Results of genicular nerve ablation by radiofrequency in osteoarthritis-related chronic refractory knee pain

Abstract

Background/aim: The aim of this study was to investigate the medium- to long-term effects of radiofrequency (RF) ablation of genicular nerves for chronic refractory knee pain due to osteoarthritis (OA).

Materials and methods: Forty-eight patients who underwent RF ablation of the genicular nerves were evaluated retrospectively. The visual analogue scale (VAS) score, Western Ontario and McMaster Universities Arthritis Index (WOMAC index), opioid and nonsteroidal anti-inflammatory drug (NSAID) use score, quality of life score, and treatment satisfaction score were examined at 1, 3, and 6 months after the procedure.

Results: The mean VAS scores were significantly lower at the 1, 3 and 6 months evaluations compared with the preoperative values ($p < 0.001$). A significant decrease was observed in the WOMAC index compared with the preoperative value ($p < 0.001$). It was found that 66.7% of opioid users and 56.3% of NSAID users stopped using medication. No serious complications were encountered during or after the procedure.

Conclusion: It was concluded that, in chronic refractory knee pain due to OA, the application of RF ablation to the genicular nerve is an effective and safe treatment option in the medium to long term.

Keywords: Knee osteoarthritis; Pain; Genicular nerves; Radiofrequency ablation

1. Introduction

Osteoarthritis (OA) is a noninflammatory chronic degenerative disease characterized by progressive cartilage damage, osteophyte formation, and subchondral sclerosis. Knee OA
is one of the most common joint diseases occurring in adults, and it has become an
important health problem all over the world with the increases in mean duration of life
and obesity [1, 2]. Its most important risk factor is age, and it has a prevalence as high as
40% in the population aged 70–75 years [3]. Especially in elderly populations, it is among
the leading causes of pain, physical disability and functional limitations.

As there is no curative treatment for OA, the current treatment approach is
increasing quality of life via patient exercise training and pain control, decreasing
physical and functional impairment and disability and preventing the progression of
disease. For this purpose, various treatment modalities that are conservative or surgical
are employed [4]. Conservative treatment modalities include pharmacological methods
(topical agents, simple analgesics opioids, antidepressants, etc.), nonpharmacological
approaches (training, exercise, physiotherapy, orthesis, acupuncture, etc.), or minimally
invasive approaches like corticosteroid, viscosupplement, or platelet-rich plasma (PRP)
injection to the intra-articular region. However, these modalities fail to treat advanced
OA or stop its progression. In mild to moderate OA, several surgical techniques have
been established; in addition to conventional arthroscopic procedures, various surgical
options are effective and safe. High tibial osteotomy (HTO) techniques, such as medial
opening wedge HTO [5] and arthroscopic “L” medial release [6], are well-accepted
procedures. Total knee arthroplasty (TKA) offers satisfactory outcomes in the treatment
of chronic refractory knee pain and loss of function caused by severe knee OA. However,
survival and complications are a source of concern. Despite satisfactory results, the
uptake of this corrective surgery has been defined to be extremely low in many parts of
the world. Many factors, such as knowledge, sociocultural factors, and expectations of
TKA influence patients’ decisions regarding this procedure. In a recent study by Al-
Mohrej et al. [7], where the researchers aimed to measure the knowledge and attitudes related to TKA among the Saudi population, it was reported that there are still misinformation among the public concerning TKA, its indications, and its results in Saudi Arabia. As emphasized by this study, efforts to address misinformation could lead to better patient–doctor interaction and increase patient satisfaction. This will allow more patients to benefit from this important and effective surgical treatment approach.

In some patients, treatment cannot be continued owing to side effects, while in others, despite the treatments administered, adequate and efficient pain control cannot be obtained [8]. In patients with OA-associated chronic knee pain that does not respond to conservative treatments, or where the patients do not want to undergo operation or surgery is counter-indicated due to accompanying pathologies, in recent years, application of radiofrequency (RF) ablation to intra-articular and periarticular regions as a novel and effective treatment option has started to be reported in the literature. Among these studies, there are also those reporting the application of this technique to genicular nerves [9-19].

It is known that the knee joint is innervated by joint branches, termed genicular nerves, which originate from distal parts of the femoral, sciatic, and obturator nerves [20]. It is evident that many studies are needed to determine the efficacy and reliability of RF ablation methods applied to the genicular nerves and develop procedural protocols and algorithms for users. The aim of the present study was retrospectively evaluating the effect of conventional RF application on the genicular nerves for medium- to long-term pain control, functional improvement, and patient satisfaction in the treatment of chronic refractory knee pain associated with OA.

