Observational Study

Cooled Radiofrequency Neurotomy of the Articular Sensory Branches of the Obturator and Femoral Nerves – Combined Approach Using Fluoroscopy and Ultrasound Guidance: Technical Report, and Observational Study on Safety and Efficacy

Leonardo Kapural, MD, PhD, Suneil Jolly, MD, Joao Mantoan, MD, Harish Badhey, MD, and Ty Ptacek, MD

From: Wake Forest University School of Medicine Winston-Salem, NC

Address Correspondence: Leonardo Kapural, MD, PhD Carolinas Pain Institute and Center for Clinical Research, 145 Kimel Park Drive Winston-Salem, NC 27103 E-mail: Lkapuralmd@gmail.com

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Background Chronic hip joint pain is a common condition with an estimated prevalence of 7% in men and 10% in women, in a population sample aged over 45. Conservative treatment can include physical therapy, weight loss, a variety of pharmacologic agents ranging from nonsteroidal antiinflammatory drugs (NSAIDS) to opioids, and intraarticular injections with various substances. Definitive treatment of hip pain, however, has primarily centered on hip arthroplasty.

Objective: We describe a novel anterior approach to cooled radiofrequency (RF) hip denervation under combined ultrasound (US) and fluoroscopy guidance to avoid the neurovascular femoral bundle and reach proper landmarks.

Study Design: Retrospective chart review of consecutive cases.

Setting: Interventional Pain Management urban private practice.

Methods: Data on 52 RF ablations of the hip in 23 patients were retrospectively collected. RF ablation was conducted with patient supine and under guidance of fluoroscopy and US. While fluoroscopy was used to place RF probes to appropriate landmarks, sole purpose of using US was to avoid femoral neurovascular bundle. Data were collected on needle placement, stimulation parameters, and short- and long-term complications.

Results: A total of 62 patients underwent 2 diagnostic blocks. Fifty-two of them had greater than 50% relief and agreed to RF ablation. Until now, the ablation was conducted in 23 patients. There were no adverse events, except one case of neuritis. Expectedly, the needle approach to the lateral articular branches of the femoral nerve was easily achieved with more than a 1 cm passage distance from the femoral nerve in all 52 RF cases (median 2.5 range 1-3.5 cm). Placement of the second trocar to the incisura acetabuli was more challenging; in 21 RF cases the passing distance was less than 1 cm (range 0.5 to 1.9 cm, median 0.8). Motor stimulation (2 Hz) at less than 1 V was positive for the obturator nerve in 26 cases, which resulted in electrode repositioning more laterally (2-5 mm). Change in the pain scores was from the baseline 7.61 ± 1.2 to 2.25 ± 1.4 after the RF ablation ($P < 0.01$). The time interval of pain relief was much longer for RF ablation.

Limitations: Limitations of this retrospective, observational study include lack of blinding and absence of a comparator group. We did not attempt to wean opioids in our patient population.

Conclusions: An anterior needle approach to the lateral articular branches of the femoral and obturator nerves, and subsequently RF denervation of these nerves, is a safe procedure when US needle guidance is combined with identification of landmarks using fluoroscopy.

Key words: Chronic hip pain, radiofrequency ablation, hip denervation

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Chronic hip joint pain is a common condition with an estimated prevalence of 7% in men and 10% in women, in a population sample aged over 45 (1). Furthermore, symptomatic arthritis of the hip has been shown in one study to affect 9.2% of adults ≥ 45 years of age (9.3% women, 8.7% men) (2). The causes of chronic hip pain can vary and include trauma such as hip fractures, dislocations, and labral tears, sequelae from lumbar spine/sacroiliac joint pathology, bursitis, osteoarthritis, surgery, cancer, and avascular necrosis. Conservative treatment can include physical therapy, weight loss, a variety of pharmacologic agents ranging from nonsteroidal antiinflammatory drugs (NSAIDs) to opioids, and intraarticular injections with various substances. Definitive treatment of hip pain, however, has primarily centered on hip arthroplasty.

The innervation of the joint is complex. Specifically, the anteromedial innervation is supplied by the branches of the obturator nerve, while the anterior portion of the joint capsule is innervated by articular branches of the femoral nerve. The posterior hip innervation is primarily derived from branches of the sciatic nerve. Groin hip pain has been thought to be generated by articular branches of the obturator nerve while trochanteric (lateral) pain may be carried by articular branches of the femoral nerve (3,4). This basic understanding of anatomy of the innervation provides targets for potential denervation and reduction of hip pain.

