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GENICULAR ARTERY PERCUTANEOUS RADIOFREQUENCY THERMOCOAGULATION: A TECHNICAL NOTE

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Background: Knee osteoarthritis (OA) is a progressive degenerative joint disease that causes chronic pain, with recent evidence suggesting angiogenesis in the development of pain.
This technical report presents a novel application of genicular artery radiofrequency thermocoagulation (RFTC) as a potential treatment for refractory knee OA.

Case Report: RFTC of the superior medial and lateral genicular arteries (SMGA/SGLA) was performed on a patient with chronic knee OA. The procedure involved RFTC at 90°C for 90 seconds per cycle, which was repeated until the arterial flow to the genicular artery was no longer visualized on ultrasound. At 6-month follow-up, visual analog scale (VAS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Patient Global Impression of Change (PGIC) were one, 30, and "Very Much Improved", respectively, with no need for analgesics or bracing.

Conclusions: This case highlights the successful and safe application of minimally invasive RFTC targeting the SGMA/SGLA in a patient with knee OA.

Key words: Genicular artery; percutaneous, radiofrequency, thermocoagulation, osteoarthritis

BACKGROUND

Osteoarthritis (OA) of the knee is a disabling disease that leads to chronic pain and can drastically limit the quality of life for affected individuals (1). It is the 11th leading cause of disability worldwide, with a high prevalence of up to 22% in men and 30% in women over 80 (1). It is a degenerative disease involving numerous factors, including age, body mass index (BMI), gender, and inflammation resulting from an imbalance between tissue damage and repair (1).

First-line treatment includes patient education on overuse, heat application, physical therapy, and pain control with nonsteroidal anti-inflammatory drugs (NSAIDs). Treatment escalation can include local intraarticular corticosteroid injections to reduce inflammation and further pain control (2). Persistent severe OA refractory to these treatments can be considered for surgical management with total knee arthroplasty (TKA) (2). Novel techniques targeting the genicular artery for embolization have shown a promising intermediary, minimally invasive step towards improving patient symptoms for patients reluctant or ineligible for TKA (2).

Although inflammation and joint space narrowing play key roles in the pathophysiology of OA, there is increasing evidence to suggest angiogenesis involvement in the development of pain (3). The proinflammatory joint space can drive the production of blood vessels in the normally avascular articular cartilage (3). This

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process may contribute to persistent inflammation and degeneration of surrounding structures, and limit the blood supply to these pathologic vessels (3).

The medial compartment of the knee bears the greatest weight and is subsequently the area most frequently affected by OA. Thus, the arterial branches here have been targeted by genicular artery embolization (GAE), which aims to embolize aberrant neovasculature, thereby reducing synovial blood flow and theoretically reducing pain and inflammation to the area (4).

Radiofrequency ablation (RFA) is a minimally invasive technique for pain that relies on thermal energy to disrupt nociceptive pathways (5). This technical report describes a novel method of treating knee OA by RFA at a higher temperature, termed radiofrequency thermocoagulation (RFTC), by targeting the genicular artery. The patient provided informed consent to be included in this technical report.

Case Presentation

A male with progressive right medial knee OA with chronic pain > 6 months, BMI of 32.3 kg/m^2, and Kellgren-Lawrence grade III knee OA with medial compartment synovium thickening demonstrated on x-ray, presented with a pre-procedural visual analog scale (VAS) of 8 and (WOMAC) of 75. Prior to this procedure, the patient's symptoms had been refractory to physical therapy, NSAIDs, and intraarticular corticosteroid injections without substantial benefit. Viscosupplementation (hyaluronic acid) was not trialed due to patient preference. The patient was brought to the procedure suite, and a thorough discussion of the procedure's risks and benefits, including nerve injury, infection, paralysis, and death, was conducted. The patient demonstrated understanding, had all questions addressed, and gave informed consent. Procedural laterality was confirmed and appropriately marked in agreement with the patient regarding the area of pain to be injected. The patient was positioned with attention to pressure points and was prepped and draped using ChloraPrep and sterile draping. Monitors for the Sonosite SII DTC system were placed, and the targeted anatomical areas were evaluated using an HFL50x (15–6 MHz) linear ultrasound probe to identify the genicular arteries. The superior medial and lateral genicular arteries (SMGA/SGLA) were targeted as these are the most consistently visualized under ultrasound, allowing a safer and reproducible technique for pain physicians. Unlike traditional genicular nerve RFA, which aims to avoid genicular arterial injury due to its anatomical proximity to the nerve, this procedure intentionally targets the genicular arteries for ablation. Although guidelines for genicular nerve RFA suggest targeting three branches, this approach was vascular rather than neural and thus was intentionally limited to 2 branches.

