

Patient Selection for Genicular Artery Embolization in Moderate Knee Osteoarthritis: A Case Report on the Role of Dynamic Contrast-Enhanced MRI

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Summary

Introduction. Osteoarthritis is a significant cause of disability worldwide. While most of the mild cases respond to conservative treatment and severe cases require surgery, managing mild to moderate osteoarthritis resistant to conservative treatment remains challenging. Genicular artery embolization has emerged as a promising treatment option for these patients. However, optimal patient selection remains unclear, emphasizing the need for advanced imaging techniques to refine selection criteria.

Case report. We present the case of a 54-year-old male with moderate knee osteoarthritis, classified as Kellgren–Lawrence grade 2, who underwent genicular artery embolization after failing conservative treatment. Pre-procedural assessment included dynamic contrast-enhanced magnetic resonance imaging to evaluate synovial inflammation and vascularity. Significant symptom improvement was observed following genicular artery embolization, with total WOMAC scores decreasing by approximately 30% at three months and 65% at twelve months, while the VAS score dropped from 7 to 1 over the same period. Magnetic resonance imaging findings demonstrated reduced synovial enhancement, indicating decreased inflammation.

Discussion Optimal genicular artery embolization outcomes depend on careful patient selection, with mild to moderate osteoarthritis responding best, while severe cases have a higher risk of pain recurrence. Standard magnetic resonance imaging may be insufficient for identifying ideal candidates, as no reliable imaging predictors have yet been established to reliably predict better outcomes. Dynamic contrast-enhanced magnetic resonance imaging provides a detailed assessment of synovial inflammation, with perfusion-related variables serving as surrogate markers of inflammation. Given these advantages, it holds significant potential for improving patient selection and treatment outcomes.

Conclusions. This case highlights the potential of dynamic contrast-enhanced magnetic resonance imaging in guiding patient selection for genicular artery embolization. Further research is required to validate imaging-based selection criteria and improve treatment outcomes.

Keywords: knee pain, minimally invasive treatment, contrast-enhanced magnetic resonance imaging.

INTRODUCTION

Osteoarthritis (OA) is a widespread and leading cause of disability among adults globally [1]. With an aging population, the incidence, prevalence, and economic burden of OA treatment and related disabilities are expected to rise [2]. Identifying effective treatments across all OA stages, from mild to severe, is therefore essential. Managing osteoarthritis (OA) involves a range of treatment options

aimed at symptom relief and functional improvement: education, exercise, weight control, pain relievers (acetaminophen, NSAIDs) and local therapies (corticosteroid or hyaluronic acid injections) help in mild to moderate cases, while severe OA may require joint replacement. However, a significant challenge remains in managing moderate OA that does not respond to nonsurgical treatments yet is not severe enough for joint replacement [3, 4]. Arthroscopic lavage and debridement have been used for years to treat

this type of moderate knee osteoarthritis. However, a Cochrane meta-analysis of double-blinded, randomized trials found no significant benefits of these interventions over placebo, recommending their exclusion from osteoarthritis treatment protocols [5]. This has created an urgent need for new, effective, and safe treatment options. Genicular artery embolization (GAE) has emerged as a promising solution, showing good results in patients with treatment-resistant mild to moderate OA [6]. However, the optimal patient selection and the role of MRI findings in predicting treatment success remain unclear. Here, we present a case of successful GAE treatment, highlighting the potential use of dynamic contrast-enhanced (DCE) MRI as a prognostic tool for treatment success.

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In August 2023, MRI of the right knee was performed together with dynamic contrast enhanced MRI (DCE MRI) in preparation for GAE (Fig. 2).



Fig. 2. Primary standard MRI examination protocol at Vilnius University Hospital Santaros Klinikos. Signs of osteoarthritis observed in the right knee: grade II–III chondromalacia (white arrows), osteophytes (open arrows), moderate effusion/synovitis (arrowheads). Additionally, postoperative changes in the tibia following corrective osteotomy are visible (curved arrows).

In September 2023, embolization of the medial genicular arteries was carried out. Genicular arteries were accessed via the right common femoral artery. They were selectively catheterized, and a 2F microcatheter was used to access the branches supplying the medial compartment of the joint. Hypervascular zones (“blush”) were embolized with 100–300 µm soluble gelatin microspheres (Nexsphere-F) (Fig. 3).

