

# Percutaneous Radiofrequency Treatment for Refractory Anteromedial Pain of Osteoarthritic Knees

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## Abstract

**Objective.** Although severe knee osteoarthritis with refractory pain is commonly treated surgically, this is often not an option for patients with poor health status or unwillingness to undergo major surgery. We examined the efficacy of radiofrequency application to sensory nerves as a novel alternative treatment for refractory knee pain.

**Methods.** This study was an open-label, nonrandomized, and controlled study. Patients complaining of refractory anteromedial knee pain associated with radiological osteoarthritis (moderate or severe) were included. They were assigned to one of two groups: those receiving radiofrequency thermocoagulation (N = 18) or those receiving nerve block (N = 17), depending on the time period that they were referred to the clinic. Radiofrequency current or local anesthetics was applied to the medial retinacular nerve and the infrapatellar branch of the saphenous nerve. Western Ontario McMaster Universities osteoarthritis index score, pain visual analog scale (VAS), and patient's global assessment were assessed with a minimum follow-up of 6 months.

**Results.** Radiofrequency treatment significantly decreased knee pain as measured by VAS for 12 weeks compared with the control group. In terms of responders, more patients in the RF group

responded to the treatment than in the control group. The differences were statistically significant at 4 weeks, 8 weeks, and 12 weeks in pain VAS. Eight patients (44%) treated with radiofrequency rated excellent or good but only three (18%) in the control group rated good, although the difference was not statistically significant.

**Conclusions.** Some patients were able to benefit substantially from radiofrequency treatment. Even if its effective period is limited, radiofrequency application is a promising treatment to alleviate refractory anteromedial knee pain with osteoarthritis. Further experience and technical improvements are needed to establish its role in the management of knee osteoarthritis.

**Key Words.** Radiofrequency; Osteoarthritis; Knee; Pain

## Introduction

Knee osteoarthritis (OA) is a major public health problem across the world. Population-based studies revealed that symptomatic knee OA is present in 20–30% of the elderly population aged >65 years [1,2], and its prevalence is increasing due in part to the aging of the population [3]. Clinical symptoms are dominated by chronic knee joint pain, which leads to disability, psychological distress, and impaired quality of life. There are multiple treatment options for knee OA. Although most patients with mild symptom respond to conservative treatments, such as physical therapy, anti-inflammatory drugs, hyaluronic acid injection, etc., these treatments are not sufficient for patients with severe symptoms. Surgery, i.e., total knee arthroplasty, is the only treatment that is validated and reliable for alleviating refractory joint pain in knee OA [4]. However, there are some fragile patients who are at high risk during surgery and other patients who are not willing to undergo surgery. There is general agreement regarding the importance of individualized, holistic, and patient-centered management of knee OA [5]. Because the number of such patients will increase as the population ages, alternative approaches to alleviate their joint pain other than conventional treatments are necessary.

Radiofrequency (RF) treatment has been used for several painful conditions such as trigeminal neuralgia, cancer

pain, and spinal pain [6]. In order to destroy nerves or disrupt the transmission of pain signals, originally by means of producing heat lesions, RF current is applied to the trigeminal ganglion, the spinothalamic tracts of the spinal cord, the medial branches of posterior rami, and the dorsal root ganglion [6]. In addition to these, there have been a few attempts to apply RF current for the treatment of painful conditions of joints of the extremities. Although some authors reported case studies about RF treatment for painful conditions of the hip joint [7–11], its substantive effects are largely unknown. Furthermore, to our knowledge, there have been no reports about RF application to sensory nerves innervating the knee joint in citable literature. The purpose of this study is to examine the effects of RF treatment for refractory anteromedial pain in knee OA.

