Ultrasound *vs.* fluoroscopic guidance in genicular nerve radiofrequency thermocoagulation for chronic knee pain: which one is the future?

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Abstract. – OBJECTIVE: Fluoroscopic guiding is commonly utilized for interventional pain management procedures. However, ultrasonography has started to be used more widely in interventional pain procedures. It has become even more popular with its advantages. The clinician who performs the pain procedure and the patient are not exposed to radiation. Vascular structures can be directly visualized. Ultrasonography is more accessible and portable than fluoroscopy. For all these reasons, its use will increase. So, in this study, we aimed to compare the efficacy of the genicular nerve radiofrequency thermocoagulation application under ultrasound guidance and fluoroscopy guidance.

PATIENTS AND METHODS: Patients with stage 2 and 3 osteoarthritis, according to the Kellgren-Lawrence classification, were included in our study (n=180). Seventy percent of patients were women. Sixty patients received medical treatment only. Genicular nerve radiofrequency thermocoagulation was performed with fluoroscopy in sixty patients and with ultrasonography guidance in sixty other patients. Visual Analogue Scale at 1 month (VAS1) and Western Ontario and McMaster Universities Arthritis (WOMAC1) were recorded before the procedure, while VAS2 and WOMAC2 were recorded at 3 months.

RESULTS: In the ultrasound and fluoroscopy group, a statistically significant difference was found between VAS1 and VAS2, WOMAC1 and WOMAC2 (p<0.05). VAS1 of the patients in the fluoroscopy group was 6.65±0.93, and it was 5.88±0.92 in the ultrasonography group, which was similar (p<0.0001). VAS2 was 2.26±1.16 in the ultrasonography group and 3.83±1.66 in the fluoroscopy group (p<0.0001). The reduction rate in pain severity in patients undergoing the procedure under ultrasonography guidance was more marked than that in the fluoroscopy group (p<0.0001).

CONCLUSIONS: For the radiofrequency thermocoagulation of the genicular nerve, both imaging approaches are available. Ultrasonography guidance appears to be better than fluoroscopy guidance in this technique because of the lower radiation dose and the ability to detect the target location and neighboring tissues more precisely under ultrasonography guidance.

Key Words:
Genicular nerve, Radiofrequency thermocoagulation, Knee, Osteoarthritis.

Introduction

Osteoarthritis is a common disease with increasing incidence recently. Knee osteoarthritis accounts for 80% of all osteoarthritis cases around the world. Especially with increased obesity and mean age, the incidence of knee osteoarthritis is observed to increase across the world[1,2].

The global prevalence of knee osteoarthritis is 16% among individuals aged 15 and older and 22.9% among those aged 40 and older. Based on this, 653.1 million people aged 40 and older have been reported[3] to have knee osteoarthritis in 2020 across the world. Chronic osteoarthritis is a disease that increases the mortality rate of patients and decreases their quality of life[4].

Conservative, minimally invasive and surgical methods are used to treat osteoarthritis[5]. Radiofrequency thermocoagulation (RFT) of genicular nerves may be life-saving if conservative treatments fail in the presence of comorbidities that may prevent surgical treatment or if the patient is too young for total knee prosthetics and in case of severe pain associated with knee osteoarthritis. Several studies have[6-10] demonstrated that RFT of genicular nerves is effective for pain palliation in the treatment of knee osteoarthritis.

Genicular nerve block (GNB) and Genicular nerve (GN) RFT can be performed under the guidance of both fluoroscopy and ultrasonography

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(USG)[11-14]. Certain points on bony structures are taken as guides during the procedure performed under fluoroscopy. Under the guidance of USG, however, again, certain points are taken as guides, but those structures can be directly visualized as well.

An essential advantage of USG guiding is locating vascular structures easily. When the injections are carried out under the USG guidance, the danger of vascular injection is significantly reduced. Neither the patients nor the physicians are exposed to radiation during the procedures performed under USG guidance, which is a significant advantage for both patients and physicians. Furthermore, using USG offers other advantages, such as ease of use, accessibility, and portability.

We believe USG has several advantages over fluoroscopy when it comes to GN RFT. We hypothesized that USG guidance would be more effective in this procedure. In order to accomplish this, we sought to compare the efficiency of GN RFT performed under USG *vs.* fluoroscopic guidance in our study.

Patients and Methods

After the examination and radiological assessment of patients admitted to our pain clinic with complaints of knee pain, patients who had to undergo interventional pain treatment were informed about GN RFT. The study was approved by the Institutional Ethics Committee of Akdeniz University.

