Prospective Evaluation

Ultrasound-Guided Genicular Nerve Pulsed Radiofrequency Treatment For Painful Knee Osteoarthritis: A Preliminary Report

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Background: Genicular nerve ablation with radiofrequency (RF) has recently emerged as a promising treatment in the management of osteoarthritis related knee pain. To date, genicular nerve injections have been performed under fluoroscopic guidance.

Objective: To evaluate the effect of ultrasound-guided genicular nerve pulsed RF treatment on chronic knee pain and function in patients with knee osteoarthritis.

Study Design: Single-arm prospective study.

Setting: University hospital and rehabilitation center in Turkey.

Methods: A review was made of 29 patients with medial knee osteoarthritis who had undergone genicular nerve block in the previous 6 months. Patients with at least 50% reduction in the visual analog scale (VAS) score after genicular nerve block and with no on-going pain relief were selected for the study. Ultrasound-guided genicular nerve pulsed RF was applied to 15 knees of 9 patients. Pain and knee function were assessed with 100-mm VAS and Western Ontario and McMaster Universities (WOMAC) index throughout 3 months.

Results: A significant reduction in VAS scores was detected over time after the pulsed RF procedure (f: 69.24, $P < 0.01$). There was a significant improvement in the WOMAC scores (f: 539.68 , $P < 0.01$).

Limitations: The small number of participants, the lack of a control group, and short follow-up period were limitations of the study.

Conclusions: Genicular nerve pulsed RF treatment has been found to be safe and beneficial in osteoarthritis related knee pain. Further studies with a larger population and randomized controlled study design are warranted to confirm the positive findings of this preliminary report.

Key words: Knee pain, osteoarthritis, genicular nerve, ultrasonography, pulsed radiofrequency

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Osteoarthritis related knee pain is one of the most common musculoskeletal problems in elderly patients with an estimated prevalence of 24% (1,2). Although there are many pharmacological and surgical treatment options for knee osteoarthritis, these entail a number of concerns. Non-steroidal anti-inflammatory drugs can be used for the initial management of osteoarthritis (3) but long-term use is limited due to severe adverse effects such as dyspepsia, gastrointestinal bleeding, increased blood pressure, aggravation of congestive heart failure, and renal toxicity (4,5). Intra-articular corticosteroid injection is another option suggested in the guidelines for the treatment of knee osteoarthritis (3,6). Although corticosteroid injections are commonly used in the pain management of osteoarthritis, repetitive injections are often needed to provide long-term pain relief (7). Furthermore, intra-articular corticosteroid injections have been reported to lead to various complications including deterioration of the articular cartilage, crystal-induced synovitis, fat necrosis, tissue atrophy, haematoma, vascular necrosis, and sepsis (8-12). Viscosupplementation has become widely used in the treatment of knee osteoarthritis. However, the results of viscosupplementation are conflicting (13). Surgical procedures are generally performed in cases unresponsive to the conservative treatment options. Joint replacement is the most commonly performed surgical procedure, particularly in the treatment of end-stage arthritis, although perioperative morbidity and a variety of complications may develop such as soft-tissue impingement syndrome, patellofemoral instability, or extensor mechanism rupture accompanied by long-term failure (14,15).

Genicular nerve ablation with radiofrequency (RF) has recently become a promising treatment option in the management of osteoarthritis related knee pain (16,17). This procedure aims to provide pain relief by inhibiting the nerve fibers that innervate the knee joint. To date, genicular nerve injections have been performed under fluoroscopic guidance, in which needle placement has been successfully applied with reference to bony landmarks. Ultrasound imaging has several advantages over fluoroscopy in pain interventions. It is inexpensive and easily repeatable and does not expose the patient or physician to ionizing radiation. Ultrasound-guided genicular nerve injections have recently been shown to be accurate (18). The aim of this preliminary report was to evaluate the effect of ultrasound-guided genicular nerve pulsed RF treatment on chronic knee pain and function in patients with knee osteoarthritis.