Some approaches were described for the hip denervation using conventional radiofrequency (RF). Those include anteroposterior (AP) and lateral approaches using only fluoroscopy (5,6). In one study, the AP approach under fluoroscopic guidance was initially utilized, but later aborted due to a series of 3 hematoma formations (5). In other studies, the RF needle was advanced from a very lateral insertion point to the incisura acetabuli (junction of the pubis and ischium) and the bottom of this "teardrop structure" on fluoroscopy (6). In most of the previous case reports, a 22-gauge RF probe was used, thus limiting denervation to a few articular branches that can have variable courses. Additionally, about half of the reports used 22-gauge RF probes with a 4-5 mm active tip. Finally, reports were limited to few patients and various time interval follow-ups (5-13).

The purpose of this study is to describe technique and initial outcomes of patients who underwent ablation of the sensory articular branches of the hip using cooled RF and guided by ultrasound (US) and fluoroscopy. Ideally, the larger thermal lesions of cooled RF should compensate for the variable distribution of innervation of the hip by the articular branches.

Methods

Following our IRB approval, data were retrospectively collected from electronic patient records on 52 RF denervations of the hip in 23 consecutive patients. We intended to collect data on longevity of the block and RF ablation in days, along with the intensity of pain relief (in verbal pain scores) at baseline, one week after the first and second block, and one month after RF ablation and opioid use. For continuous data, means and standard deviations were calculated, and comparisons were made using t-tests. Statistical significance was defined as $P < 0.05$ for all analyses.

All patients were required to have 2 blocks of the obturator and femoral articular branches with at least 50% improvement in pain scores to qualify for RF ablation. Blocks were completed under fluoroscopic guidance and using 25-gauge, 3.5 or 5 in spinal needles. AP views were used with the needle directed to the bottom of incisura acetabuli for the lateral articular obturator branches block. The outer upper quarter (10 or 2 o'clock position) of the joint capsule approximately 0.5 to 1 cm outside of the joint was targeted for the lateral articular femoral branches block. The needles were advanced under fluoroscopy to the target site until a bony endpoint is met, and aspiration was performed to ensure no blood return. Later, 2 mL of 0.5% bupivacaine was injected at each of the 2 sites. There were 62 patients who underwent such block with 52 of them deemed candidates for RF.

RF ablation was completed in sedated, but responsive patients. It was completed in the supine position and under sterile prep and drape. The Halyard CoolieftTM RF probe with introducers, in combination with the RF generator (PMG-115-TD/PMG-230-TD), was used for creation of RF lesions in nervous tissue.

A 17-gauge trocar was passed through the skin to the lateral aspect of the upper joint edge after 2 mL of 0.5 % lidocaine was used for skin infiltration. The trocar position in relationship to the femoral nerve, artery, and vein was confirmed and guided using US imaging. It was advanced until the tip of the trocar rested on the fluoroscopically-identified bony landmark (Fig. 1). This was followed by placement of the second trocar of the same size and length. It was passed medial to the femoral vein under US guidance with the tip of the trocar directed to the bottom of the incisura acetabuli under fluoroscopic guidance (Fig. 1). The femoral vein, artery,