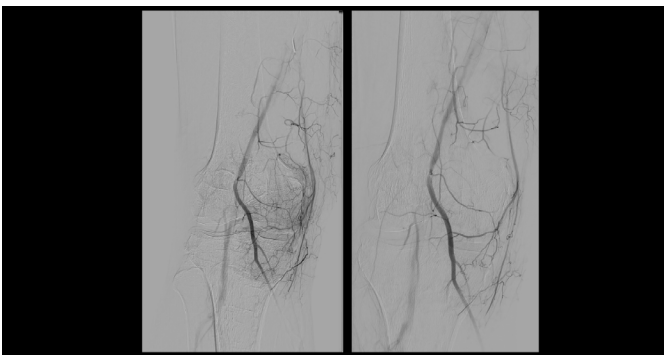


Fig. 3. Angiographic findings before (A) and after (B) transcatheter arterial embolization: A – selective angiography from descending medial genicular artery before embolization shows a cluster of abnormal neovessels (“blush”) (black arrow) adjacent to medial compartment of the knee joint; B – angiography after embolization shows elimination of previously seen pathological hypervascularity.

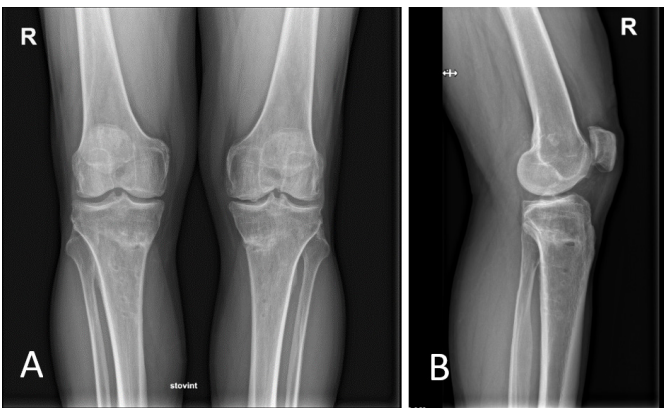


Fig. 1. A – anterior projection, B – right knee lateral projection. Primary osteoarthritis of both joints is observed. On the right some subchondral sclerosis and small osteophytes are visible medially. On the left more prominent osteophytes and subchondral sclerosis are observed together with joint space narrowing. Osteoarthritis in the right joint is classified as KL grade 2, and in the left joint as KL grade 3.

Follow up was performed 3 and 12 months after embolization with DCE MRI and clinical assessment using WOMAC and VAS scores. On MRI, smaller joint effusion and synovial thickness were observed as well as reduced

perfusion in the synovium on both lateral and medial sides of the joint (Fig.4). Total WOMAC scores decreased about 30 and 65 percent and VAS score decreased from 7 to 1 after 3 and 12 months respectively (Table).

Table. Changes in WOMAC scores (Parts A, B, C, and total) and VAS (Visual Analog Scale) before and after Genicular Artery Embolization (GAE). It shows significant improvement in pain, stiffness, and physical function over time.

Date	WOMAC part A	WOMAC part B	WOMAC part C	WOMAC total	VAS
Before GAE	7	4	24	35	7
After 3 months	4	2	17	23	1
After 12 months	2	3	7	12	1

Positive dynamics was observed on MRI. Standard sequences (PD FS, T1, T2) showed reduced joint effusion with no new changes in cartilage, subchondral bone or other structures. Reduced synovial enhancement was observed on DCE sequences (Fig. 4 and 5) as well as decreased synovial thickness on contrast enhanced sequences (Fig. 6).

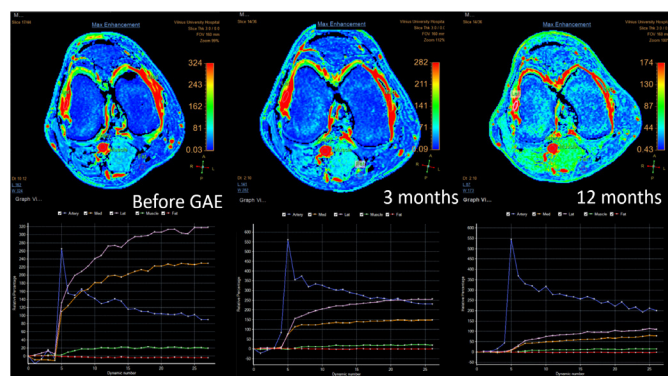


Fig. 4. Synovial perfusion before GAE, 3 months and 12 months after GAE. On maximum enhancement maps (top row) before GAE high enhancement is seen in synovium around the knee joint space, both medially and laterally.

After three months the maximum enhancement map remains quite similar. Significantly reduced enhancement is observed on the last map 12 months after GAE on both sides of the joint. Similar observations can be made from the relative time intensity enhancement curves. Before GAE avid enhancement crossing the arterial curve (blue) is seen on both medial (orange) and lateral (purple) sides, especially laterally. After three months, synovial enhancement is significantly reduced, with medial curve remaining lower than the arterial curve. After 12 months, further reduction is observed with both synovial enhancement curves lower than the arterial curve.