## Methods

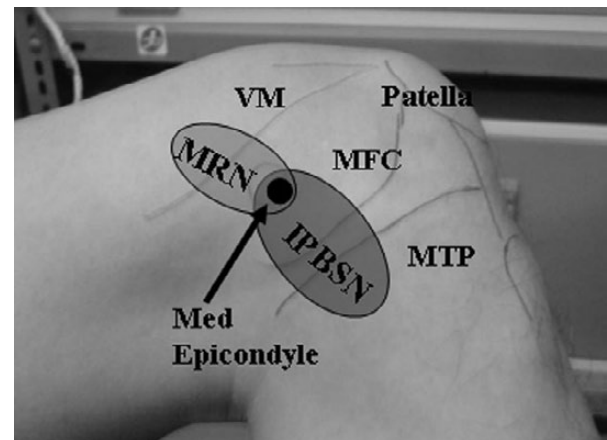
### Patients and Protocol

This study was a prospective, open-label, and controlled study of a convenience sample of patients complaining of refractory anteromedial knee pain associated with radiological knee OA who came to the clinic and were recruited for this study between August 2005 and May 2006. Inclusion criteria were age older than 65 years, previous conservative treatments longer than 3 months, 100-mm pain visual analog scale (VAS) greater than 30 mm, and radiological OA grade 3 and 4 according to the Kellgren–Lawrence grading system (0 = none, 1 = doubtful, 2 = minimal, 3 = moderate, and 4 = severe) [12]. Exclusion criteria were mental handicap or psychiatric conditions precluding adequate communication, coagulation disturbances, allergies to local anesthetics, history of septic arthritis, steroid users, and cardiac pacemaker users. Patients who visited our hospital between August and December 2005 were assigned as candidates for RF treatment (RF group), while patients between January and May 2006 were assigned for nerve block using local anesthesia (control group). The study protocol was as follows: 3 weeks before the first intervention, other concomitant treatments for their knee pain were stopped. Other concomitant treatments included physical therapy performed by a physical therapist, acupuncture, regular use of aspirin or nonsteroidal anti-inflammatory drugs, and intra-articular injection with corticosteroids or hyaluronic acid. Home exercises, as regularly performed by the patients, were allowed to continue. The patients in the RF group underwent two treatments that were 2 weeks apart. In the control group, the same procedures except the application of RF current were performed. All of the patients were assessed at pre-procedure (baseline) every 4 weeks up to 12 weeks (4 weeks, 8 weeks, and 12 weeks) and approximately 6 months (6 months) after the first procedure in the outpatient clinic. Other concomitant treatments were restarted at 12 weeks after the first procedure. Loxoprofen sodium (Daiichi Sankyo, Tokyo, Japan) up to three tablets per day was used as a rescue analgesic drug. Ethics committee approval from our institution was obtained prior to the study. Before study inclusion, each patient was

informed of the objectives and risks of the study and gave his or her consent in writing. Patients were allowed to choose other treatments at anytime. The study was conducted in compliance with the Declaration of Helsinki.

### Procedures

The procedures were performed as an outpatient procedure by a single physician (MI). RF current was applied to two sensory nerves innervating the anteromedial aspect of the knee joint capsule [13]. One was the medial retinacular nerve (MRN), which is the terminal branch of the nerve to the vastus medialis. The other was the infrapatellar branch of the saphenous nerve (IPBSN). Before needle insertion, several landmarks around the medial aspect of the knee including the medial border of the vastus medialis, patella, patella tendon, and the contour of medial femoral condyle and medial tibial plateau were delineated (Figure 1). With the patient in a supine position and the knee slightly flexed, skin at the needle insertion site was locally anesthetized with 0.5 mL lidocaine using a 26G needle. The electrode with a 5-mm active tip (RDG Medical, Croydon, UK) was inserted through a cannulated 22G–50 mm straight needle (Hakko, Nagano, Japan). The active tip was positioned almost parallel to the target nerve. Impedance was verified at 300 to 700  $\Omega$  to confirm proper electrode placement. Applying electrical sensory stimulation via the electrode (100 Hz), the targeted nerves were sought and identified by specific radiating pain. Sensory stimulation threshold was required to be less than 0.5 V. The MRN was sought between the medial border of the



**Figure 1** Medial view of the left knee joint. Several anatomical landmarks were delineated. Each target nerve was sought within each oval area. VM = vastus medialis; MRN = medial retinacular nerve; MFC = medial femoral condyle; IPBSM = infrapatellar branch of the saphenous nerve; MTP = medial tibial plateau; Med Epicondyle = medial epicondyle of the femur.