2. Materials and Methods

2.1. Patient Selection
The present study was carried out in our department after approval was obtained from the local ethics committee. In the present study, data from 50 patients who were diagnosed with OA between January 2016 and January 2017 were evaluated retrospectively through the review of patient file records obtained via telephone or face-to-face interview. The patients were diagnosed using the criteria of the American College of Rheumatology (ACR). They had stage III or IV knee OA as determined on physical examination and using the Kellgren–Lawrence (KL) radiological scale. Moreover, due to chronic refractory knee pain that did not respond to conservative treatments, they underwent diagnostic genicular nerve block, which resulted in more than a 50% decrease in pain; subsequently, the patients underwent conventional RF ablation in the genicular nerves.

Patients with the following characteristics were excluded from the study: metabolic diseases like chronic rheumatism, inflammatory diseases like gout, advanced cardiac/renal disease, liver disease, uncontrolled diabetes, dementia, or psychiatric disorders; those who used antiplatelets/anticoagulants or had a coagulation disorder; and finally, those who had undergone intra-articular intervention in the last 3 months with infection at the site of intervention. In addition, one patient was excluded due to inadequate file records and another because an emergency cardiac operation was necessary during the follow-up period. Overall, 48 patients who fulfilled the criteria were included in the study.

### 2.2. Application of the diagnostic block to the genicular nerves

The application of the diagnostic block to the genicular nerves was performed by the same physician under operating theater conditions and standard monitoring (electrocardiogram [ECG], pulse oximeter, noninvasive arterial pressure) and superficial sedoanalgesia,
accompanied by fluoroscopic imaging as an outpatient intervention. The details of the procedure are described below.

The anatomical topography of the genicular nerves is shown in Figure 1. In the supine position with the knee at 30–40° flexion and supporting the region under the knee, the region was cleaned in accordance with the asepsis/antisepsis rules. Fluoroscopy with a C arm was brought to the anteroposterior position, and the tibiofemoral joints were visualized. Subsequently, the probable positions of the superior-medial, superior-lateral, and inferior-medial genicular nerves were identified with anteroposterior images. Skin anesthesia was provided under sterile conditions with a 25G needle and 0.5 cc of 1% lidocaine. Subsequently, each nerve was reached using 22G Whitacre spinal needles. The needles were advanced while maintaining bone contact after their positions were corroborated in images of fluoroscopy (intersection point of 2/3 anterior and 1/3 posterior of the femur and tibia), each genicular nerve was blocked with 1 cc of 2% lidocaine.

2.3. Application of conventional RF ablation to the genicular nerves

Patients whose pain decreased by over 50% after diagnostic block underwent conventional RF application. The steps described in the diagnostic block were followed in a similar manner until the administration of local anesthesia. Following local anesthesia, 22G RF needles with an active tip and 100 mm length were inserted from predetermined entrance points to produce a lesion in the nerve. The needles were advanced while maintaining contact with the bone, and the positions of needles were confirmed with lateral fluoroscopy images at the intersection point of 2/3 anterior and 1/3 posterior of the femur and tibia. Then, an electrode placed in an RF needle was connected to an RF generator (Neurotherm NT-1100), and motor (0.5V) and sensorial (50 Hz) stimulations were applied to each genicular nerve to ensure the correct position of the
needle. After ensuring that the motor stimulus was not received until about 2V, the RF
denervation procedure was initiated. Before RF application, each nerve was administered
2 ml of 2% lidocaine and then conventional RF was applied at 80°C for 60 seconds. The
electrode position is shown in Figure 2.

2.4. Evaluation of the patients
The demographic information of all the patients, as well as their clinical characteristics
before the procedure and KL radiological staging, were recorded. The primary aim of the
study was determining the decrease in the severity of pain in the moderate and long term,
while the secondary aim was the determination of the increase in moderate- to long-term
quality of life and patient satisfaction. For this purpose, in the evaluation at 1, 3 and 6
months and in the follow up, the variables described below were used.

