# Retrograde tibiopedal access as an alternative procedural technique for genicular artery embolization

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## ABSTRACT

**Objective:** The aim of this study is to assess the feasibility, safety, and technical outcomes of genicular artery embolization (GAE) performed via retrograde tibiopedal access.

**Materials and Methods:** GAE was performed in 357 patients utilizing tibiopedal access. Patient eligibility was determined through a comprehensive clinical evaluation and radiographic imaging. Embolic agents were delivered through a microcatheter to the targeted arteries by an interventional cardiologist with an additional 1 year of fellowship training in endovascular medicine and certification from the American Board of Vascular Medicine. Technical success was defined as successful embolization of at least two genicular arteries, with subsequent resolution of arterial blush. Peri and post-procedural data and complications related to the access site were assessed.

**Results:** Technical success was obtained in 96.6% of cases. Patient ages ranged from 38 to 98 years, with body mass index ranging from 18.01 to 63.23 kg/m$^2$. Across this study cohort, 3.7 ± 1.0 genicular arteries were embolized, with a mean procedure time of 51.3 ± 13.0 minutes. Procedure time was measured from initial injection of lidocaine to application of hemostatic device. Results also show 25% improvement in average procedure duration after 50 cases, suggesting a brief learning curve for GAE. Post-procedural complications occurred in 4.5% of cases (n = 16) and were associated only with minor, transient side effects.

**Conclusions:** GAE via tibiopedal access offers a viable alternative to the conventional femoral approach reported in recent literature. In this study, retrograde access consistently enabled successful completion of GAE without notable discrepancies in treatment efficacy or safety. This approach resulted in a high technical success rate with no significant complications. Study findings support the potential for widespread adoption of the retrograde approach for treating osteoarthritis with GAE, particularly in patients in whom an antegrade approach may pose a higher risk of complications. (JVS-Vascular Insights 2026;4:100339.)

**Keywords:** Artery; Blush; Embolization; Osteoarthritis

Traditionally regarded as a progressive wear-and-tear of articular cartilage, osteoarthritis (OA) is one of the most common joint diseases in adults worldwide.[1,2] As of 2020, an estimated 528 million people worldwide are living with OA, with knee OA accounting for an estimated 365 million cases.[3] The United States alone accounts for about 33 million total cases of OA.[4] Treatments for knee OA typically include pain medications, steroid injections, physical therapy, braces, and/or surgical interventions such as total knee arthroplasty (TKA).[5]

Recent studies indicate that angiogenesis contributes to synovitis in patients with OA.[6,7] Evidence from recent literature suggests OA may be heavily influenced by this inflammation of the synovium, rather than sole progressive deterioration of articular cartilage.[8–12] In light of this pathology, genicular artery embolization (GAE) has emerged as an alternative treatment for knee OA by directly targeting inflammation of the synovium.[5,13] There are typically six genicular arteries that supply the synovium: the inferior lateral, inferior medial, superior lateral, superior medial, descending, and anterior tibial recurrent genicular arteries.[7] Branches of these arteries are selectively targeted and embolized in this procedure.[9] GAE can be used either as an adjunct to standard

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care or when patients continue to experience pain despite treatment.[5,10,12]

The conventional approach for GAE involves common or superficial femoral artery access, which can predispose patients to complications from access site bleeding, such as hematomas, pseudoaneurysms, and arteriovenous fistulas.[14,15] As such, retrograde tibiopedal access has emerged as an option that may reduce complications and enhance procedural efficiency. This technique is widely adopted across various endovascular procedures in treating occlusive peripheral artery disease.[16,17] However, there is a paucity of research on this method, suggesting this approach is underutilized. The current study presents a large-scale feasibility analysis of GAE via retrograde tibiopedal access to assess its procedural utility for this treatment.

## ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center, prospective, observational study
- **Key Findings:** Among 357 patients undergoing genicular artery embolization, technical success was 97%, with an average of four arteries embolized, 51-minute procedure time, and a 5% complication rate. Procedure time improved by 25% after the first 50 cases.
- **Take Home Message:** Tibiopedal arterial access is a safe, efficient technique for genicular artery embolization and may be particularly advantageous in patients at higher risk for femoral access complications, supporting broader adoption of retrograde tibiopedal access for knee osteoarthritis treatment.

## METHODS

This is a single-center prospective study with full Institutional Review Board approval (IRB: 20,241,915). Participants in the study were referred by primary care physicians, orthopaedic surgeons, and pain management clinics, or were self-referred. All patients were provided with informed consent forms prior to both the procedure and study enrollment. Patients who presented with complete tibial artery occlusions at the site of access were not selected for this approach. In these cases, a femoral approach was deemed more appropriate. Angioplasty was performed on patients with occlusive tibial disease to provide a route to the genicular arteries.

Patients presented consecutively with chronic OA-related knee pain that could not be treated with standard of care, including pain medications, steroid injections, physical therapy, and/or TKA. Eligibility for this procedure was determined through a comprehensive clinical evaluation and radiographic imaging. Severity of OA was determined using the Kellgren-Lawrence (KL) classification system; patients were classified as KL-2, KL-3, or KL-4, with KL-2 indicating mild OA and KL-4 indicating severe OA. Patients who had undergone TKA yet experienced persistent knee pain unrelated to implant malalignment or degradation, as assessed by their referring orthopaedic physicians, were also eligible for GAE. Magnetic resonance imaging was referenced to confirm synovial involvement of knee pain in patients with chronic knee pain of uncertain etiology. Patients with severe structural damage to the knee resulting in malalignment of the femur and tibia, varus or valgus deformity (>10° medial or lateral angulation of the tibia relative to the femur, respectively), and meniscal or ligament tears were not eligible for GAE. Severity of pain was assessed via self-reported Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Visual Analog Scale (VAS) questionnaires.

All cases were performed by a board-certified interventional cardiologist with an additional 1 year of fellowship training in endovascular medicine and certification from the American Board of Vascular Medicine. Ultrasound-guided access was obtained in a retrograde manner via the distal anterior tibial artery (ATA), posterior tibial artery, or dorsalis pedis artery with a 4 Fr, 7 cm Prelude IDeal sheath (Merit Medical Systems). The ATA was primarily selected for access because of its streamlined route to the anterior tibial recurrent genicular artery, and easier hemostasis compared to the posterior tibial artery. A compressible segment of a tibial artery above the level of the ankle joint was selected for puncture, as identified by arterial duplex ultrasound. Selective popliteal angiography was then performed with a 4 Fr 65 cm RIM catheter to ascertain the anatomy of the genicular arteries and to account for anomalous vessel origins and branching.[18] Target genicular arteries were subselected with a 300 cm Fielder XT-R wire and 135 cm Caravel microcatheter (Asahi Intecc Medical). Then, 50 mcg nitroglycerin was injected, followed by a saline flush and contrast dye to demonstrate inflammatory capillary blush, indicating hypervascularization of the synovium supplied by genicular arteries.[9] All genicular arteries were attempted to be cannulated and were excluded only in cases of severe arterial disease. Arterial disease was considered significant when ostial disease precluded selective cannulation, or when the genicular arteries were severely and diffusely diseased. Branches supplying regions of synovium corresponding to areas of maximal pain on physical examination were especially targeted. Embolization was performed in genicular branches demonstrating abnormal periarticular hypervascular blush corresponding to the site of pain on angiography. Treatment was performed with 50-100 μm Embospheres (Merit Medical Systems), 100-300 μm Embospheres (Merit Medical Systems), 125-275 μm