patella and the adductor tubercle along the inferior border of the vastus medialis [13]. It was commonly located around the point 1 cm proximal and 1 cm anterior to the adductor tubercle (Figure 1). The IPBSN was sought between the adductor tubercle and the pes anserinus along the anterior border of the medial collateral ligament [14]. Specifically, it was sought along accompanying veins that are often visible through the skin. It was commonly located around the point 1–3 cm distal to the adductor tubercle. After checking the radiating pain by electrical stimulation, 1 mL lidocaine was injected. RF thermocoagulation was performed at 70°C for 90 seconds using NeuroTherm (RDG Medical, Croydon, UK).

### Outcome Measures

The Western Ontario McMaster Universities OA index (WOMAC) [15] total score, pain VAS, and the patient's global assessment were used as outcome measures. The WOMAC index is based on Likert scales that allow the patient to self-evaluate the status of his or her condition. The WOMAC score has three discrete domains—pain (five questions, possible subscale score 0–20), stiffness (two questions, 0–8), and physical functioning (17 questions, 0–68)—and has a minimum score of 0 (best score) and a maximum score of 96 (worst score). Pain was evaluated with a 100 mm VAS where 0 indicates no pain, whereas 100 indicates intractable pain. A response to treatment was defined as a 50% or greater decrease in the pain VAS or the WOMAC pain subscale according to a proposal of Outcome Measures in Rheumatology Clinical Trials and Osteoarthritis Research Society International [16]. The patient's global assessment was scored at 6 months after as 3, excellent; 2, good; 1, moderate; and 0, bad.

### Statistical Analysis

For between group comparisons of the WOMAC and pain VAS across time, two-way repeated measures analysis of variance (ANOVA) was used. Simple effects were assessed by one-way ANOVA. For comparisons of patient's global assessment, Mann–Whitney's *U*-test was used. For comparisons of demographic data and treatment responders, unpaired *t* test, chi-square, and Fischer's exact tests were used. Significant difference was set at  $P < 0.05$ .

### Results

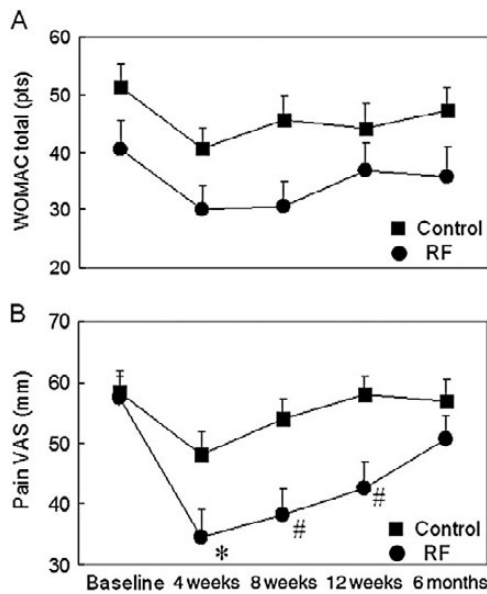
During the enrollment period, 19 patients in each group were included in this study. One patient in the RF group and two patients in the control group chose to undergo surgery (total knee arthroplasty) within 6 months because no pain relief was achieved. Eighteen patients in the RF group and 17 patients in the control group completed all assessments and were analyzed in this study. The baseline characteristics of each group were similar (Table 1). The RF group averaged lower on the WOMAC total score throughout the treatment cycle, including at baseline, although overall, this difference was not significant (group main effect,  $F = 3.616$ ;  $P = 0.066$ ). Consistent with this pattern, only the time main effect was actually significant ( $F = 11.05$ ;  $P < 0.001$ ), while the interaction between group and time was not ( $F = 1.287$ ;  $P = 0.278$ ) (Figure 2A). Regarding pain VAS, the main effects of group ( $F = 5.846$ ;  $P = 0.021$ ), time ( $F = 12.817$ ;  $P < 0.001$ ), and interaction between group and time ( $F = 3.310$ ;  $P = 0.013$ ) were statistically significant. RF group averaged lower than control group and there were significant differences between groups at 4 weeks ( $P = 0.028$ ), 8 weeks ( $P = 0.007$ ), and 12 weeks ( $P = 0.006$ ) (Figure 2B). The percentage of responders in the RF group was approximately 50% at 4 weeks, 30% at 12 weeks, and less than 10% at 6 months while that in the control group was less than 12% at 4, 8, 12 weeks, and 0% at 6 months. There were significant differences in responders between the two groups at 4 weeks ( $P < 0.01$  for both the WOMAC pain subscale and pain VAS), 8 weeks ( $P < 0.05$  for both), and 12 weeks ( $P < 0.05$  for pain VAS) (Figure 3). The mean (standard deviation) of the patient's global assessment taken at 6 months was 1.5 (0.8) in the RF group and 1.1 (0.6) in the control group. There was no significant difference in patient's global assessment between the RF and control groups ( $P = 0.126$ ), while 44 % of the patients (8/18) in the RF group rated excellent or good, but only 18 % (3/17) in the control group rated good ( $P = 0.088$ ).