Methods

Study Design and Patients

This study was conducted in 2 parts with a retrospective examination of patient records followed by prospective pulsed RF applications to the selected sample. In the first part of the study, potential participants who met the inclusion criteria were determined by scanning the medical records of the patients who had undergone ultrasound-guided genicular nerve block in the previous 6 months. In the second part of the study, the effectiveness of pulsed RF treatment on the selected patients was investigated prospectively. Pulsed RF was applied to patients who had at least a 50% reduction in the visual analog scale (VAS) score after the genicular nerve block procedure and had no on-going pain relief. A total of 29 patients with the diagnosis of knee osteoarthritis were included in the study. The inclusion criteria were to have experienced dominant knee pain for more than 6 months, a diagnosis of radiologically verified grade III or IV osteoarthritis according to the Kellgren-Lawrence Grading Scale with prominent narrowing in the medial compartment of the tibiofemoral joint space. Exclusion criteria were determined as a history of knee surgery, experiencing acute knee pain with inflammation findings, connective tissue disease affecting the knee joint, a serious psychiatric disorder or neurological disease, sciatica, current use of anticoagulant drugs, and having received intra-articular steroid or hyaluronic acid injection within the previous 3 months. All participants signed the informed consent form. Approval for the study was granted by the Local Ethics Committee.

Ultrasound-Guided Genicular Nerve Block

The ultrasound-guided genicular nerve block procedure was applied to a total of 47 knees (n = 29; 18 bilateral, 11 unilateral). Ultrasound scanning of the knees was performed by an experienced investigator using a 12-5 MHz linear transducer (LOGIQ E Portable; GE Healthcare, China). The examination of the superior medial and inferior medial genicular nerves using ultrasound was performed in accordance with the study of Yaşar et al (18). The course of the superior medial genicular nerve (SMGN) is that it curves around the femur shaft and passes between the adductor magnus tendon and the femoral medial epicondyle, then descends approximately 1 cm anterior to the adductor tubercle. The inferior medial genicular nerve (IMGN) is situated horizontally around the tibial medial epicondyle and passes beneath the medial collateral ligament at the midpoint between the tibial medial epicondyle and the tibial insertion of the medial collateral ligament. The adductor tubercle for the SMGN and the medial collateral ligament for the IMGN were used as anatomic landmarks for ultrasound. During the examination, the ultrasound probe was placed sagittal in the medial aspect of the knee in full extension with the patient lying on the lateral side. Thus, the anatomic landmarks of the patients were imaged. The transducer was placed in a sagittal orientation over the femoral medial epicondyle. Then the transducer was translated proximally to the level of the adductor tubercle and the insertion of the adductor magnus tendon was imaged. The bony cortex 1 cm anterior to the peak of the adductor tubercle was targeted for the injection of the SMGN (Fig. 1). Thereafter, the transducer was placed in a sagittal orientation over the tibial medial epicondyle. The medial collateral ligament was visualized. The transducer was then translated distally to the level of the tibial insertion site of the medial collateral ligament below the tibial medial epicondyle. The point of the bony cortex at the midpoint between the peak of the tibial medial epicondyle and the initial fibers inserting on the tibia of the medial collateral ligament was targeted for the injection of the IMGN (Fig. 2). A 22-gauge 38-mm spinal needle was advanced in parallel to the long axis of the transducer (in-plane approach). A standard mixture of 0.5 mL bethametasone and 2 mL lidocaine (1%) was then injected into each area.