Invasive procedures were performed under fluoroscopy or USG in the clinic by the same physician. Patients who were older than 18, had stage 2, 3 and 4 osteoarthritis according to Kellgren-Lawrence classification and had been regularly followed up were included in the study. The age, sex, and body mass index of the patients were recorded. Pain assessment was made using the Visual Analogue Scale (VAS, 0-10) and Western Ontario and McMaster Universities Arthritis (WOMAC) scores by a blinded nurse in the clinic.

Patients who agreed to the RFT technique were chosen using a computer-generated random number generator. Patients who underwent GN RFT under USG were categorized as group U, those who underwent GN RFT under fluoroscopy were categorized as group F, and those who did not receive GN RFT were categorized as group N (none). During the procedure, the patients were positioned in the supine position. A tiny cushion was placed under their knees to keep them suitable for the procedure. Bilateral knees of patients where the procedure would be performed were cleaned and draped. Patients' knees were imaged in an anteroposterior (AP) position. The points adjacent to the femur periosteum in the lateral and medial side of the junction between femur epicondyles and femur shaft for the superomedial and superolateral genicular nerves and the point adjacent to the tibial periosteum in the medial side of the junction between tibial medial epicondyles and tibial shaft for inferomedial genicular nerve were imaged under fluoroscopy. 1 cc 2% lidocain (20 mg) was injected subcutaneously to each point determined. For each genicular nerve, a 10-cm-long, 22-gauge RFT cannula with a 10-mm-long active tip (NeuroThermTM, Medpoint GmbH, Hamburg, Germany) was advanced under fluoroscopy with the assistance of anteroposterior (Figure 1) and lateral (Figure 2) imaging.

Needles were brought to the final position. Then, sensational (50 Hz) and motor (2V) stimuli were given to verify the position of the needles. From each cannula, 1 cc 2% lidocaine was injected. Then, radiofrequency thermocoagulation was applied to each location at 80 degrees for 90 seconds.

They were positioned in the same way in group U and in group F. They were cleaned in the same way and draped. Musculoskeletal ultrasound imaging (Mylabfive, Esaote Europe BV, Maastricht, Netherlands) with linear transducer (8-14 MHz) was used for the group U. USG transducer was placed in the long axis in the lateral and medial of the junction between femoral epicondyles and femoral shaft and in the medial of the junction between the tibial medial epicondyle and femoral shaft. Then the transducer was moved slightly downward to detect the genicular arteries. The inferomedial (Figure 3), superomedial (Figure 4), and superolateral genicular (Figure 5) arteries that were detected were used as a guide to navigate the needle as they were adjacent to the nerves with the same names. Later on, the local anesthetics, cannulas, stimulation doses, and RFT techniques were precisely similar to the fluoroscopy group.

A blinded nurse evaluated patients' VAS (0-10) and WOMAC scores. VAS and WOMAC were used to record the degree of pain and arthritis score experienced by patients during their initial examinations prior to the procedure. The VAS and WOMAC were used to measure the level of pain and arthritis score experienced by patients one and three months following their GN RTF procedure.

All patients in group F (fluoroscopy), group U (USG), and group N (none) continued to take non-

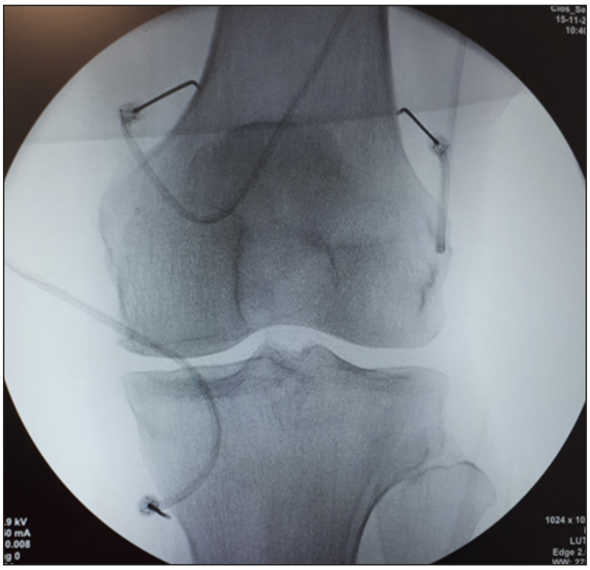

Figure 1. RFT cannulas on AP imaging.