There were no serious adverse effects but some minor effects during the current study were noted. Subcutaneous bleeding at the site of needle insertion was the most frequent side effect, which was observed in 67 % of the

**Table 1** Comparison of baseline characteristics between the RF and control groups

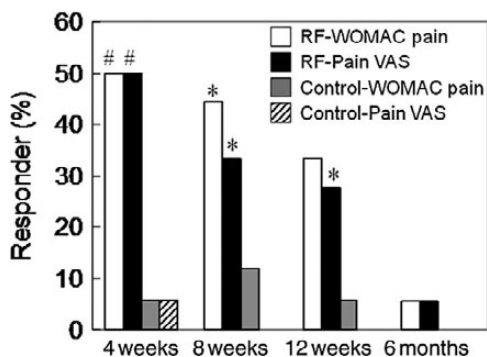
	RF (N = 18)	Control (N = 17)	<i>P</i>
Age (year)	77 ± 7	77 ± 8	0.949
Female (%)	94	82	0.261
Disease duration (year)	10 ± 8	9 ± 5	0.809
Hydrarthrosis (%)	33	18	0.289
Femoro-tibial angle (deg)	183 ± 5	181 ± 4	0.193
Western Ontario McMaster Universities osteoarthritis index score	41 ± 22	51 ± 16	0.113
Pain visual analog scale (mm)	57 ± 15	58 ± 15	0.858

Values are mean ± standard deviation.



**Figure 2** Comparison of treatment results between the RF and control groups in (A) WOMAC total score and (B) pain visual analog scale. Error bar represents standard error of the mean (SEM). pts = points. # $P < 0.01$ ; \* $P < 0.05$  vs control group.

patients (12/18) in the RF group and 82 % (14/17) in the control group. There was no hematoma formation. Prolonged hypoesthesia at the IPBSN region was observed only in patients of the RF group (14/18), which lasted for 2–6 weeks after the initial treatment. The size of hypoesthesia area gradually shrank and disappeared. All of the patients who responded to the RF treatment showed prolonged hypoesthesia.



**Figure 3** Percentage of patients who responded to treatment (defined as a >50% decrease in Western Ontario McMaster Universities osteoarthritis index pain subscale or pain visual analog scale). # $P < 0.01$ ; \* $P < 0.05$  vs control group.

## Discussion

The RF treatment significantly decreased knee pain measured by the pain VAS and the WOMAC pain subscale for 2–3 months compared with the control group. On the other hand, there was no significant difference in the WOMAC total score between groups. The RF treatment had little effect on the WOMAC stiffness and physical function subscales. One possible reason why the RF treatment affected only the WOMAC pain subscale is that patients in this study complained exclusively of their knee pain rather than stiffness and physical dysfunction.