**Table I.** Baseline demographic and characteristics of patients undergoing genicular artery embolization (n = 357)

| | Patient demographics | | |
|---|---|---|---|
| | Male | Female | Total |
| Number of patients | 129 | 228 | 357 |
| Body mass index, kg/m$^2$ | 31.5 ± 6.4 | 35.0 ± 8.7 | 33.7 ± 8.1 |
| Age, years | 68.5 ± 9.7 | 67.5 ± 10.7 | 67.9 ± 10.3 |
| Race/ethnicity | | | |
| White | 79 | 122 | 201 |
| Black | 25 | 70 | 95 |
| Asian | 7 | 17 | 24 |
| Hispanic | 2 | 2 | 4 |
| Other | 6 | 4 | 10 |
| Did not specify | 10 | 13 | 23 |

Data are presented as number or mean ± standard deviation.
All data was self-reported by each individual patient.

HydroPearl microspheres (Terumo Medical), and/or an embolic mixture prepared with 500 mg imipenem-cilastatin and 15 mL of 300 mg/mL contrast medium. Selection of embolic material and amount injected varied based on patient anatomy. Treatment continued until angiographic blush of the inflamed tissue was appropriately resolved as determined by the operator.[5,9] Patent hemostasis was obtained in all patients using a 26 cm Safeguard Radial device (Merit Medical Systems) and confirmed with duplex ultrasound. This hemostatic device is used as an off-label adaptation implemented by the clinic. Patients were discharged after 30 to 90 minutes of bed rest and were assessed for embolization-related complications immediately post-procedure and again at 4 weeks by physical examination and ultrasound. Patients were prescribed celecoxib 200 mg orally as needed for 7 days and a 6-day tapered course of oral methylprednisolone (Medrol Dosepak, 4 mg tablets) to assist with any post-procedural soreness. Technical success in this study was defined as embolization of at least two genicular artery branches, with subsequent abolition of arterial blush indicating procedural success.

## RESULTS

The study cohort consisted of 357 patients (129 male, 228 female). Ages ranged from 38 to 98 years, with body mass index ranging from 18.01 to 63.23 kg/m$^2$ (Table I). All patients had a diagnosis of OA and had previously attempted to relieve knee joint pain through conservative therapy and/or TKA. Pain relief was reported in 339 patients (95.0%) at the time of 4-week follow-up.

Post-procedural angiographic imaging demonstrated a reduction of arterial blush, indicating procedural success (Fig). A greater number of embolized arteries is associated with a more substantial reduction in arterial blush, which corresponds to a greater decrease in synovial inflammation.[9,12]

Across the 357 cases, the average procedure time was about 64.2 ± 23.1 minutes for the first 50 patients, and about 49.5 ± 13.2 minutes for the remaining 307. Procedure time was measured from injection of lidocaine immediately prior to obtaining arterial access, and confirmation of ultrasound-guided patent hemostasis with the Safeguard Radial hemostatic device. A total of 345 cases (96.6%) had technical success, with a mean of 3.7 ± 1.0 arteries embolized per patient. Cases of failure were seen when either angiography did not demonstrate significant arterial blush necessitating embolization of more than one artery, or when genicular arteries were severely diseased. Of note, 334 procedures (93.6%) utilized ATA access (Table II).

There were 16 instances of post-procedural complications at the access site in this study cohort (Table III). There were no major complications. Minor complications included small hematomas, skin irritation, numbness, or mild swelling. No patients required additional intervention or hospitalization for these symptoms, and complications were found to have resolved at the 4-week follow-up visit. Duplex ultrasound ruled out pseudoaneurysms or arteriovenous fistulas associated with tibiopedal access in all patients prior to discharge.

## DISCUSSION

The results of this study demonstrate that GAE performed through a retrograde tibiopedal approach is safe and effective, offering a feasible alternative to femoral access. Average procedure time was 51.3 ± 13.0, with a technical success rate of 96.6%. Notably, average procedure times for GAE decreased by 25% after the first 50 patients, with a 14.7-minute decrease in mean time. This suggests a steep learning curve for retrograde tibiopedal GAE.

