents in CAS [17].

This study has the following limitations. Firstly, this study lacks a direct comparison with other access routes and does not have a control group with the proximal radial artery or femoral artery approach, which limits a comprehensive assessment of the advantages and disadvantages of rdTRA compared to other commonly used interventional treatment routes. Future studies should consider including these comparisons and even utilize historical control data to further explore the unique value of rdTRA. Secondly, the sample size is relatively small and the follow-up time is limited. Although the preliminary results of this study suggest a high surgical success rate and a low complication rate, due to the small number of participants and the short follow-up period, it is not sufficient to fully reveal all potential risks and long-term effects. Therefore, it is suggested that subsequent studies expand the sample size and extend the follow-up time to more accurately evaluate the effect of rdTRA. As a relatively new technique, the operational difficulty and learning curve of rdTRA have not been fully clarified. The surgeries in this study were performed by experienced neurointerventional physicians, which means that

beginners may need more time and practice to achieve similar success rates and safety standards.

Conclusion

This study demonstrates that CAS using a 6 F guiding catheter through rdTRA is a safe and feasible approach. These outcomes depend on proper patient screening, thorough preoperative and intraoperative evaluations, and the surgeon's experience in performing carotid angioplasty through the radial artery. Furthermore, this study provides a detailed summary of the surgical technique to serve as a reference for clinicians.

However, there are several limitations to this study which should be noted. First, the small sample size, limited follow-up time, and potential biases in data analysis constrain the generalizability of the findings. Future studies will aim to include a larger sample size and longer follow-up periods. Second, the study involved a limited number of surgeons, emphasizing the need for broader surgeon participation to validate the evaluation protocol. Third, further research comparing dTRA with alternative access routes is required to comprehensively confirm its efficacy and safety.

Author contributions

Conception and design of the research: Lifeng Wang Xu GuoAcquisition of data: Xia Ma Xiaofen He Zhe SongAnalysis and interpretation of the data: Lifeng Wang Xu Guo Xiaoping ZhangStatistical analysis: Xia Ma Xiaofen He Zhe Song Xiaoping ZhangWriting of the manuscript: Lifeng Wang Xiaoping ZhangCritical revision of the manuscript for intellectual content: Lifeng Wang Xu GuoAll authors read and approved the final draft.

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Data availability

The datasets used or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of Beijing Anzhen Hospital, Capital Medical University. This study was conducted in accordance with the declaration of Helsinki. Informed consent to participate was obtained from all of the participants in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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References