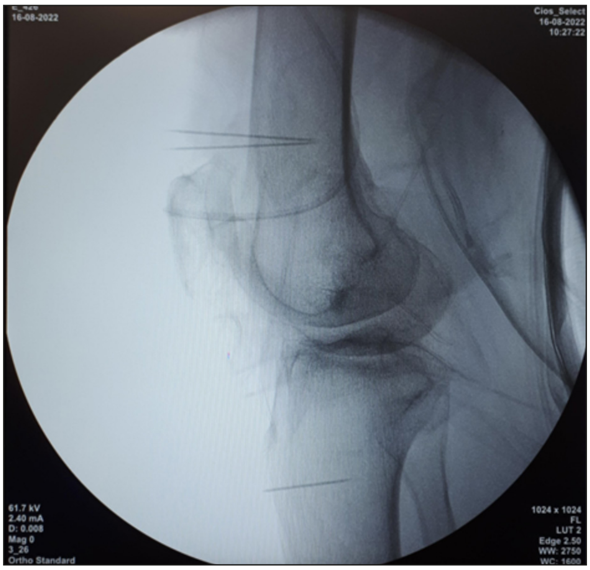

Figure 2. RFT cannulas on lateral imaging.

steroidal anti-inflammatory drugs (NSAIDs) for 3 months. Patients in group N did not accept the interventional procedure and were given just NSAIDs therapy. The VAS scores of the patients in these three groups were recorded on Day 0, day 30, and Day 90. The pain scores of all patients were assessed.

Statistical Analysis

The statistical analysis of the study was performed using SPSS software (IBM Corp., Armonk, NY, USA). To assess age, sex and body mass index (BMI), an independent *t*-test was used. Temporal variations in pain severity and differences between the groups were assessed with repeated measures of ANOVA. The values were expressed as mean ± standard deviation (mean±SD). $p<0.05$ was considered significant.

Results

197 patients who were admitted due to knee pain were included in our study. Seventeen patients were lost to follow-up. Data from 180 patients were recorded. 140 of the patients included in our study (n: 180) (78%) were females, while 40 (22%) were males. All patients had a history of taking NSAIDs. No complications were observed. The mean age of the patients was 64.01±8.75. There was no statistically significant difference between the three groups as regards their age. The BMI of the patients was assessed. The BMI of all patients was 29.91±4.44. The difference was statistically insignificant between the three groups. The patients' demographics are shown in Table I.

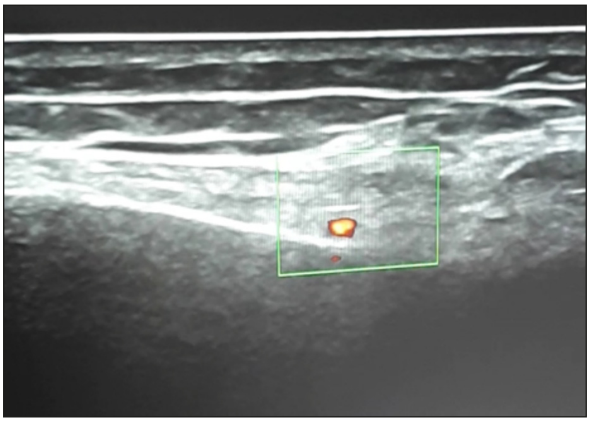

Figure 3. Inferomedial genicular artery.

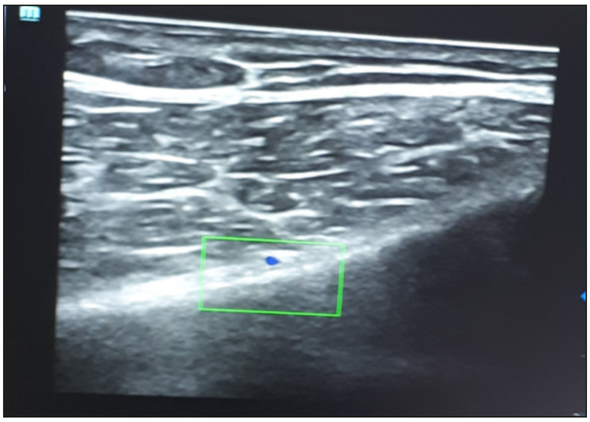

Figure 4. Superomedial genicular artery.