Pulsed RF Procedure

This process included a total of 15 knees (n = 9; 6

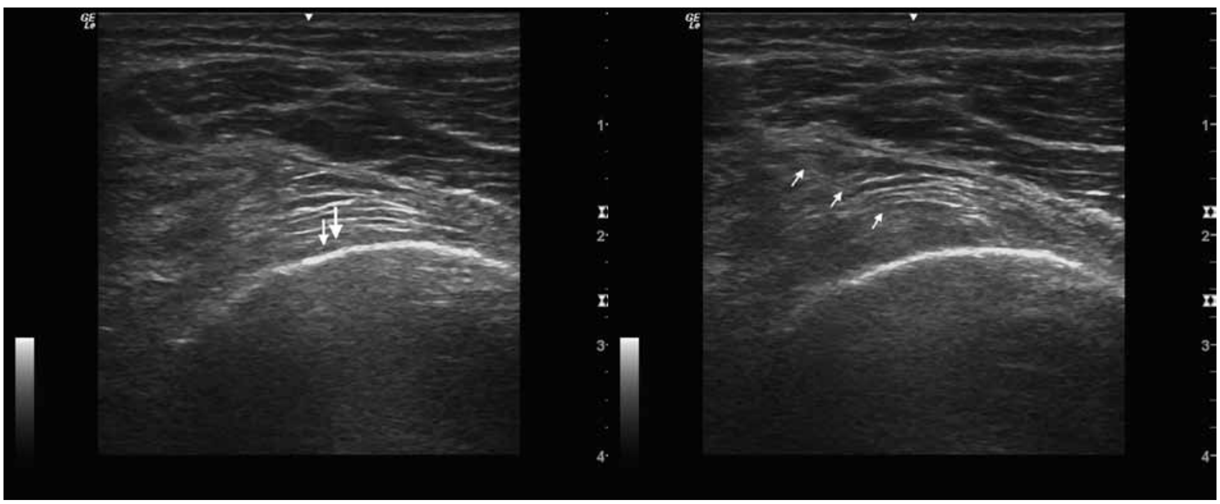

Fig. 1. *(a) Transverse ultrasound image of the knee at the level of the femoral medial epicondyle. Superior medial genicular nerve (thick arrow) and the corresponding artery (thin arrow) were visualized. (b) The needle (arrows) was placed to the bony cortex 1 cm anterior to the peak of the adductor tubercle for the superior medial genicular nerve.*

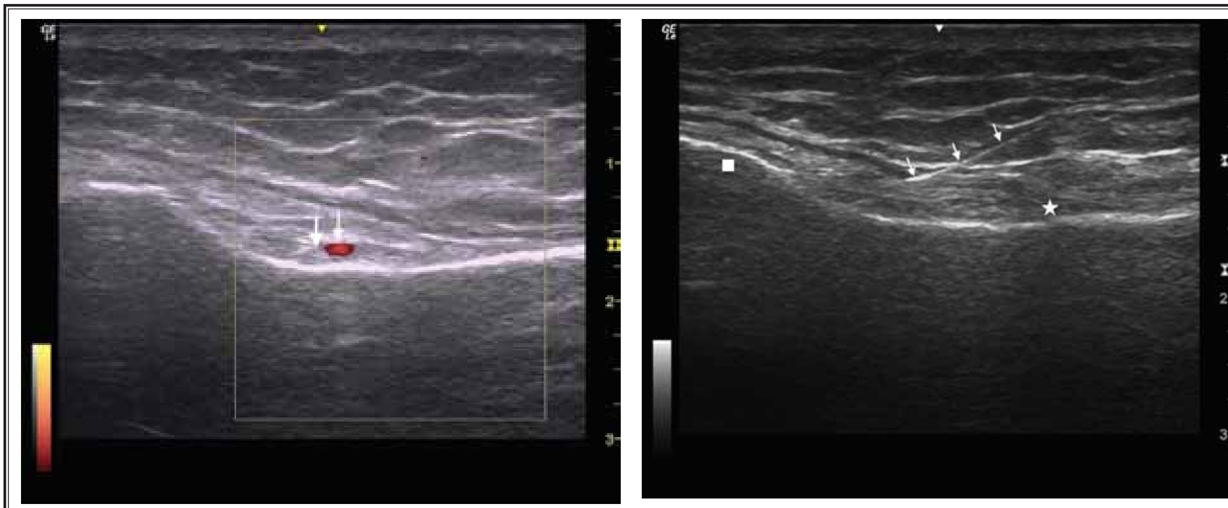

Fig. 2. *(a) Longitudinal ultrasound image of the knee at the level of the tibial medial epicondyle. Inferior medial genicular nerve (thick arrow) and the corresponding artery (thin arrow) were visualized using power doppler. (b) The needle (arrows) was placed to the bony cortex at the midpoint between the peak of the tibial medial epicondyle (square) and the initial fibers inserting in the tibia of the medial collateral ligament (star) for inferior medial genicular nerve.*

bilateral, 3 unilateral). Before the implementation, the patient was placed in a supine position and the genicular nerves were imaged using the aforementioned ultrasound technique. A 10 cm length of 22-gauge RF cannula (NeuroTherm) was advanced to the specific target points until the needle reached the bone. The RF probe was placed perpendicular to the presumed length of the nerve. A 50 Hz-frequency sensorial stimulation was applied with a threshold of < 0.6 V. During the sensorial stimulation, the patients were asked if they felt tingling, pain, or discomfort inside the knee. The RF probe was maintained in place until one of those feelings was elicited. In addition, 2.0 V motor stimulation was applied at a frequency of 2 Hz to determine the absence of fasciculation. Before the activation of the RF generator, an injection of 2 mL 1% lidocaine was applied. Subsequently, RF lesions were generated by applying pulsed RF treatment to the superior medial and inferior medial genicular nerves for 120 seconds twice at 42°C. The entire procedure for one knee was completed in 8 minutes.