Under sterile conditions, the skin and subcutaneous tissue were anesthetized with 3 mL of 1% lidocaine using a 25-gauge needle. A 25-gauge, 1.5-inch needle was advanced under ultrasound guidance to the vicinity of the SMGA/SGLA visualized in Fig. 1. Negative aspiration confirmed the absence of vascular puncture before ablation needle insertion. A 10 cm Stryker radiofrequency needle with a 5 mm active tip was advanced to the genicular artery, with appropriate positioning either adjacent to or traversing the arterial structure. Coagulation was performed using a Stryker RFA generator at 90°C for 90 seconds, repeated until the artery was no longer visible on ultrasound. The number of cycles varied between 2-3 per artery.

Following ablation, a solution of 4 mL of 0.25% bupivacaine and 4 mL of 1% lidocaine was injected slowly through the needle, with intermittent aspiration to ensure the absence of intravascular placement. The needle was then removed, the skin was cleansed, and a sterile bandage was applied to the puncture site. Because this procedure targets vascular rather than neural structures, it is easily reproducible using ultrasound guidance. The genicular artery serves as a clear sonographic target, and successful coagulation can be directly visualized by the loss of arterial flow signal (Fig. 2), enhancing procedural reliability for pain management practitioners.

At the one-month follow-up, VAS decreased to 3, WOMAC decreased to 48, and the Patient's Global Impression of Change (PGIC) was reported as "Much Improved", without the need for pain medications or braces. At the 3-month follow-up, VAS decreased to one, WOMAC decreased to 30, and PGIC was reported as "Very Much Improved.". By 6 months, VAS, WOMAC, and PGIC were sustained and no adverse events were observed.

DISCUSSION

This technical report details the novel usage of percutaneous RFTC of the SMGA/SGLA for knee OA pain and stiffness without complications. RFTC may present a quicker and less complex outpatient procedure compared to embolization, as the former requires only a needle, ultrasound, and radiofrequency, while the

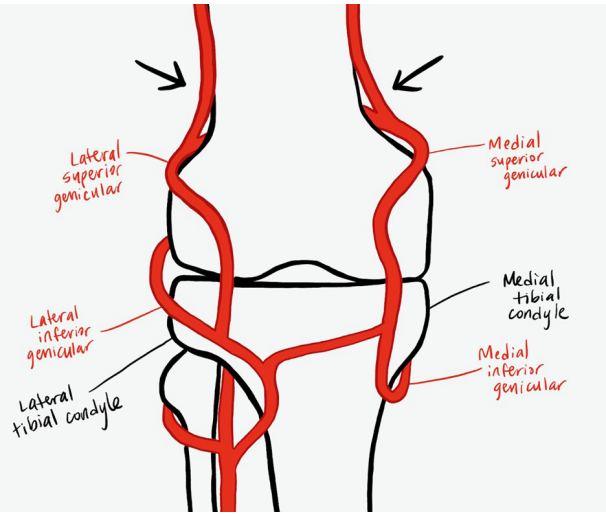

Fig. 1. Targeting the superior medial and lateral genicular arteries.

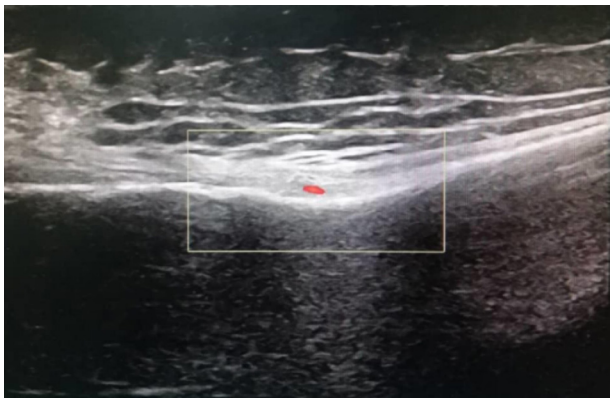

Fig. 2. Ultrasound-guided radiofrequency thermocoagulation of the genicular artery demonstrates post-procedural loss of arterial flow signal.

latter requires angiography, catheter, embolic material, radiation from fluoroscopy, and contrast agents. Additionally, there may be reduced complications attributed to embolization, such as non-target embolization (potentially damaging the cruciate ligaments), ischemia, tissue necrosis, or other intra-arterial procedural risks. RFTC directly coagulates the artery with precise and controlled energy, minimizing the risk of non-target embolization and vascular occlusion. Furthermore, this technique may potentially serve as an adjunct to genicular nerve RFA by targeting both the nerve and artery to improve pain scores. We suggest doing as many cycles of RFTC as possible until the artery is no longer visualized under ultrasound.