Prior to the procedure, the VAS score of group F was 6.65±0.94, while it was 5.88±0.92 in group U and 6.40±1.12 in group N. There was no statistically significant difference between the baseline VAS of the three groups. At 1 month, the VAS score was 3.83±1.67 in Group F, 2.27±1.16 in Group U and 6.42±1.17 in Group N. At month 3, the VAS was 3.92±1.67 in Group F, 2.28±1.11 in Group U, and 6.47±1.11 in Group N. VAS values of the patients are presented in Table II.

Regarding VAS values before and after the procedure, a statistically significant difference was found between the three groups. The VAS values of group U and group F at 1 month and 3 months were observed to be significantly lower than that of group N. Moreover, the VAS value of group U was found to be lower than that of group F, which was statistically significant. The difference between the values before and after the procedure in Group U was found to be higher than that of group F and statistically significant.

As for WOMAC values of the patients, the value of group F before the procedure was 61.42±11.73, while it was 57.55±10.74 in group U and 61.47±11.72 in group N. There was no statistically significant difference between the baseline WOMAC of the three groups. At 1 month, WOMAC was 38.47±15 in group F, 24.73±13.15 in group U and 63.37±13.03 in group N. At 3 months, WOMAC was 37.5±13.06 in group F, 24.98±12.05 in group U and 62.97±12.22 in group N. WOMAC values of the patients are presented in Table III.

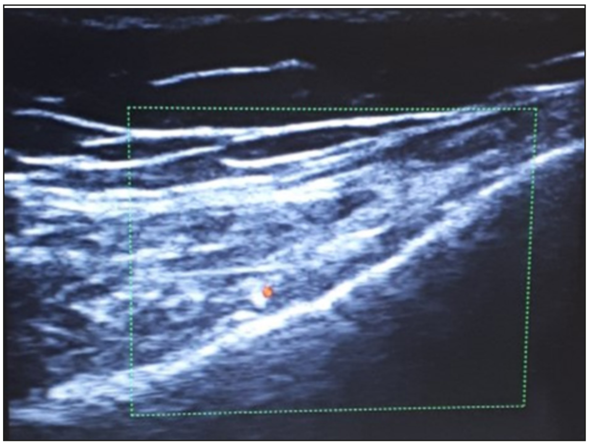

Figure 5. Superolateral genicular artery.

A statistically significant difference was found between the WOMAC values of the 3 groups before and after the procedure. As for the WOMAC values at 1 month and 3 months, group U and group F had significantly lower value than group N. Moreover, the WOMAC value of Group U was observed to be lower than that of group F, which was found to be statistically significant. The difference between the values of group U before and

Table I. The demographics of patients.

	Group U	Group F	Group N	*p*
Age	64.77±8.83	62.73±7.93	64.53±9.42	0.381
Body Mass index	30.23±4.08	29.66±4.84	29.85±4.43	0.592
Gender (male/female)	13 (21.7%)/47 (78.3%)	11 (18.3%)/49 (81.7%)	16 (26.7%)/44 (73.3%)	0.543

Table II. VAS values of patients prior to the procedure and at 1 month and 3 months after the procedure.

	Group U	Group F	Group N	*p*
VAS baseline	6.65±0.94	5.88±0.92	6.4±1.12	0.0001
VAS 1. month	3.83±1.67	2.27±1.16	6.42±1.17	0.0001
VAS 3. months	3.92±1.67	2.28±1.11	6.47±1.11	0.0001

Table III. WOMAC values of the patients before the procedure and at 1 month and 3 months after the procedure.

	Group U	Group F	Group N	*p*
WOMAC baseline	61.42±11.73	57.55±10.74	61.47±11.72	0.1
WOMAC 1. month	38.47±15	24.73±13.15	63.37±13.03	0.0001
WOMAC 3. month	37.5±13.06	24.98±12.05	62.97±12.22	0.0001