Outcome Measures

The patient demographic characteristics including age, gender, body mass index (BMI), and duration of pain were noted. A 100-mm VAS was used to assess knee pain before the procedure and one week, one month, and 3 months after the procedure. The Western Ontario and McMaster Universities (WOMAC) index was used to evaluate the knee function of the patients. The validity and reliability of the WOMAC index has been demonstrated in Turkish patients with knee osteoarthritis (19). The assesments were performed before the procedure and one month and 3 months after the procedure.

Statistical Analysis

Statistical analysis was performed using SPSS software program (Chicago, IL, USA) for Windows version 11.0. Data were shown as mean ± standard deviation. To test for the effect of injections, changes in outcome measures over time were evaluated using the repeated measurement general linear model. A value of $P < 0.05$ was considered statistically significant.

Results

Genicular nerve block was performed on 29 patients. A total of 20 patients had a positive response (at least 50% reduction in VAS score) to the genicular nerve block procedure. Seven patients had on-going pain relief and 13 patients had recurrent pain when they were assessed for pulsed RF treatment. Four patients refused the treatment and 9 patients underwent the pulsed RF treatment. The flowchart of the study is presented in Fig. 3. The mean age of the patients was 67.18 ± 7.65 years. There was a female dominance in the patients with a ratio of 82.8 % (n = 24). The mean value of BMI was found to be 31.5 ± 5.16. The mean duration of pain symptoms was 44.5 ± 24.4 months. The patient characteristics are presented in Table 1.

A significant reduction in VAS scores was detected over time after the pulsed RF procedure (f: 69.24, $P < 0.01$) (Fig. 4). There was also a significant reduction in the WOMAC scores (f: 539.68, $P < 0.01$) (Fig. 4). Six patients had pain relief of more than 50% reduction in VAS score. No adverse effects or complications were observed in the follow-up periods.

Discussion

The effect of genicular nerve pulsed RF treatment on osteoarthritis related knee pain and knee functions was investigated in this preliminary report. The patients had significant pain relief and improvement in knee functions throughout a follow-up period of 3 months. Ultrasound guidance was used successfully for localization of the genicular nerves.

RF is a type of alternate current that creates heat in the target tissues by providing friction between the molecules; thus a thermal lesion is formed by the heat generated from this current (20). The RF procedure is used in various clinical conditions such as trigeminal neuralgia, cervicogenic headaches, spinal pain, and orchialgia. Recently, this process has been applied in the pain management of knee osteoarthritis. Choi et al (16) examined the efficacy of RF genicular neurotomy on chronic knee pain and function in 38 patients with osteoarthritis. The findings of the study showed that there was a significant improvement in pain and satisfaction in the RF treatment group and it was concluded that RF neurotomy of genicular nerves appears to be a safe, effective, and minimally invasive treatment process for chronic knee osteoarthritis. In another report, genicular RF provided improvement in chronic knee pain after total knee replacement (17). In both previous reports, conventional RF, which leads to permanent injury in the nerves, was implemented in the genicular nerve branches. This method is generally preferred for patients with end-stage knee osteoarthritis who are candidates for total knee replacement. To the best of our knowledge, the present study is the first study of