Severity of pain was evaluated with 10 cm visual analog scale (VAS). A VAS
score < 4 was considered to represent adequate analgesia. The physical functions of the
knee were evaluated using the Turkish validated form of Western Ontario McMaster
Universities Osteoarthritis Index (WOMAC) [21]. For pain, stiffness, and physical
functions, WOMAC-P, WOMAC-S, and WOMAC-PF index scores, respectively, and
total WOMAC (WOMAC-T) scores obtained from the sum of these three parts were
recorded. In patients who were on nonsteroidal anti-inflammatory drugs (NSAIDs) and/or
opioids prior to the procedure, whether the treatment used had any effect on drug use was
evaluated using a 3-point scale (1: similar, 2: decreased, 3: discontinued). To evaluate the
effects of the treatment on quality of life, the following question was asked: “How did
your quality of life change?” In response, the patients were instructed to choose one of
four options, namely, better, good, similar, or bad. At the end of the study, the patients
were asked if they were satisfied with the treatment, and the responses were scored as follows: 1: bad, 2: moderate, 3: good, and 4: perfect.

2.5. Statistical analysis

With the analysis made using the G-Power program before the study, it was calculated that, with an error margin of 0.05, statistical power of 0.95, and effect size of 0.5, at least 30 patients needed to be included in the study. Predicting that there could be missing follow-up forms, 50 patients were enrolled.

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) 15.0 program. The descriptive statistics were expressed as the mean, standard deviation, median, and minimum and maximum for continuous variables and the number of cases and percentage (%) for categorical variables. The Shapiro–Wilk test was used to evaluate whether continuous variables were normally distributed.

Whether there were statistically significant differences between the VAS, WOMAC, and quality scores at different follow-up times was investigated using the Friedman test for data that were nonlinearly distributed. When the result of Friedman test was found to be significant, the Wilcoxon signed-rank test was employed to determine the follow-up timepoint(s) creating the difference. When the data were linearly distributed, the follow-up timepoint creating the difference was detected with the paired-samples t-test. Whether there was significant difference in the use of opioids and NSAIDS at 1, 3 and 6 months compared with the baseline was investigated using Pearson’s chi-square test. Whether there was correlation between the VAS scores and WOMAC, satisfaction, and quality of life scores was investigated with Spearman correlation tests in data that were not linearly distributed. A \( p \)-value < 0.05 was considered significant for all the results.
3. Results

The demographic and clinical characteristics of the 48 patients (29 [60.4%] female, 19 [39.6%] male) included in the study are demonstrated in Table 1. The mean VAS scores of the patients included in the present study at different time points are shown in Table 2. VAS values were found to be under 4 in all the patients except for one at the end of 1 month and three patients at the end of 6 months. Compared with the VAS score before the procedure, the mean VAS scores at 1, 3 and 6 months after the procedure were significantly lower ($p < 0.001$; Figure 3).

Post-treatment opioid use scores of patients who were on opioids prior to the procedure are demonstrated in Figure 4. Before treatment, 18 patients (37.5%) were taking opioid analgesic drugs. At 1, 3 and 6 months after treatment, the measurements showed that 61.1%, 27.8%, and 33.3% of the patients, respectively, had decreased their opioid use, and 38.9%, 72.2%, and 66.7% discontinued opioid use, with statistically significant changes ($p < 0.001$; Figure 4).

Before the procedure, 100% of the patients were on NSAIDs. It was established that, at 1, 3 and 6 months post treatment, 41.7%, 43.8%, and 39.6% of the patients, respectively, decreased their NSAID use, while 50%, 52.1%, and 56.3% completely discontinued them, with statistically significant changes between the values before the procedure and those after the procedure ($p < 0.001$; Figure 5).

The changes in the mean WOMAC scores of the patients are shown in Table 3. Compared with the values before the procedure, the WOMAC-P, WOMAC-PF, and WOMAC-S scores were found to be significantly decreased at 1, 3 and 6 months after treatment. Similarly, the total WOMAC scores were lower at 1, 3 and 6 months compared with the baseline, and they were significantly lower at 3 and 6 months compared with 1
The greatest decrease in the WOMAC-T score compared with the pretreatment values occurred at 6 months.

Significant improvement was observed in quality of life after treatment (Figure 6). At 1, 3 and 6 months after treatment, 79.1%, 79.2%, and 79.1% of the patients, respectively, reported that their quality of life was “better.” It was established that, at 1, 3 and 6 months, the quality of life scores increased as the VAS scores decreased, but a significant correlation was only found between the 6 month VAS scores and quality of life scores (coefficient of correlation = −0.41, p = 0.003).