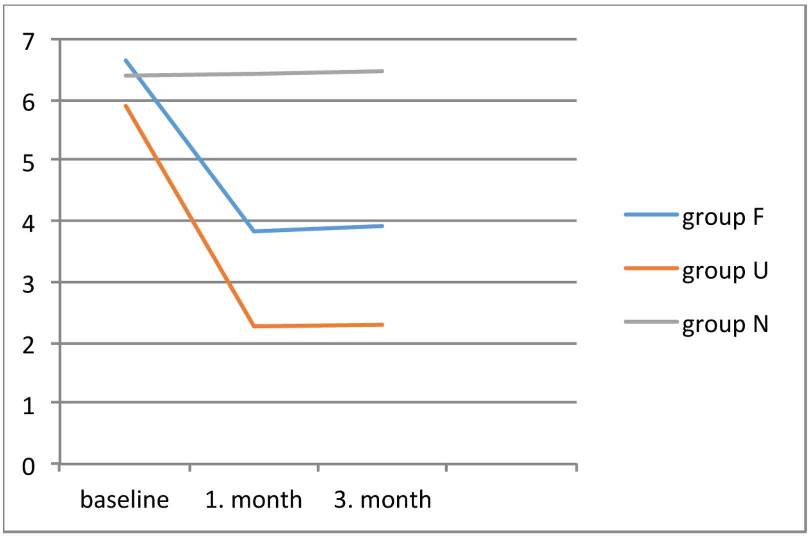

Figure 6. Variations in VAS before and after the procedure.

after the procedure was greater than that of group F, which was statistically significant.

Finally, VAS and WOMAC values of group U decreased greater than those of group F (Figure 6, 7), which was found to be statistically significant.

Discussion

Knee osteoarthritis is a disease with an increasing incidence that leads to disability. There are several studies in literature showing that RFT of genicular nerves is beneficial in the treatment of pain due to osteoarthritis. Fluoroscopic guided GN RFT has been commonly used, and several studies[15,16] showing the effectiveness of this procedure have been published since Choi et al[6] reported the successful results of patients for whom GN RFT was applied under fluoroscopy.

In our study, a marked difference was found comparing the fluoroscopy and USG group with the control group. With the recently increased

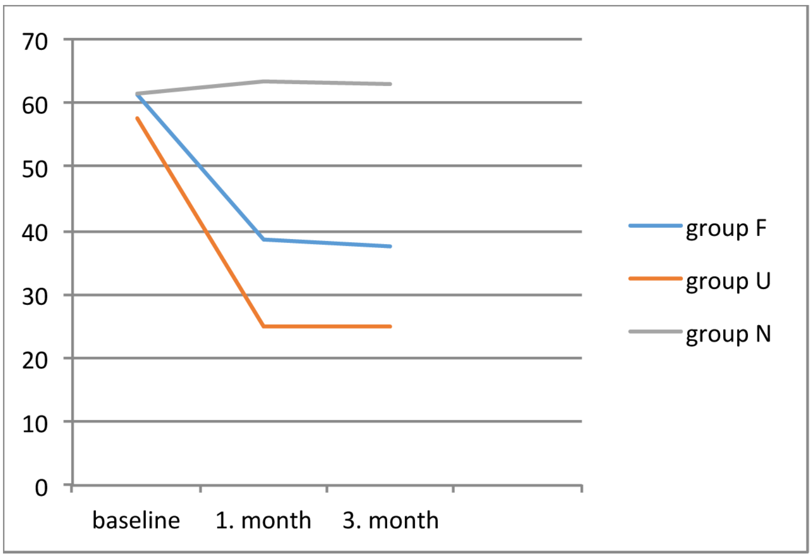

Figure 7. Variations in WOMAC before and after the procedure.

use of USG in pain treatment recently, USG-guided GNB and GN RFT have been performed[17-19]. Compared to the use of fluoroscopy, the use of USG during the procedure has several advantages. Many studies[11,13,20] using USG-guided GNB also highlighted the advantages of USG.

In a study comparing fluoroscopy *vs.* USG-guided GNB, both methods were demonstrated to have similar results in terms of pain relief, functional improvement, and safety[12]. In another study[11] comparing USG and fluoroscopy-guided GN RFT, VAS scores were found to be lower in the USG group at 3 and 6 months, although they were similar at 1 month.

When comparing patients who received the genicular nerve RFT under USG guidance to those who underwent the same procedure under fluoroscopic guidance, it was discovered that the rate of reduction in pain severity in the USG-guided patients was significantly higher in our study.

We think the location of the nerve could be determined more precisely under USG guidelines. During fluoroscopy-guided GN RFT, we placed the needle on the junction between the femoral epicondyle and femur shaft tangentially to the femur shaft. As a matter of fact, we can easily see these bony structures via USG. Besides, we could also visualize the genicular artery, which allowed us to use another landmark. Therefore, we think that the procedure can be performed more accurately. The disadvantage of USG is that it may be difficult to see these landmarks in obese patients.