The observed technical success rate underscores the reliability of accessing the genicular arteries via retrograde tibiopedal access. A previous study using similar

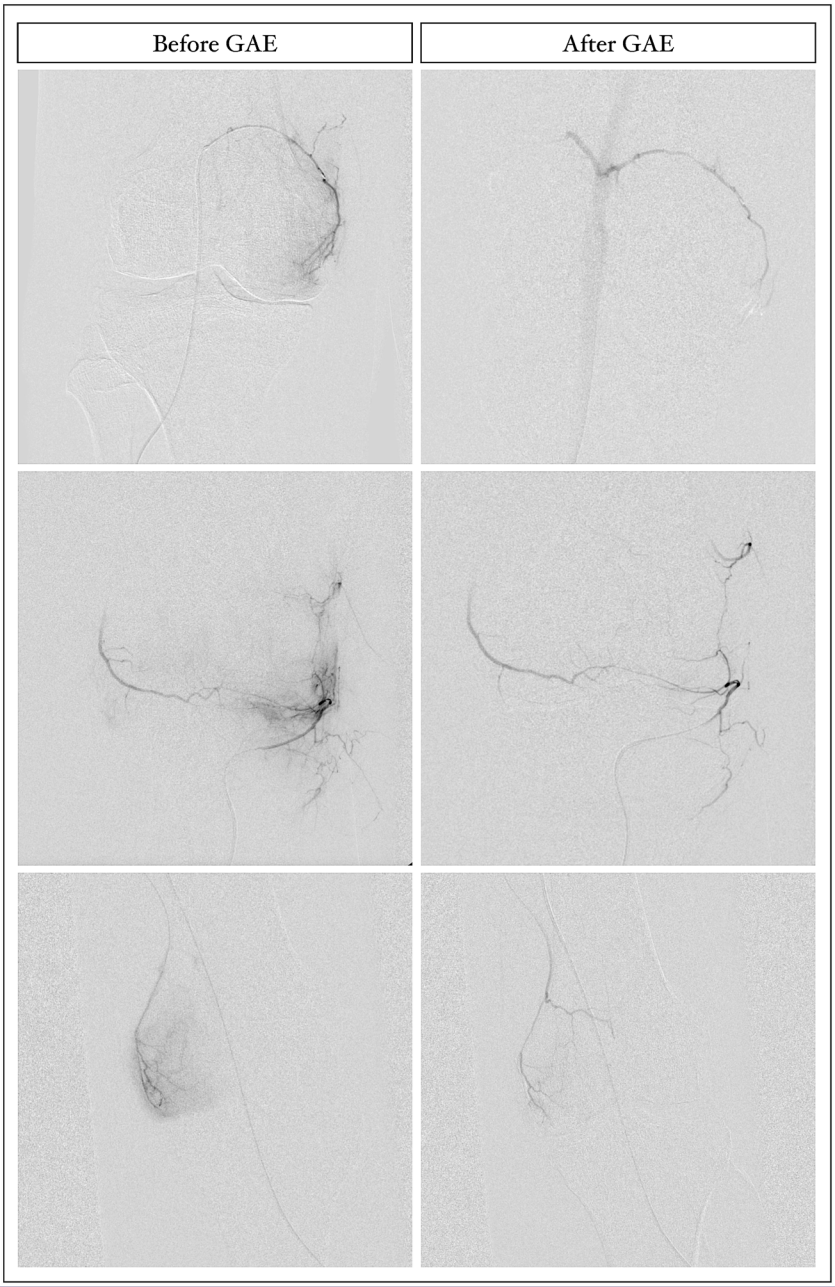


**Fig.** Pre- and post-procedural angiographic imaging depicting reduced arterial blush following embolization of genicular artery branches. Arteries depicted are as follows: right superior medial genicular artery (*top*), left inferior lateral genicular artery (*middle*), and right descending genicular artery (*bottom*).

procedural methods suggested femoral access to be a safer and faster treatment method than tibiopedal access.[19] However, the authors believe that tibiopedal access should not be dismissed for GAE. The present study offers a counterexample with a large sample size of 357 patients and an average of 3.7 arteries embolized per case. Retrograde tibiopedal access achieved a high degree of technical success, while avoiding the typical risk of complications associated with the conventional antegrade approach.