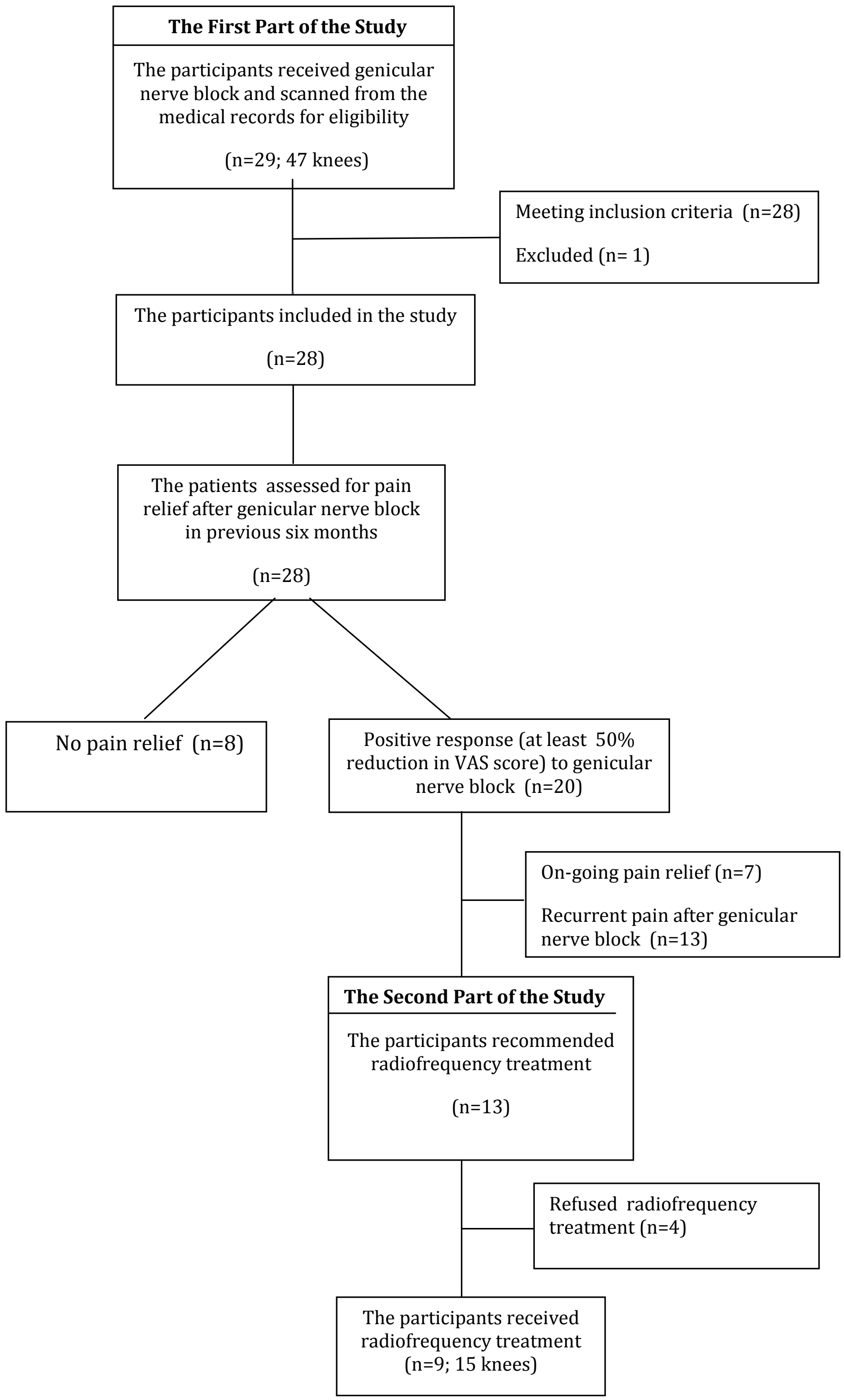

Fig. 3. *Flowchart of the study.*

Table 1. *Patients' characteristics.*

	Patients (n = 28)
Age (years)*	67.18 ± 7.65
Gender	
Female	24 (82.8%)
Male	5 (17.2%)
Body mass index (kg/m^2)*	31.5 ± 5.16
Duration of pain (months)*	44.5 ± 24.4
Affected side	
Right	4 (14.3%)
Left	7 (25%)
Bilateral	17 (60.7%)

ultrasound-guided genicular nerve pulsed RF treatment in patients with osteoarthritis related knee pain. Pulsed RF uses RF current in short high–voltage bursts and the silent phase of pulsed RF allows time for heat elimination, generally keeping the target tissue below 42°C. Therefore, pulsed RF does not cause thermal lesions and avoids any nerve destruction which could lead to Charcot joints and neuropathic pain.