In a cadaver study, Fonkoue et al[21] reported that the commonly used landmarks located during fluoroscopic-guided GN RFT were not accurate and should be revised. In our study, we also used these landmarks used by Choi et al6, as we described above in the methods section. In that cadaver study[21], they argued that the landmarks used to locate the superomedial genicular nerve and superolateral genicular nerve using fluoroscopic-guided RFT might not be fully accurate, while they also reported that the landmarks used to locate inferomedial genicular nerve were consistent with their study. We think that one of the reasons why we had more successful results with USG-guided GN RFT in our study might be because the fluoroscopic landmarks are more up-to-date. However, there is a need for further studies to verify this hypothesis.

A similar cadaver study[22] was conducted to locate superomedial and inferomedial genicular nerves under USG guidance. Medial collateral ligament and adductor tubercule of the femur were used as landmarks to locate genicular nerves, and it was reported that the authors located the genicular nerves definitively with USG. In our study, we used genicular arteries as landmark. In the cadaver study, arteries could not be visualized. Genicular nerves are very small, which makes it difficult to visualize them. However, genicular nerves run in parallel to arteries, and close proximity of genicular arteries to nerves is an advantage for us[23]. Another cadaver study[24] showed that genicular nerves and arteries might have a different course proximally and were almost in contact with the femur and tibia in the distal end. Therefore, we think the genicular arteries we used as landmarks during USG-guided GN RFT are extremely guiding landmarks.

Protzman et al[25] located the bony landmarks during GN RFT under fluoroscopy he performed for a patient with knee prosthetic and identified genicular branches under USG guidance. He also checked the final position of the needles under fluoroscopy. In fact, as we mentioned above, landmarks can also be located under USG guidance unless patient is very obese. We think that extra radiation exposure is unnecessary.

Patients and interventionists are not exposed to radiation during the procedures performed under USG guidelines, which is a significant advantage for both patients and physicians. Target images are compromised due to patient movement, but target tissues can be seen repeatedly under ultrasound without radiation exposure.

An essential advantage of ultrasound guidance is locating vascular structures easily. In this way, vascular structures around joints can be easily visualized. Vascular complications may develop due to the injury of genicular arteries during surgical procedures performed for knee joints. The most common injury has been observed in the lateral superior genicular artery. This is followed by the medial superior genicular artery and medial inferior genicular artery. Pseudoaneurism and arteriovenous fistula, hemarthrosis, and osteonecrosis of the patella are the most common conditions that are caused by vascular injuries[24]. Vascular structures may be missed because they cannot be visualized during fluoroscopy-guided GN RFT due to these complications observed during surgical procedures. Anteromedial hematoma of the thigh was reported[26] in a patient after fluoroscopy-guided GN RFT.

When the injections are carried out under the USG guidance, the danger of vascular injection is significantly reduced. Because the needle and target tissue can be seen during block under USG guidance, the number of needle movements can be reduced, and puncture of vascular structures can be avoided in patients taking anticoagulants. The danger of bleeding and hematoma is reduced; as a result, it represents a significant advantage compared to the blocks under fluoroscopic guidance. We observed no complications during the procedures we performed.

One of the most important goals of employing ultrasound during interventional pain therapy is to increase the safety of both the patient and the physician. Complications can be caused by various circumstances, including technical difficulties, patient-related factors, and, most crucially, physician-related factors. The placement of the needle tip during the injection, the anatomy of the operation site, and precise imaging of neighboring structures help reduce the risk of complications during the procedure.

The use of USG offers other advantages, such as ease of use, accessibility, and portability. At the same time, it is well-recognized that the use of USG can improve the safety of patients and procedures.

Conclusions

Our study results show that we obtained more successful results with USG-guided GN RFT. We think that the main reasons why USG is preferred for the procedures are because there is no radiation exposure during the procedure, USG is affordable, usable, and portable; target tissue, surrounding soft tissues and vascular structures can be clearly visualized and thus the success of the procedure can be increased, and potential complications can be prevented. Due to all these reasons, we think that the use of USG is safer and more effective than the use of fluoroscopy in RFT of genicular nerves.

Conflict of Interest

The Authors declare that they have no conflict of interest.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Ethics Approval

The study was approved by the Research Ethics Committee (REC) of Akdeniz University with number 70904504/133.

Data Availability

The data that support the findings of this study are available from the corresponding author, [GD], upon reasonable request.

Authors' Contributions

All the authors equally contributed, read and approved the final manuscript. Both authors confirm responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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