The nerve supply of the knee joint comes from the tibial, common peroneal, femoral, and obturator sources. Among them, the tibial, common peroneal, and posterior branch of the obturator nerve innervate lateral and posterior aspects of the knee joint. Innervation of the anteromedial aspect of the knee joint is intricate. There are at least four peripheral nerves that innervate anteromedial soft tissues around the knee joint: MRN, the terminal branch of the femoral nerve to the vastus medialis; IPBSN, the branch of the largest sensory branch (saphenous nerve) of the femoral nerve; medial femoral cutaneous nerve, the sensory branch of the femoral nerve; and anterior branches of obturator nerve [13]. In addition, innervation of the bone tissue is even more complex and quite distinct from soft tissue innervation. Although pain source of knee OA is largely unknown, intra-articular structures, including synovium, capsule, and ligament rather than skin and bone are considerably responsible for pain in knee OA [17]. Therefore, we decided to apply RF current to putative nerves innervating anteromedial aspect of intra-articular structures, i.e., MRN and IPBSN [13].

The effective period observed in the current study was somewhat shorter than that in previous reports concerning the hip joint [7–10]. There are some possible reasons for this difference. First, there were difficulties in placing the electrode tip close to the target nerve in the knee joint. Technical procedures for RF lesioning in the hip joint under fluoroscopy have been described in detail [7,9,10,18]. In contrast, in the knee joint, there are no radiological landmarks for RF treatment and few anatomical studies specific to target nerves. Second, there was no proof that the target nerves chosen in the current study were responsible for their symptoms. For instance, if the pain originates predominantly from the bone, the RF lesioning for MRN and IPBSN will not be effective. Third, there are considerable anatomical differences between the hip and knee joints especially in terms of their biomechanics. Roughly speaking, the hip joint is a ball-and-socket joint, whereas the knee is a hinge joint. Only a hinge joint (knee) is affected by malalignment such as varus and valgus alignment. Dynamic force borne by a malaligned joint is much greater than that in a normal joint, which consequently results in joint pain. We think that the knee joint is more prone to treatment failure than the hip joint unless the biomechanical abnormality is corrected.



RF current produces heat lesions within about two electrode-widths from the surface of the electrode. If a temperature of 80–85°C is established at the surface of the electrode, the tissues within a few millimeters will be denatured [6]. Therefore, it is essential to place the electrode tip as close as possible to the target nerve. In this study, the palpation-based technique seemed to be inaccurate in some patients. There are several reasons for the difficulty in localizing the target nerve. One is that the anatomical course of each target nerve is variable [13,14]. Another reason is that the target nerves are purely sensory. It is impossible to elicit objective response by the electrical nerve stimulation, such as muscle contractions in localizing a motor nerve. To overcome these issues, it would be better to adopt some other technique. Recently, ultrasound guidance for peripheral nerve block has been developed and reported to be more effective than electrical stimulation technique [19]. Lundblad et al. [20] reported reliable blockade of the IPBSN using ultrasound. We think the ultrasound-guided technique could improve the accuracy of nerve localization especially for the pure sensory nerves. There is another technique that we can adopt. Bademkiran et al. [21] reported an easy and useful electrophysiological test for neuropathies of the IPBSN. They successfully monitored sensory nerve action potential of the IPBSN with surface electrode for stimulation at the knee and with needle electrode for recording at the inguinal region. Although this technique is somewhat invasive because of needle insertion, it could also be useful in identifying target nerves. In addition, because of anatomical variability of the target nerves, multiple lesions with the active tip parallel to the target nerve [18] may be necessary to increase the chance of coagulating them. In terms of nerve selection, diagnostic nerve block in advance of RF treatment may be helpful to achieve greater success.

Because this was an open-label, nonrandomized, controlled study, there were several limitations related to the study design. Firstly, it is difficult to be sure that there were no placebo effects. However, the patients in the RF group clearly showed significant reduction in joint pain despite the lower WOMAC total score at baseline. In addition, most of the patients in the RF group showed prolonged hypoesthesia at the IPBSN region. Therefore, we believe that RF treatment has substantial effects in alleviating joint pain by disrupting the transmission of pain signals. Secondly, although the baseline characteristics of each group were similar, there could be unmeasured differences between two groups. For instance, patients in spring and summer could be physically more active than those in fall and winter.

In conclusion, RF treatment for refractory anteromedial knee pain was effective for 2–3 months in spite of the fact that all of the patients were candidates for total knee arthroplasty. Although there were possible placebo effects because this was not a blinded study, we believe that RF treatment has substantial effects in alleviating joint pain and that RF application can be a useful alternative treatment. Further experience and technical improvements are

needed to establish its role in the management of knee OA.