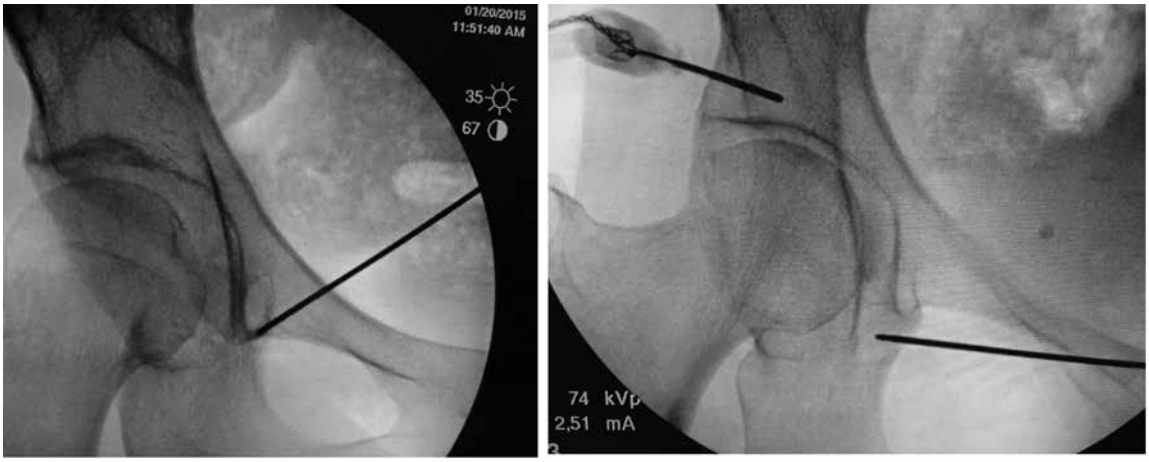

Fig. 1. *Anterior-posterior fluoroscopic images of the right hip during RF ablation of lateral femoral and lateral obturator branches using cooled RF electrode. A) Proper placement of the RF electrode tip to the bottom of the incisura acetabuli, landmark for denervation. Notice that electrode introducer was advanced from medial, pubic skin entry position, and directed toward the incisura acetabuli. B) Other 2 RF denervation landmarks are shown here, that include outer position of lateral upper quadrant of the hip to denervate lateral femoral branches, and additional lateral obturator branches denervation landmark over the anterior ischium and just below the incisura acetabuli (second lesion to the lateral obturator branches).*

and nerve were in close proximity of the introducing trocar when US was applied (Fig. 2). However, real-time US guidance provided safe passage of the trocar in all 52 cases conducted.

Using AP fluoroscopy, the target sites were identified: the first landmark was at the bottom of the incisura acetabula, appearing as a teardrop shape (Fig. 1A), to denervate the bulk of lateral obturator articular branches. Another lesion was conducted at the outer quarter of the femoral joint to denervate the lateral articular femoral branches (Fig. 1B). A second articular obturator branch denervation was completed during the last 7 RF cases at the anterior ischium and just below the incisura acetabuli by slightly repositioning RF electrode from the bottom of the incisura acetabuli and toward the top of the anterior ischium. Such approach was adopted based on more recent hip dissection studies demonstrating an abundance of lateral obturator fibers in that area (personal communication with Drs Gofeld and Petersohn).

Results

We identified from electronic records 16 women and 7 men spanning in age from 27 to 73 years old. Their body mass index (BMI) ranged from 18 to 50. All except 2 patients were on opioids ranging from 10 to 450 mg of daily oral morphine equivalents. All were also given various membrane stabilizers and antidepressants for pain. All patients except 3 carried secondary chronic pain diagnoses, with the most frequent being lumbosacral spondylosis, lumbar spinal stenosis, and chronic knee pain. In general, all treated patients were either not candidates for or previously had an arthroplasty (2 patients) with ongoing severe, intractable chronic hip pain after surgery. Most patients carried a hip related diagnosis of degenerative joint disease of the hip (18 patients), avascular necrosis of the hip (2 patients), Ehlers-Danlos Syndrome (1 patient) , and neuropathic pain after arthroplasty (2 patients).

Twenty-three patients underwent hip RF denervation with at least 180 days follow-up after the procedure. 29 patients either did not undergo the procedure yet, or follow up was less than 180 days. There were 15 patients who received a bilateral procedure and 8 who received unilateral procedures. Eight patients already had a repeated procedure, with 6 of those patients having a repeat bilateral procedure. This resulted in a total of 52 RF hip denervations.

Expectedly, the trocar approach to lateral femoral branches was straightforward, with more than 1 cm of passage distance from the femoral nerve in all 52 RF cases. Placement of a second trocar to the incisura acetabuli passing near the femoral vein under US guidance was much more challenging (Fig. 2). In 21 RF

cases, the passing distance was less then 1 cm (as measured by US; range 0.5 to 1.9 cm, median 0.8). Sensory stimulation (50 Hz) in both locations (bottom of the incisura acetabuli and outer upper quarter of the joint (10 or 2 o'clock position) was concordant at less than 0.5 V in all of the patients. Motor stimulation (2 Hz) at less than 1 V was negative for the lateral femoral branches and positive for the obturator nerve at the lateral obturator branches denervation location in 26 cases. This resulted in repositioning of the electrode more lateral (2-5 mm).

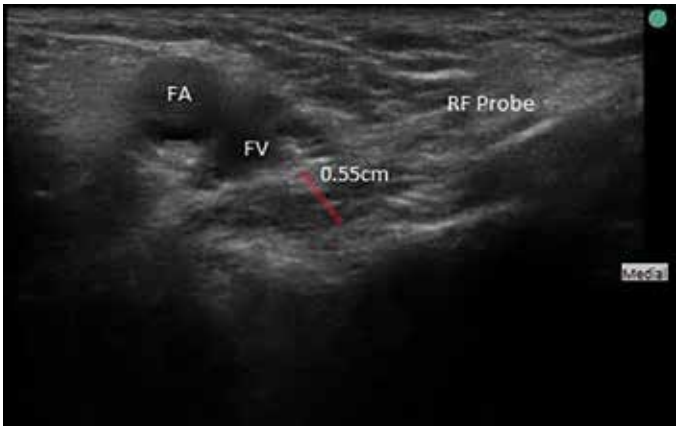

Fig. 2. *US guided passage of RF introducer and probe of femoral neurovascular bundle. Careful US guided advancement of RF probe just next to the femoral vein (FV). Lateral to the vein is a femoral artery (FA). Measured distance of RF electrode to femoral vein was 0.55 cm.*