Fig. 5. T1 vibe subtraction MIP images. Diffuse avid enhancement in the synovium is seen before GAE. Enhancement is reduced after 3 and after 12 months following GAE.



Fig. 6. Contrast enhanced T1 fat saturation images. Reduced joint effusion (non-enhancing, white arrow) and reduced synovial thickness (enhancing, arrowhead) are observed after 3 and after 12 months following GAE.

DISCUSSION

The GAE procedure yields positive outcomes for patients with OA. A meta-analysis by Torkian et al. [6] provided a comprehensive evaluation of its effectiveness in patients with mild to moderate OA, demonstrating significant and sustained pain relief along with improved functional status. Analyzing results from eleven recent studies, the review observed a consistent downward trajectory in absolute VAS and WOMAC scores, with reductions of approximately 64% and 80% in VAS, and 73% and 85% in WOMAC at the 6- and 24-month follow-ups, respectively. In addition, GAE significantly reduced pain management needs in knee OA patients: Opioid use dropped 27%, NSAID use 65%, and hyaluronic acid injections 73% [6].

Achieving optimal results with the GAE procedure requires careful patient selection, with osteoarthritis severity being a key consideration. A study by Lee et al. [7] demonstrated that patients with mild-to-moderate osteoarthritis (Kellgren–Lawrence grade 1–3) experienced effective pain relief following GAE. However, in those with severe osteoarthritis (Kellgren–Lawrence grade 4), pain relief was short-lived—initial improvement within the first month was followed by a gradual return to pre-treatment levels over three months. These findings suggest that the extensive loss of articular cartilage in advanced OA, leading to direct bone-to-bone contact, may contribute to pain relapse, making GAE more effective in earlier disease stages. However, this study has a limitation regarding patient assessment for the GAE procedure, as it relies solely on Roentgen imaging. Since MRI provides a more comprehensive evaluation of knee joint soft tissues and bone marrow lesions, it is widely considered a superior tool for optimizing patient selection [8]. Therefore, incorporating MRI

findings may enhance the identification of suitable candidates for GAE treatment. Zadelhoff et al. [9] examined MRI features to determine their prognostic value in predicting response to the GAE procedure. They found that GAE resulted in better clinical outcomes on both WOMACpain and WOMACtotal scores when OA-related MRI features were less advanced. Specifically, the presence and severity of full-thickness cartilage defects, effusion-synovitis, bone marrow lesions, osteophytes, and cartilage surface area loss at baseline were associated with less favorable clinical outcomes at 6 months. No specific MRI finding was predictive of a more favorable response. Only a small, statistically insignificant correlation was observed between Hoffa's synovitis and pain reduction. However, this study did not use contrast enhancement, as MRIs for knee OA are typically performed without intravenous contrast, even though it is generally accepted that it provides many benefits. One key advantage of contrast-enhanced MRI (CE-MRI) is its ability to clearly differentiate synovitis from joint effusion, making it the preferred method for assessing synovial inflammation [10]. Furthermore, specialized form of CE-MRI, Dynamic Contrast-Enhanced MRI (DCE-MRI), offers significant advantages over conventional MRI in knee osteoarthritis. By capturing dynamic changes in blood flow, DCE-MRI enables early detection of inflammation, precise assessment of synovitis activity, quantification of cartilage degradation, and effective monitoring of treatment response [11, 12]. Considering these factors and recognizing that the pathogenesis of OA is driven by chronic inflammation and neoangiogenesis, we were motivated to use DCE-MRI as a tool for patient selection and monitoring treatment response. Assessment of synovitis on DCE MRI was also performed by Riis et al [13], who found that most DCE MRI variables showed statistically significant correlations with KOOS-Pain score. Also, correlations between the static MRI variables and KOOS-Pain score were all statistically significant. We did not find any studies using DCE-MRI for patients undergoing GAE; therefore, our study adds valuable insights to the scientific literature. This gap may exist because both methods (DCE MRI and GAE) are relatively new and focus is set more on clinical outcomes than on radiological findings.

In our case, knee OA was categorized as moderate, with grade II–III chondromalacia. We also ensured that our patient met key MRI criteria for selection, including the absence of grade IV chondromalacia, subchondral bone lesions, meniscal tears larger than one-third of the meniscus, avascular necrosis, acute traumatic changes, or rheumatological disease [14–17]. In our case GAE resulted in significant clinical improvement, with Total WOMAC scores decreasing by approximately 30% at 3 months and 65% at 12 months, while the VAS score dropped from 7 to 1 over the same period. These improvements correlated with DCE-MRI parameters, including maximum enhancement maps, relative time-intensity enhancement curves (Fig. 4), and T1 VIBE subtraction MIP images (Fig. 5). Most interestingly, we observed reduced perfusion throughout the

entire synovium, despite embolization being performed only on the medial side of the joint. This brings the idea that GAE is a systemic, rather than only local treatment in OA. As DCE-MRI variables measure perfusion and serve as surrogate markers of inflammation, they can be used for treatment monitoring and have the potential to be the most accurate MRI features for predicting clinical improvement after the GAE procedure. Since we perform DCE MRI on our patients, we believe that this is a strength of our ongoing research and an important topic for further studies.