No conflicts of interest to declare in relation with the article.

## References

- 1 Mannoni A, Briganti MP, Di Bari M, et al. Epidemiological profile of symptomatic osteoarthritis in older adults: A population based study in Dicomano, Italy. *Ann Rheum Dis* 2003;62:576–8.
- 2 Andrianakos AA, Kontelis LK, Karamitsos DG, et al. Prevalence of symptomatic knee, hand, and hip osteoarthritis in Greece. The ESORDIG study. *J Rheumatol* 2006;33:2507–13.
- 3 Leveille SG. Musculoskeletal aging. *Curr Opin Rheumatol* 2004;16:114–8.
- 4 NIH Consensus Statement on total knee replacement. *NIH Consens State Sci Statements* 2003;20:1–34.
- 5 Roddy ED, Doherty M. Guidelines for management of osteoarthritis published by the American College of Rheumatology and the European League against Rheumatism: Why are they so different? *Rheum Dis Clin North Am* 2003;29:717–31.
- 6 Bogduk N. Pulsed radiofrequency. *Pain Med* 2006;7:396–407.
- 7 Malik A, Simopolous T, Elkersh M, Aner M, Bajwa ZH. Percutaneous radiofrequency lesioning of sensory branches of the obturator and femoral nerves for the treatment of non-operable hip pain. *Pain Physician* 2003;6:499–502.
- 8 Akatov OV, Dreval ON. Percutaneous radiofrequency destruction of the obturator nerve for treatment of pain caused by coxarthrosis. *Stereotact Funct Neurosurg* 1997;69:278–80.
- 9 Fukui S, Nosaka S. Successful relief of hip joint pain by percutaneous radiofrequency nerve thermocoagulation in a patient with contraindications for hip arthroplasty. *J Anesth* 2001;15:173–5.
- 10 Kawaguchi M, Hashizume K, Iwata T, Furuya H. Percutaneous radiofrequency lesioning of sensory branches of the obturator and femoral nerves for the treatment of hip joint pain. *Reg Anesth Pain Med* 2001;26:576–81.
- 11 Okada K. New approach to the pain of the hip joint. *Pain Res* 1993;8:125–35.
- 12 Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthritis. *Ann Rheum Dis* 1957;16:494–502.

- 13 Horner G, Dellon AL. Innervation of the human knee joint and implications for surgery. *Clin Orthop Relat Res* 1994;301:221–6.
- 14 Ebraheim NA, Mekhail AO. The infrapatellar branch of the saphenous nerve: An anatomic study. *J Orthop Trauma* 1997;11:195–9.
- 15 Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: A health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol* 1988;15:1833–40.
- 16 Pham T, van der Heijde D, Altman RD, et al. OMERACT-OARSI initiative: Osteoarthritis Research Society International set of responder criteria for osteoarthritis clinical trials revisited. *Osteoarthritis Cartilage* 2004;12:389–99.
- 17 Creamer P, Hunt M, Dieppe P. Pain mechanisms in osteoarthritis of the knee: Effect of intraarticular anesthetic. *J Rheumatol* 1996;23:1031–6.
- 18 Locher S, Burmeister H, Bohlen T, et al. Radiological anatomy of the obturator nerve and its articular branches: Basis to develop a method of radiofrequency denervation for hip joint pain. *Pain Med* 2008;9:291–8.
- 19 Abrahams MS, Aziz MF, Fu RF, Horn JL. Ultrasound guidance compared with electrical neurostimulation for peripheral nerve block: A systematic review and meta-analysis of randomized controlled trials. *Br J Anaesth* 2009;102:408–17.
- 20 Lundblad M, Kapral S, Marhofer P, Lonnqvist PA. Ultrasound-guided infrapatellar nerve block in human volunteers: Description of a novel technique. *Br J Anaesth* 2006;97:710–4.
- 21 Bademkiran F, Obay B, Aydogdu I, Ertekin C. Sensory conduction study of the infrapatellar branch of the saphenous nerve. *Muscle Nerve* 2007;35:224–7.