No clinically significant procedural complications were observed in this study. All patients were clinically assessed to ensure no distal ischemia immediately after embolization. Duplex scanning documented patent hemostasis at closure. Polyphasic waveforms with normal velocities were noted at the time of discharge and at the clinic visit 4 weeks post-intervention with a high-frequency ultrasound probe. The procedural complication rate was 4.5%. The complication rate of the tibiopedal access cases demonstrates the safety of this access

**Table II.** Technical information relating to the procedure, including mean arteries embolized, procedure duration, technical success rate, complications, and accessed artery in cases

| Intervention characteristics | |
|---|---|
| Technical success | 357 |
| Arteries embolized | 3.7 ± 1.0 |
| Procedure duration | 50.9 ± 15.4 |
| Complications | 16 |
| Access | |
| Anterior tibial artery | 334 |
| Posterior tibial artery | 20 |
| Dorsalis pedis artery | 3 |

Data are presented as number or mean ± standard deviation.

**Table III.** Frequency of procedural complications in the study cohort

| Procedural complications | |
|---|---|
| Skin irritation | 1 |
| Numbness | 2 |
| Swelling | 12 |
| Hematomas | 1 |
| Total | 16 |

Data are presented as number.

method. These findings are significant as endovascular interventions that utilize femoral access pose a higher risk of hemorrhagic complications associated with groin puncture, especially in patients with elevated body mass index or significant abdominal pannus.[15] The use of retrograde tibiopedal access in this study greatly mitigates these risks by avoiding large-vessel arteriotomy entirely, including risks associated with closure devices used in the femoral arteries.[20–22]

Differences in arterial blush and vascular anatomy among patients were qualitatively assessed using angiography. Cases with pronounced hypervascularity often correlate with successful embolization, associated with the reduction of inflammation in the synovium.[6,9,23] Technical success in this study was defined as embolization of at least two arteries. Of 357 procedures, 12 (3.4%) did not meet this threshold. In this case cohort, technical failures were not a result of the chosen access method, but rather variation in patient anatomy that altered the need for arterial embolization. Of the 12 cases, nine did not present significant blush with subselective angiography in more than one artery. The remaining three cases were attributed to hostile vascular anatomy, including diffusely diseased arteries and/or severely calcified ostial flow-limiting disease. Notably, there were no cases where zero vessels were embolized.

This study does not compare efficacy of tibiopedal access vs femoral access in GAE. As such, no conclusion can be made about which method to choose over another. Moreover, this study focuses solely on the viability of the seldom adopted retrograde approach for the GAE procedure and does not assess long-term patient outcomes or complications. Investigations that focus on post-procedure patient outcomes or discrepancies between access methods will help address these limitations.

## CONCLUSIONS

GAE performed via retrograde tibiopedal access consistently allowed for the successful completion of the procedural technique without any notable discrepancies in treatment efficacy. This approach achieved a technical success of 96.6% (n = 345) with no significant peri- or post-procedural complications. Study findings support the potential for widespread adoption of the retrograde approach in treating OA with GAE, particularly in patients in whom an antegrade approach may pose a higher risk of complications.

## AUTHOR CONTRIBUTIONS

Conception and design: NK, SR
Analysis and interpretation: NK, AN
Data collection: NK, SR
Writing the article: NK, AN
Critical revision of the article: NK, AN, SR
Final approval of the article: NK, AN, SR
Statistical analysis: Not applicable
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Overall responsibility: NK

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## DISCLOSURES

None.

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