After treatment, the patients’ satisfaction levels were high. The satisfaction levels were as follows: 77.1% “perfect,” 14.6% “good,” 6.3% “moderate,” and 2.1% “bad.” After the end of the study, 97.9% of the patients (all except one) reported that they would undergo the procedure again. A significant negative correlation was found between patient satisfaction and the WOMAC-T score; that is, at all timepoints, the patient satisfaction level was seen to increase as the WOMAC-T score decreased.

No serious side effects or complications occurred in association with the treatment applied. In two patients, hematoma and ecchymosis occurred at needle sites; in one patient, painless paresthesia around the knee was evident, and this resolved spontaneously without treatment in 1 day.

4. **Discussion**

In the present study, it was demonstrated that, in chronic refractory knee pain associated with OA, application of conventional RF ablation led to decreased analgesic use and increased quality of life and patient satisfaction. Moreover, it resulted in effective analgesia and functional improvement in the medium and long term, without serious side effects.
Ever since the first publication on pulsed RF application to the intra-articular region [22], studies investigating the efficacy of various RF modalities, such as conventional RF [9-16], cooled RF [17-19], and pulsed RF [23-25] applied to the intra-articular and periarticular regions in patients with chronic knee pain. Many such studies have been reported in the literature in the last decade.

The application of conventional RF to genicular nerves under fluoroscopic guidance was originally described by Choi et al. [9] in 2011. In their randomized, double-blind study, in which genicular nerve blockage and conventional RF were compared, it was stated that there was over 50% relief and associated functional improvement in knee pain for 12 weeks without any side effects. In this procedure, a 100 mm RF needle with active tip was used, and at each nerve lesion, it was operated at 70°C for 90 seconds.

In the present study, for conventional RF application, a 100 mm active-tip RF needle was used, and unlike in Choi et al.’s study [9], a lesion was produced at each nerve at 80°C for 60 seconds. In the median VAS scores, a 75% reduction was observed in the 1, 3 and 6 months measurements. At 6 months, when follow up was terminated, the percentage of patients with VAS scores ≤ 4 was found to be quite high (93.75%). In parallel to the satisfactory analgesia obtained, analgesic consumption decreased, while quality of life increased significantly. Moreover, no serious side effects occurred. As the duration of follow up was 6 months, it could not be determined how long the obtained effect lasted. However, it has been observed in clinical practice that the clinical effect was maintained for up to 1 year.

In the present study, for the evaluation of the efficacy of treatment, the WOMAC OA index was also used and compared with that of the preprocedural period, and a significant decrease was found in the total and subgroup scores of WOMAC at all follow-
up timepoints. The results of the present study are compatible with those of many studies using WOMAC as an indicator of improvement in quality of life, and similar to those studies, it demonstrated that conventional RF considerably decreased knee pain, stiffness, and disability after 6 months of follow up [9,13,16].

In conventional RF, the size of the lesion varies depending on the distance to the nerve, duration of application, target heat, and length of the active tip. In the studies regarding conventional RF application to genicular nerves, there is no standardization in the parameters used. For example, the length of the active tip varies between 5 and 10 mm, the heat of the procedure varies between 60 and 80°C and duration of procedure varies between 90 and 270 seconds. Although comparative studies have not been carried out, it is our view that these technical differences may change the long-term of efficacy of conventional RF. For instance, in studies with 3–6 months of follow up and 10 mm active-tip RF needles [9-12,15,16], the improvements lasted for similar periods to that in the present study. In the study by Ikeuchi et al. [14], who used a 5 mm active-tip RF needle, the improvement disappeared within 6 months. In contrast, in a retrospective study in which the lesion was applied at 60°C, which is generally preferred in the literature, a temperature of 80°C was reported to achieve physical and functional improvement for 6 months, similar to the results of other studies [12]. In the present study, in which the lesion was produced at 80°C using an RF needle with a 10 mm active tip, unlike other studies, the duration of the procedure was 60 seconds, but adequate physical and functional improvement was obtained. Therefore, it is our suggestion that randomized prospective studies comparing the degree and duration of lesion production, as well as an active tip, are required.
In RF applications, in addition to conventional method, cooled RF and pulsed RF methods may also be utilized. Although there has been no randomized study comparing these methods on a one-to-one, in a recent review by Gupta et al. [26] evaluating the efficiency of three methods, it was reported that all three have similar safety and efficiency profiles.

In the literature, there are also studies comparing RF methods with conservative treatments. In a study in which intra-articular steroid, local anesthetic, and opioid injections were compared with conventional RF, it was concluded that conventional RF application to the genicular nerves provided better analgesia and improved joint functions efficiently and reliably [16].