The nerve supply of the knee joint is provided by various articular branches. Kennedy et al (21) described 2 groups of articular branches in the knee: the anterior and posterior groups. The nerves in the anterior group are the articular branches of the femoral,

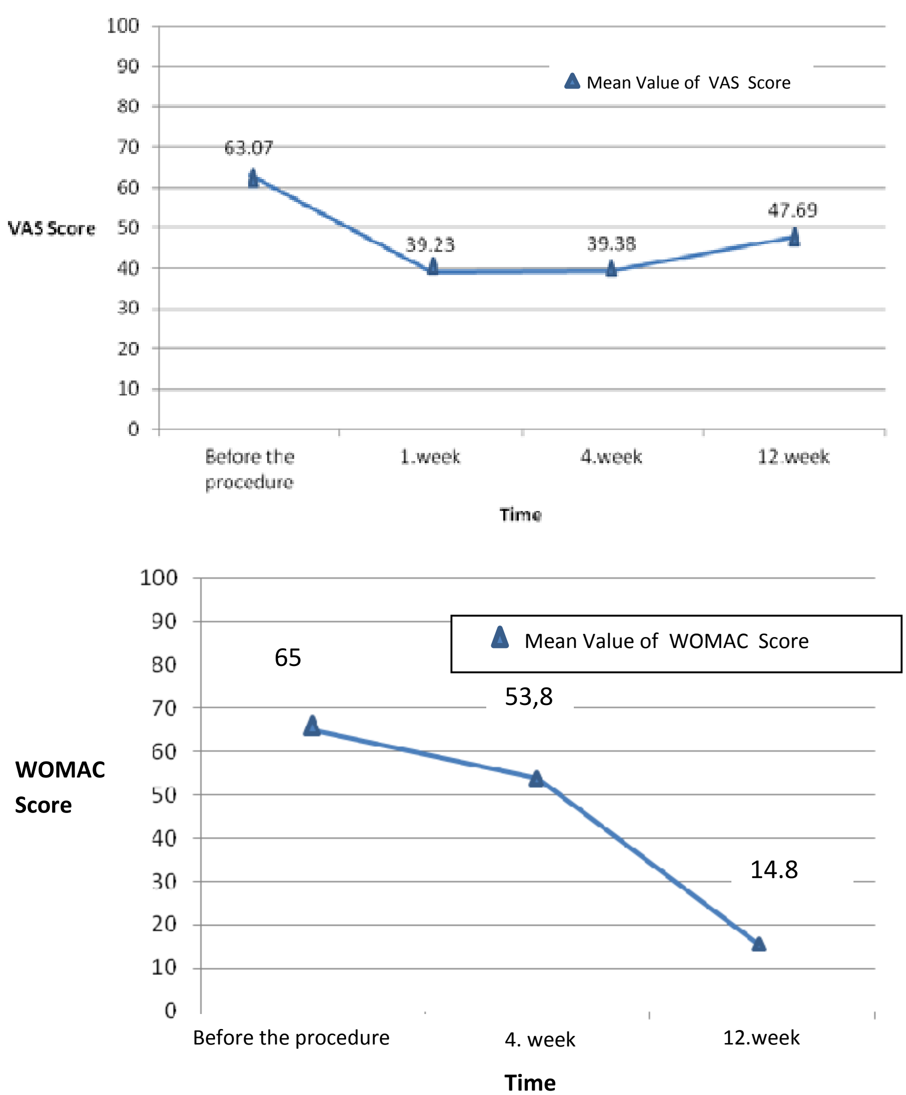

Fig. 4. *Changes in 100-mm VAS pain score (a) and WOMAC score (b) over time.*

the common peroneal and the saphenous nerve. The posterior group consists of the articular branches of the tibial, the obturator, and the sciatic nerves (21,22). The tibial nerve projects articular branches at the popliteal fossa and is mainly responsible for innervation of the medial and posterior aspect of the knee joint (23). The articular branches of the common peroneal nerve innervate the inferolateral and anterolateral aspect of the articular capsule (22,23). The saphenous nerve gives sensation to the anteroinferior side of the capsule (23). In the reports of of Choi et al (16) and Protzman et al (17), RF teatment was implemented on the superolateral, superomedial, and inferomedial genicular nerve branches. Only 2 (superomedial and inferomedial branches) of the previously reported 3 genicular nerves were targeted for the pulsed RF treatment in the present study, as it has been suggested that only these 2 genicular nerves are involved in clinically evident knee pain related with medial compartment knee osteoarthritis. It may be considered as a more specific treatment for knee osteoarthritis affecting the medial compartments only. There have also been studies investigating the effect of interventional procedures to other peripheral nerves around the knee joint for acute and chronic pain. Vas et al (24) conducted a study to examine the efficacy of ultrasound-guided RF treatment of the saphenous, tibial, and common peroneal nerves along with subsartorial, peripatellar, and popliteal plexuses in 10 patients with osteoarthritis. They revealed that the RF procedure on the sensory and motor nerves appeared to be a safe, effective, and minimally invasive technique. In another study, Egeler et al (25) performed nerve block to the lateral and intermediate cutaneous nerves of the thigh, the infrapatellar nerve, and 3 genicular nerves including the superomedial, superolateral, and infero medial branches. Improvements in postoperative pain after total knee arthroplasty were obtained. The results of the present study suggested that pulsed RF treatment to the superomedial and inferomedial genicular branches might be sufficent for pain relief in medial compartment osteoarthritis. It should also be recognized that the most frequently affected component in knee osteoarthritis is the medial compartment as a result of knee varus torque in the 3 knee joint components (26). This means that pulsed RF treatment to these 2 genicular branches has the advantage of being used widely in clinical practice as well as being easier and safer than interventional procedures to more nerves around the knee joint.