After proper positioning, sensory and motor stimulation, and injection of 1 mL of 2 % lidocaine, denervation was conducted at 75 degrees for 180 seconds, once at the lateral femoral position and once or twice at the lateral obturator position.

Comparable improvements in the pain scores were achieved after both blocks and RF ablations (Fig. 3). Change in the pain scores was from the baseline 7.61 ± 1.2 to 2.25 ± 1.4 after the RF ablation ($P < 0.01$). The time interval of pain relief was much longer for RF ablation ranging from 30 to 320 days for the first ablation and 42 to 300 days for the second RF ablation (Fig. 4; $P < 0.01$). Patients were very satisfied with pain relief, and most claimed improved mobilization. There were 2 patients who underwent successful blocks, but had no improvement after RF; both were included in Figs. 3 and 4.

Opioid use did not decrease significantly (Fig. 5). There were no reported adverse events during the procedure - immediately after and at 3 months after procedure - except one case of neuritis (severe burning in the groin area), that resolved within one week post-denervation.

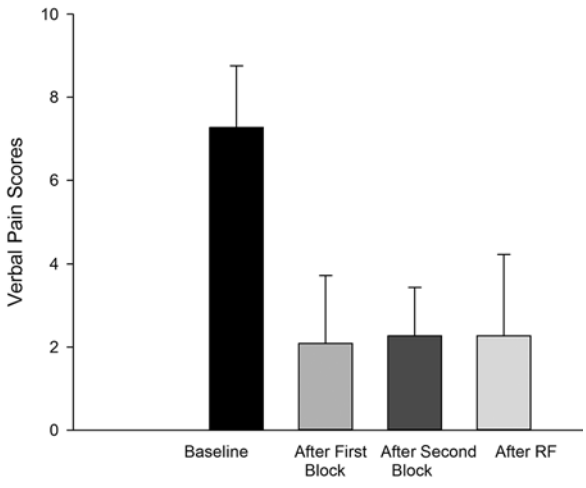

Fig. 3. Improvements in the pain scores were compared for all 23 patients. Comparable improvements in the pain scores were achieved after either blocks or RF ablations.

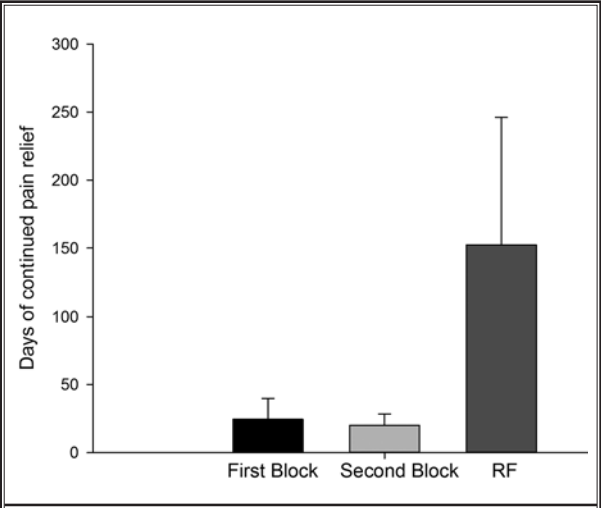

Fig. 4. *Time interval of pain relief was much longer for RF ablation ranging from 30 to 320 days for the first ablation and 42 to 300 days for second RF ablation.*

Discussion

Many patients with moderate to severe chronic hip pain may not become arthroplasty candidates (clinical exclusion criteria, or patient preference). This patient group relies mainly on medical management, resorting primarily to opiates. Present literature on RF denervation of the hip for chronic pain is scarce, and it is comprised only of case-report, case-series, and anatomical studies.

All of the published reports used a conventional, small size 22-gauge RF probe and utilized single or multiple RF lesions. This ultimately results in a smaller denervation area (6-13). Considering the abundance of lateral obturator and lateral femoral articular nerves as previously described in literature, such an approach may not provide significant and lasting benefits as evidenced in a prospective randomized study (6). In addition, there is no properly executed outcome study detailing evidence on long-term efficacy and safety of hip RF denervation. Here we report, for the first time, in a larger case-series, on the technical aspect and safety of a modified approach to RF ablation of the lateral obturator and lateral femoral articular branches using a large cooled RF probe.