Recently, RF application to genicular nerves, which has traditionally been carried out under fluoroscopy, has begun being carried out with the accompaniment of ultrasonography (USG) [15,22]. Compared with fluoroscopy, the advantages of USG are that it is easier, provides more accurate visualization of neurovascular structures, and does not involve exposure to radiation [22]. However, there is not adequate evidence at present indicating the superiority of USG to fluoroscopy; furthermore, the need for devices and the requirement for additional training are among its disadvantages. In a recent anatomic study performed with cadavers, it was demonstrated that, although the course of nerves were variable at the proximal area, in the distal region, where there was contact between the femur and tibia, it was constant [27]. Therefore, it is our opinion that the probability of unsuccessful block due to anatomic variation is not high in this region, and conventional RF application to the genicular nerves can be carried out safely and efficiently under guidance of fluoroscopy.
In OA-associated knee pain, conventional RF application to the genicular nerves is regarded as a safe method with low complications rates, since no serious side effect has been reported so far. The results of the present study also confirm this, with no complications occurring except for hematoma and ecchymosis at the needle sites in two patients and painless paresthesia lasting for 1 day around the knee and resolving spontaneously in one patient. Recently, in a study by McCormick and Walega [28], a case of third degree skin burn of a size of 8 mm was reported in the injection region following the application of conventional RF with a 100 mm active-tip needle at 80°C for 90 seconds. Investigators have stressed that, to prevent skin burns that may develop in RF ablation applications, especially in patients with a low body mass index, the length of the electrode’s active tip, degree of the lesion, and duration of the procedure should be individualized, and to avoid the risk of electrode migration, fluoroscopic images should be obtained at certain intervals. Although no complications occurred in the present study, considering the complications reported more frequently in the literature with the increasing popularity of the procedure and emphasis placed on probable complications, we suggest that it is important to take precautions during applications in accordance with the recommendations; furthermore, when necessary, treatment should be individualized in this context.

The study’s lack of a control group, retrospective nature, and follow-up duration limited to 6 months can be considered the limitations of the present research. It is our view that the present study may serve as guidance for further prospective, controlled, and long-term studies comparing RF applications with both placebo and other RF methods (pulsed RF, cooled RF, etc.).
In conclusion, in chronic refractory knee pain associated with OA, conventional RF ablation application to the genicular nerves is an effective analgesia method that decreases the consumption of NSAIDs and opioids in the medium and long term, provides functional improvement with satisfactory and adequate analgesia, and increases quality of life, with high patient satisfaction and no serious side effects. However, further longer term randomized, controlled, double-blind studies with larger patient series are required to substantiate these findings.
References


# Table 1. Demographic and clinical characteristics of the patients

<table>
<thead>
<tr>
<th>Variables</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong> (year)</td>
<td>77.2 ± 5.2</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>29 (60.4%)</td>
</tr>
<tr>
<td>Male</td>
<td>19 (39.6)</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>77.1 ± 5.1</td>
</tr>
<tr>
<td><strong>Side</strong></td>
<td></td>
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<tr>
<td>Single knee</td>
<td>42 (87.5%)</td>
</tr>
<tr>
<td>Both knees</td>
<td>6 (12.5%)</td>
</tr>
<tr>
<td><strong>Duration of pain (Year)</strong></td>
<td>4.7 ± 1.8</td>
</tr>
<tr>
<td><strong>KL stage</strong></td>
<td></td>
</tr>
<tr>
<td>Stage 3</td>
<td>41 (85.4%)</td>
</tr>
<tr>
<td>Stage 4</td>
<td>7 (14.6%)</td>
</tr>
<tr>
<td><strong>Arthroscopic Surgery</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>11 (22.9%)</td>
</tr>
<tr>
<td>No</td>
<td>37 (77.1%)</td>
</tr>
<tr>
<td><strong>Baseline Opioid use</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>18 (37.5%)</td>
</tr>
<tr>
<td>Absent</td>
<td>30 (62.5%)</td>
</tr>
<tr>
<td><strong>Baseline NSAID use</strong></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>100 (100%)</td>
</tr>
<tr>
<td>Absent</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Data are expressed with mean ±SD (standard deviation) and n (number of patients)
Table 2. Mean (±SD), median, minimum and maximum VAS scores at different follow up times