Genicular nerve block is usually performed as a diagnostic test. Nevertheless, long-term efficacy of the genicular nerve block procedure was also seen in 7 patients out of 29 patients in the present study. In a study by Choi et al (16), 4 of 63 patients had no pain after diagnostic genicular nerve block. More patients were determined to have obtained long-term benefit from the nerve block in the current study, which may be due to the administration of both lidocaine and betamethasone in the genicular nerve block injections. Corticosteroid was used to contribute an analgesic effect to the local anaesthetic. It has been reported that corticosteroids may provide analgesia by blocking the transmission in nociceptive C-fibers (27). Further studies are needed to illuminate the potential benefit of genicular nerve block in knee osteoarthritis. It could be recommended that clinicians apply RF treatment if there is no lasting pain relief from genicular nerve block.

The use of ultrasonography has recently become more widespread in the monitoring of neuroaxial structures and peripheral nerve block (28). Ultrasonography is superior to fluoroscopy based on the visualization of neurovascular bundles and identification of the nerves. In a study by Vas et al (24), where ultrasound was used to visualize the peripatellar plexus and saphenous, tibial, and femoral nerves, ultrasonography was reported to facilitate the location of various nerves. Protzman et al (17) used ultrasonography to define the inferomedial, superomedial, and superolateral genicular nerves. Before applying the RF nerve ablation procedure, the anatomical location of the nerves defined by ultrasonography was confirmed with the fluoroscopic imaging system. In a recent cadaveric study by Yaşar et al (18), the locations of the superomedial and inferomedial genicular nerve branches were investigated and anatomic landmarks were determined for ultrasound-guided genicular nerve block. In addition, the accuracy of genicular nerve ink injection using anatomical landmarks and ultrasound guidance was also examined. It was concluded that the superior and inferior medial genicular nerve branch injection can be performed accurately using anatomic landmarks and ultrasound guidance in the cadaveric model. These anatomic landmarks were also used successfully for localization of the genicular nerves via ultrasonography in the present study.

The present study achieved the specified objectives, but there are some limitations to the study. The number of participants was limited, so there is a requirement for further research with larger patient populations to assess the efficacy and adverse reactions of genicular pulsed RF. Another limitation of the study is the lack of a control group. Thus, these protocols could not be compared with other treatment modalities. Finally, although the effect of treatment was monitored for 12 weeks that might not have been a sufficient length of time to determine the long-term effects of the procedure. Further studies are also needed to evaluate the long-term effect of pulsed RF treatment.

Conclusion

In conclusion, the results of this study have shown that genicular nerve pulsed RF treatment is safe and beneficial in osteoarthritis related knee pain. Further studies with larger populations and a randomized controlled study design are warranted to confirm the positive findings of this preliminary report.

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