CONCLUSIONS

Genicular artery embolization (GAE) is an effective treatment option for moderate knee osteoarthritis in patients who have not responded to conservative therapies but are not yet candidates for surgery. This case report presents a case of the patient, who experienced significant pain relief and functional improvement, correlating with MRI findings of reduced synovial enhancement. Dynamic contrast-enhanced MRI (DCE-MRI) emerged as a valuable tool for patient selection and post-treatment monitoring, revealing changes in soft tissue perfusion both in the area of most severe pain and globally in all synovium. Therefore, this advanced imaging technique holds promise for refining patient selection and providing a quantitative method to assess treatment response, potentially improving clinical outcomes. Further research is needed to establish standardized MRI-based criteria for optimizing patient selection and monitoring in GAE treatment.

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Santrauka

VIDUTINIO SUNKUMO KELIO OSTEOARTRITU SERGANČIŲ PACIENTŲ ATRANKA KELIO ARTERIJŲ EMBOLIZACIJAI: KLINIKINIS ATVEJIS IR DINAMINIO KONTRASTINIO MAGNETINIO REZONANSO TYRIMO VAIDMUO

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Įvadas. Osteoartritas yra reikšminga negalios priežastis visame pasaulyje. Nors dauguma lengvų osteoartrito atvejų reaguoja į konservatyvų gydymą, o sunkiais atvejais prireikia chirurginės intervencijos, vidutinio sunkumo osteoartrito gydymas, kai konservatyvus gydymas neefektyvus, išlieka sudėtingas.

Kelio arterijų embolizacija yra perspektyvi šių pacientų gydymo galimybė. Tačiau optimalūs pacientų atrankos embolizacijai kriterijai kol kas nėra iki galo išgryninti. Tiksliau nustatant gydymui tinkamus kandidatus labai svarbios pažangios vaizdinimo technologijos.

Klinikinis atvejis. Pristatome 54 metų vyro, sergančio vidutinio sunkumo kelio osteoartritu (rentgenologinis Kellgren–Lawrence II laipsnis), klinikinį atvejį. Šiam pacientui buvo atlikta kelio arterijų embolizacija po nesėkmingo konservatyvaus gydymo. Prieš procedūrą atliktas dinaminis kontrastinis magnetinio rezonanso tyrimas, siekiant įvertinti sinovito aktyvumą. Po procedūros pastebėtas reikšmingas simptomų pagerėjimas: WOMAC skalės bendras balas sumažėjo apie 30 % po trijų mėnesių ir 65 % po dvylikos mėnesių, o vaizdinės analogijų skalės (VAS) balas – nuo 7 iki 1 per aptariamąjį laikotarpį. Magnetinio rezonanso tyrimu nustatytas sumažėjęs kontrastinės medžiagos kaupimas sinovijoje, rodantis, kad uždegimas atslūgsta.

Diskusija. Geriausi kelio arterijų embolizacijos rezultatai gaunami, jei osteoartritas yra lengvas ar vidutinio sunkumo, o sunkesniais osteoartrito atvejais skausmo pasikartojimo rizika po procedūros yra didesnė. Standartinis magnetinio rezonanso tyrimas gali būti nepakankamas atrenkant tinkamiausius kandidatus, nes iki šiol nebuvo nustatyta patikimų radiologinių požymių, kurie leistų tiksliai prognozuoti geresnius rezultatus. Dinaminis kontrastinis magnetinio rezonanso tyrimas leidžia detalai įvertinti sinovijos uždegimą, o perfuzijos rodikliai gali būti naudojami kaip uždegimo žymenys. Dėl tokių pranašumų šis tyrimas turi didelį potencialą pagerinti pacientų atranką ir savo ruožtu gydymo rezultatus.

Išvados. Šiuo klinikiu atveju pabrėžiamas dinaminio kontrastinio magnetinio rezonanso tyrimo potencialas atrenkant pacientus kelio arterijų embolizacijai. Reikalingi papildomi tyrimai, siekiant patvirtinti vaizdinimu pagrįstus atrankos kriterijus.

Reikšminiai žodžiai: kelio skausmas, minimaliai invazinis gydymas, kontrastinis magnetinio rezonanso tyrimas.

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