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean ±SD</th>
<th>Median</th>
<th>Smallest</th>
<th>Largest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the procedure * ± €</td>
<td>48</td>
<td>7.4 ± 1.3</td>
<td>7</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>1. month *</td>
<td>48</td>
<td>2.2 ± 1.0</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>3. month ±</td>
<td>48</td>
<td>1.5 ± 1.0</td>
<td>1.5</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6. month €</td>
<td>48</td>
<td>2.0 ± 1.2</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

* The difference between the baseline and 1. month is statistically significant (p < 0.001)

± The difference between the baseline and 3. month is statistically significant (p < 0.001)

€ The difference between baseline and 6. month is statistically significant (p < 0.001)
Table 3. Mean WOMAC-P, WOMAC-S, WOMAC-PF and WOMAC-Total scores at different follow up times

<table>
<thead>
<tr>
<th></th>
<th>Before procedure</th>
<th>1. month</th>
<th>3. month</th>
<th>6. month</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOMAC-P</td>
<td>12.0 ± 2.3</td>
<td>4.9 ± 1.7&lt;sup&gt;±z&lt;/sup&gt;</td>
<td>4.1 ± 1.2&lt;sup&gt;±z&lt;/sup&gt;</td>
<td>3.7 ± 1.2&lt;sup&gt;±z&lt;/sup&gt;</td>
</tr>
<tr>
<td>WOMAC-S</td>
<td>4.4 ± 1.4</td>
<td>2.7 ± 0.9&lt;sup&gt;*&lt;/sup&gt;</td>
<td>2.7 ± 0.9&lt;sup&gt;*&lt;/sup&gt;</td>
<td>2.7 ± 0.9&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>WOMAC-PF</td>
<td>46.1± 6.4</td>
<td>28.8 ± 5.8&lt;sup&gt;*&lt;/sup&gt;</td>
<td>28.7 ± 5.5&lt;sup&gt;*&lt;/sup&gt;</td>
<td>28.5 ± 5.5&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>WOMAC-Total</td>
<td>62.2 ± 9.4</td>
<td>36.5± 7.4&lt;sup&gt;β&lt;/sup&gt;</td>
<td>35.5 ± 6.3&lt;sup&gt;*&lt;/sup&gt;</td>
<td>35.1 ± 6.4&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data are expressed as mean ±SD

* statistically significant difference between before procedure and 1,3,6. month (p < 0.01),

± statistically significant difference between 1. month and 3. month (p < 0.001)

£ statistically significant difference between 3. month and 6. month (p < 0.006)

¥ Statistically significant difference between 1. month and 6. month (p < 0.001)

β Statistically significant difference between 1. month and 3. month. (p < 0.05)

# Statistically significant difference between 1. month and 6. month (p < 0.001)
Figure 1. Innervation of the anterior knee joint [29].

Figure 2. A: anterior/posterior and B: lateral fluoroscopic images of the final electrode positions during conventional RF ablation of the genicular nerves.
Figure 3. The graphic for the change in VAS scores at different follow-up times

* Difference between baseline and 1. month is statistically significant (p < 0.001)

± Difference between baseline and 3. month is statistically significant (p < 0.001)

€ Difference between baseline and 6. month is statistically significant (p < 0.001)

¥ Difference between 1. month and 3. month is statistically significant (p < 0.001)

£ Difference between 3. month and 6. month is statistically significant (p < 0.001)

µ Difference between 1. month and 6. month is not statistically significant (p = 0.26)
Figure 4. Opioid usage scores during follow-up times

Data are as expressed as the percentage of patients

* At 1. month compared to baseline, decrease in opioid use and its discontinuation is statistically significant ($p < 0.001$).

± At 3. month compared to baseline, decrease in opioid use and its discontinuation is statistically significant ($p < 0.001$).

€ At 6. month, decrease in opioid use and its discontinuation is statistically significant ($p < 0.001$).
Figure 5. NSAID usage scores during follow-up times

* At 1. month compared to baseline, decrease in NSAID use and its discontinuation is statistically significant (p < 0.001).

€ At 3. month compared to baseline, decrease in NSAID use and its discontinuation is statistically significant (p < 0.001).

± At 6. month compared to baseline, the decrease in NSAID use and its discontinuation is statistically significant (p < 0.001).
**Figure 6. Quality of life scores during follow-up times**

* 1. month quality of life scores significantly better ($p < 0.05$)

± 3. month quality of life scores significantly better ($p < 0.05$)

¥ 6. month quality of life scores significantly better ($p < 0.05$)