In utilizing direct US control of an advancing trocar tip, and by identifying bony landmarks using fluoroscopy, we were able to create a predictable procedure time and a consistently safe procedure in this large clinical case-series of 52 RF denervations. The purpose of US guidance was to safely pass a 17-gauge trocar medial to the femoral vein with respect to denervation of the lateral obturator articular branches, and lateral to the femoral nerve for the lateral femoral articular branches denervation (14). The distance to fluoroscopic landmarks and patient discomfort levels were much less than one could anticipate if a lateral or even an inferior approach was used (additional data for lateral and inferior approach using Coolief™ RF probe on file with Halyard, Atlanta). The learning curve seemed to be relatively steep, but because of the real time US visualization of the femoral neurovascular bundle, the safety of this executed procedure is high. The Coolief™ probe provides a significantly larger volume lesion then the same size conventional RF electrode (15,16). Such a probe seems to be ideal to denervate the rather widely and variably positioned lateral articular branches of both the obturator and femoral nerves.

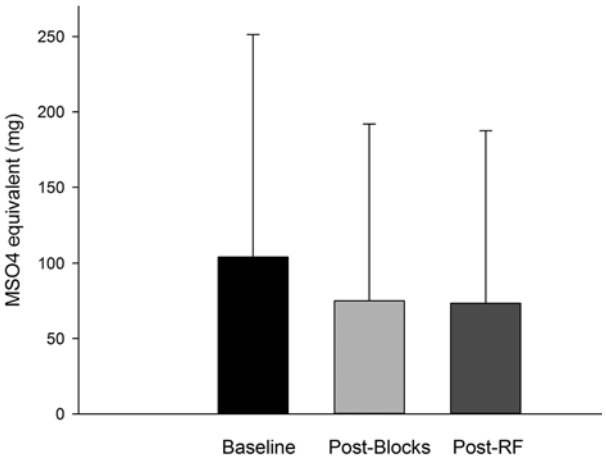

Fig. 5. *An average opioid daily use in patients who underwent diagnostic blocks and then RF hip denervation.*

Using such direct approach as described here makes it possible to achieve a large size denervation without the need to repeatedly pass or reposition near the femoral neurovascular bundle with multiple RF needles. This in turn may improve safety of what could be an otherwise painful hip denervation procedure. Thus, this anterior approach to lateral femoral and lateral obturator articular sensory branches for RF denervation, and RF denervation itself is a safe procedure when US needle guidance was combined with identification of landmarks using fluoroscopy. The distance to neural denervation target was short compared to the lateral or inferior approach technique, rendering this procedure as utilizing the least amount of time, local anesthetic, procedural sedation, and patient discomfort when compared to these other described techniques. However, minimal distance to the femoral vein of the RF introducer for the lateral obturator branches denervation (Fig. 2), provides reason for caution and further reassertion that slow needle advancement toward incisura acetabula is safest.

Conversely, advancement of the needle to denervate the lateral femoral branches may be facilitated with little concerns related to the neurovascular bundle. Moreover, one should also consider more superficial anatomical obstacles, like the genitofemoral, ilioinguinal, or iliohypogastric nerves. Advancement of the introducer should be careful, and initial skin position should be thoughtful until we collect more clinical data regarding this approach. We were very pleased with consistent improvements in pain scores following 2 diagnostic blocks and RF denervation (Fig. 3).

Conclusion

Similar and consistent improvements in pain scores after the block and RF suggested a positive predictive value of lateral femoral and lateral obturator articular branch blocks for success of RF denervation. We did not observe an improvement in opioid use in the population of the patients who received RF denervation of the hip. There may be several reasons for this observation. For instance, there was a lack of a formulated protocol to wean opiates after the procedure was completed and after treated patients received substantial pain relief. This was secondary to the fact that the majority of patients who underwent hip denervation using this novel approach had other sources of chronic pain, such as chronic back and joint pain. Obvious limitations of such a study include lack of blinding and comparator group, and a lack of data regarding changes in functional capacity and quality of sleep. Our goal here was to describe a technical aspect and report of this anterior approach to denervation of the lateral obturator and lateral femoral branches and document the safety of this procedure. In order to properly assess the efficacy of the lateral obturator and lateral femoral articular nerves denervation, a prospective randomized study of properly selected patients is warranted.

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