1. Naylor R, Rantner B, Ancetti S, de Borst GJ, De Carlo M, Halliday A, Kakkos SK, Markus HS, McCabe DJH, Sillesen H, van den Berg JC, Vega de Ceniga M, Venermo MA, Vermassen FEG, ESVS Guidelines Committee. Editor's Choice 2023 European society for vascular surgery (ESVS) 2023 clinical practice guidelines on the management of atherosclerotic carotid and vertebral artery disease. Eur J Vasc Endovasc Surg 65 1 7–111 https://doi.org/10.1016/j.ejvs.2022.04.011 Epub 2022 May 20. PMID: 35598721.
2. Mizuguchi Y, Izumikawa T, Hashimoto S, Yamada T, Taniguchi N, Nakajima S, Hata T, Takahashi A. Efficacy and safety of the distal transradial approach in coronary angiography and percutaneous coronary intervention: a Japanese multicenter experience. Cardiovasc Interv Ther. 2020;35(2):162–7. https://doi.org/10.1007/s12928-019-00590-0. Epub 2019 May 24. PMID: 31127474.
3. Park SE, Cho SB, Baek HJ, Moon JI, Ryu KH, Ha JY, Lee S, Won J, Ahn JH, Kim R, Choi SY. Clinical experience with distal transradial access for endovascular treatment of various noncoronary interventions in a multicenter study. PLoS ONE. 2020;15(8):e0237798. https://doi.org/10.1371/journal.pone.0237798. PMID: 32822396; PMCID: PMC7444561.
4. Montorsi P, Cortese B, Cernetti C, Lanzellotti D, Di Palma G, Marchese A, Cremonesi A. Transradial approach for carotid artery stenting: A position paper from the Italian society of interventional cardiology (SICI-GISE). Catheter Cardiovasc Interv. 2021;97(7):1440–51. https://doi.org/10.1002/ccd.29677. Epub 2021 Apr 12. PMID: 33844439.
5. Di Gioia G, Salemme L, Ferrone M, Cioppa A, Popusoi G, Pucciarelli A, Verdoliva S, Franzese M, Marga S, Barbato E, Tesorio T. Carotid artery stenting using Five-French distal radial vascular access. Diagnostics (Basel). 2023;13(7):1266. https://doi.org/10.3390/diagnostics13071266. PMID: 37046483; PMCID: PMC10093593.
6. Joshi KC, Beer-Furlan A, Crowley RW, Chen M, Munich SA. Transradial approach for neurointerventions: a systematic review of the literature. J Neurointerv Surg. 2020;12(9):886–92. https://doi.org/10.1136/neurintsurg-2019-015764. Epub 2020 Mar 9. PMID: 32152185; PMCID: PMC7476364.
7. ZHANG X, FANG Y B, YANG Z G. Comparative interpretation of expert consensuses on the transradial access for neurointerventional diagnosis and treatment. Chin J Clin Med. 2024;31(1):50–5. https://doi.org/10.12025/j.issn.1008-6358.2024.20240192.
8. Xiaofen HE, Xu GUO, Chengzhe FAN, Yudong MA, Nan ZHANG, Lei YU, Lifeng WANG. The safety and feasibility of neurointerventional diagnosis and treatment via distal transradial access. J Interventional Radiol 2022 31 10:954–7. https://doi.org/10.3969/j.issn.1008-794X.2022.10.003
9. Eid-Lidt G, Rivera RodríguezA, Jimenez Castellanos J, Farjat Pasos JI, Estrada López KE, Gaspar J. Distal Radial Artery Approach to Prevent Radial Artery Occlusion Trial. JACC Cardiovasc Interv. 2021;14(4):378–385. https://doi.org/10.1016/j.jcin.2020.10.013. PMID: 33602433.
10. Aminian A, Sgueglia GA, Wiemer M, Kefer J, Gasparini GL, Ruzsa Z, van Leeuwen MAH, Ungureanu C, Leibundgut G, Vandeloo B, Kedev S, Bernat I, Ratib K, Iglesias JF, Al Hage E, Posteraro GA, Pascut D, Maes F, Regazzoli D, Kakonyi K, Meijers TA, Colletti G, Krivoshei L, Lochy S, Zafirovska B, Horák D, Nolan J, Degrauwe S, Tobita K, Saito S. Distal versus conventional radial access for coronary angiography and intervention: the DISCO RADIAL trial. JACC Cardiovasc Interv. 2022;15(12):1191–201. https://doi.org/10.1016/j.jcin.2022.04.032. Epub 2022 May 17. PMID: 35595673.
11. Ferrante G, Condello F, Rao SV, Maurina M, Jolly S, Stefanini GG, Reimers B, Condorelli G, Lefèvre T, Pancholy SB, Bertrand O, Valgimigli M. Distal vs Conventional Radial Access for Coronary Angiography and/or Intervention: A Meta-Analysis of Randomized Trials. JACC Cardiovasc Interv. 2022;15(22):2297–2311. https://doi.org/10.1016/j.jcin.2022.09.006. PMID: 36423974.
12. Wang J, Ma L, Cai H, Zeng H, Pei F, Cao J, Li M, Cao G. Distal radial access for neuroangiography and neurointerventions: systematic review and meta-analysis. BMC Neurol. 2023;23(1):405. https://doi.org/10.1186/s12883-023-03416-y. PMID: 37968640; PMCID: PMC10648363.
13. Chalouhi N, Sweid A, Al Saiegh F, Sajja KC, Schmidt RF, Avery MB, Mouchtouris N, Khanna O, Weinberg JH, Romo V, Tjoumakaris S, Gooch MR, Herial N, Rosenwasser RH, Jabbour P. Feasibility and initial experience of left radial approach for diagnostic neuroangiography. Sci Rep. 2021;11(1):1089. https://doi.org/10.1038/s41598-020-80064-z. PMID: 33441762; PMCID: PMC7806974.
14. Orscelik A, Senol YC, Kobeissi H, Ghozy S, Bilgin C, Arul S, Kadirvel R, Brinjikji W, Kallmes DF. Distal versus conventional transradial access for diagnostic cerebral angiography and neurointerventional procedures: A systematic review and meta-analysis. Interv Neuroradiol. 2023 Nov 7:15910199231210411. doi: 10.1177/15910199231210411. Epub ahead of print. PMID: 37936400.
15. Hoffman H, Bunch KM, Mikhailova T, Cote JR, Ashok Kumar A, Masoud HE, Gould GC. Transition from proximal to distal radial access for diagnostic cerebral angiography: learning curve analysis. World Neurosurg.

2021;152:e484–91. https://doi.org/10.1016/j.wneu.2021.05.125. Epub 2021 Jun 16. PMID: 34098135.
16. Consensus of Chinese Experts on Coronary interventional Diagnosis and Treatment via Distal Radial Artery, Thumb Club. Consensus of Chinese experts on coronary interventional diagnosis and treatment via distal radial artery. Chin J Intervent Cardiol 2020,28: 12:667–74.
17. Kühn AL, Singh J, Moholkar VM, Satti SR, Rodrigues KM, Massari F, Gounis MJ, McGowan A, Puri AS. Distal radial artery (snuffbox) access for carotid artery stenting - Technical pearls and procedural set-up. Interv Neuroradiol. 2021;27(2):241–8. Epub 2020 Sep 13. PMID: 32924692; PMCID: PMC8050532.

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