Although the American Society of Interventional Pain Physicians (ASIPP) recommends targeting 3 branches during genicular nerve RFA, our technique involves arterial coagulation rather than neural ablation (5). Furthermore, conventional RFA was used, which creates elliptical lesions that can reliably produce focal coagulation for effective obliteration of the artery. Cooled RFA produces spherical lesions, which would result in larger lesions due to the continued energy delivery. Additionally, cooled RFA involves the circulation of fluid into the area that may affect the perivascular tissues. Although cooled RFA has been more commonly used for genicular nerve RFA, its role in vascular ablation warrants further study. Potential complications, such as bleeding, infection, hematoma formation secondary to vascular injury, or ischemic complications such as neuropathy or bone infarction, can theoretically occur if multiple arteries are ablated. Though hematoma formation is less of a concern, as the procedure requires the loss of visualization of the artery under ultrasound. Many of the contraindications reported with GAE are relevant for this procedure as well (4). Relative contraindications may also include significant smoking history, malignancy, being on anti-coagulation, and advanced OA, where vascular involvement may not be the main pain generator (5). However, the authors believe that these would not be contraindications due to the relatively straightforward procedure that can be performed in the office or outpatient surgery center settings.

GAE has promising results and involves targeting the synovial hypervascularity of the knee and treating OA pain by reducing synovial blood flow, theoretically reducing knee pain by decreasing inflammation, neovascularity, and neoinnervation (4). A meta-analysis of nine studies (n = 270, 339 knees) consisting of primarily case series found improved VAS/WOMAC scores and a high technical success rate, though this definition varied between studies, with criteria depending on successful embolization of one or more genicular arteries. At the 2 year follow-up, 5.2% underwent total knee replacement and 8.3% underwent a repeat GAE (4). Skin discoloration (10% to 65%) and access site hematomas (0% to 17%) are the most commonly reported adverse events (7). Notably, a pilot study using contrast-enhanced MRI found that GAE was able to significantly reduce synovitis ($P < 0.001$) and found a moderate negative correlation between synovitis and pain scores ($P = 0.005$) (8). However, peripheral arterial disease (PAD) is a contraindication for this

procedure, as the genicular arteries supply collateral circulation to sustain leg perfusion (9). Severe PAD with genicular artery stenosis can increase the risk of arterial dissection. Furthermore, general contraindications to arteriography, such as renal and coagulation functions and allergy to contrast agents, must be investigated during the initial evaluation (9).

Familiarity and understanding of the anatomy and the considerable variability that can be seen with the genicular artery are essential during preprocedure planning and target selection to minimize adverse events and maximize efficacy. Callese et al. (10) conducted a retrospective study of patients who underwent GAE to analyze the course and branching patterns of the genicular arteries. Of the 205 patients, there was 197 descending genicular arteries (DGA) (96%) with two branches in 152 (77%), 186 superior medial genicular arteries (SMGA) (91%), 203 superior lateral genicular artery (SLGA) (99%), 195 inferior medial genicular artery (IMGA) (95%), 196 inferior lateral genicular artery (ILGA) (95%), and 200 median genicular arteries (MGA) (97%). Additionally, several unique branching patterns were found: common trunk of the SLGA and MGA (n = 115, 56%), independent origins (n = 45, 22%), trifurcation of the SLGA, SMGA, and MGA (n = 32, 15.5%), and a common trunk of the SMGA and MGA (n = 12, 6%) (10). The superior patellar artery was identified in 175 patients (85%) and the anterior tibial recurrent artery (ATRA) in 156 patients (76%) (10). Sighary et al. (11) similarly investigated genicular artery variation and included 198 DGAs (3 types, 26% A, 71% B, 5% C), 204 politeal-origin genicular arteries (28% I, 22% II, 15% III, 15% IV, 10% V, 6% VI), and 183 ATRAs. Despite the large number of possible variations, the authors found that 6 main patterns were found in over 96% of these cases, with no significant differences in vessel distances comparing right to left sides (11).

Future studies with larger patient cohorts and comparisons with a control or active comparators, such as GAE, conventional RFA, cooled RFA, and combination techniques to better characterize the effectiveness and safety profile of this technique. Long-term pain relief, functional improvement, complication rates, and their potential impact on joint health and progression of OA are also paramount. Investigation of whether RFTC can reduce synovitis similar to embolization is also warranted, as the thermal coagulation theoretically produces a similar occlusion to embolization. Longer-term studies are also required to allow clinicians to make informed decisions when advising patients on which method would be better suited for their particular presentations.

CONCLUSION

OA of the knee presents with significant pain and disability, drastically affecting quality of life. Our case demonstrates a novel safe and effective application of RFTC of the genicular artery using ultrasound-guidance and confirmation of the ablated targets.

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