Retrospective Review

Cooled Radiofrequency Ablation of the Articular Sensory Branches of the Obturator and Femoral Nerves using Fluoroscopy and Ultrasound Guidance: A Large Retrospective Study

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Background: We previously reported on a combined technique and initial data of hip denervation using an anterior approach and cooled radiofrequency.

Objectives: A large retrospective study to evaluate the long-term effectiveness of cooled radiofrequency ablation (CRFA) in the general chronic hip pain population.

Study Design: Retrospective electronic chart review.

Setting: A single specialty private practice.

Methods: Retrospective chart review of 235 consecutive (CRFA) in 136 patients with chronic hip pain.

Results: Out of 235 CRFA, 178 (96 initial procedures and 82 repeats) were performed in 84 patients with 12 or more months follow-up. The average decrease in visual analog scale (VAS) pain scores was 7.3 ± 1.3 to 2.3 ± 1.5 and 2.48 ± 1.5 for the first and second diagnostic block, respectively, and was statistically significant ($P < 0.001$). Similarly, the average decrease in VAS pain scores at 6 and 12 months after CRFA denervation was 3.44 ± 2.5 and 4.23 ± 2.5, respectively; $P < 0.001$. Out of the 96 initial procedures in 84 patients, 66 procedures (69%) provided more than 50% relief at 6 months, and 50 (52%) at 12 months. There were 82 repeat denervations in 36 patients. Repeated procedures in the same patients provided a similar degree of pain relief with no statistically significant difference in the median pain scores (2.8 ± 2.1 cm vs 3.1 ± 1.7 cm ; $P = 0.197$) or time interval of pain relief (12.7 ± 10.9 vs 10.3 ± 4.7; $P = 0.508$). There were 3 minor complications.

Limitations: Retrospective nature of the study.

Conclusion: Improvements in pain scores and longevity of pain relief from chronic hip pain using a simple, anterior approach to radiofrequency denervation of the lateral obturator and lateral femoral nerves justifies further randomized prospective trials. Repeated CRFAs demonstrated consistency in pain relief and absolute safety of repeated denervation.

Key words: Hip denervation, degenerative joint disease, chronic hip pain, radiofrequency denervation, lateral obturator nerve, lateral femoral nerve

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The prevalence of chronic pain from the hip is between 7% and 10% in the population older than 45 years of age (1). Furthermore, symptomatic painful arthritis of the hip has been shown to affect 9.2% of adults ≥ 45 years of age (9.3% women, 8.7% men) (2). Chronic hip pain is caused by osteoarthritis, hip fractures and dislocations, labral tears, , bursitis, and avascular necrosis (1,2). Current conservative therapies include physical therapy, nonsteroidal anti-inflammatory drugs, opioids, and

intraarticular injections of steroids and other substances (3,4). Hip arthroplasty is considered a more definitive treatment of chronic hip pain (5).

The innervation of the joint is complex (6,7). Lateral branches of the obturator nerve supply anteromedial innervation, while articular branches of the femoral nerve innervate the anterior portion of the joint capsule. The sciatic nerve supplies most of the posterior hip innervation. Groin hip pain is mostly generated by lateral branches of the obturator nerve, while trochanteric pain is carried by lateral articular branches of the femoral nerve (6). Described approaches to block and denervate an affected hip are based on our understanding of hip innervation anatomy (7-19).

Initially, described were several approaches to denervate the hip by conventional radiofrequency (RF) ablation. Documented were anterior ischial and lateral approaches with fluoroscopic guidance (8-12). These authors typically used a 22-guage RF probe, which pcould provide only limited joint denervation considering variable anatomical course of gesticulate nerves articular branches. Furthermore, any conclusions on the efficacy of these used techniques were precluded as few patients were studied and there was a short interval follow-up interval (8-19). In our case series of more than 235 denervations, we used a large, 17-guage, cooled radiofrequency system to achieve much larger lesions to account for the target nerve branch density and path variability, while at the same time reducing the risk of femoral neurovascular bundle damage by using ultrasound guidance for the needle passage. Still, our final landmarks were determined under fluoroscopy (18,19).

We published an initial data set and technical report on hip denervation using cooled radiofrequency ablation (CRFA)(18) for chronic hip pain from various causes. We described a novel, anterior approach to cooled RF hip denervation under combined ultrasound and fluoroscopic guidance to avoid the neurovascular femoral bundle and to reach the proper anatomic landmarks. This study documented improvements in pain scores and longevity of pain relief in 23 patients who underwent 51 procedures. Recently, we published another small case-series using the same approach in a subpopulation of patients suffering from painful avascular necrosis of the hip (19). This difficult-to-treat, population of patients with chronic pain benefited greatly from cooled RF denervation (19). Here we present a large set of data from a single site in order to asses the long-term safety and efficacy of CRFA for hip denervation.

Methods

Two hundred thirty-five radiofrequency denervations for chronic hip pain using a cooled RF system were completed from January 2014 through July of 2019 at the Carolinas Pain Institute. Following the Forsyth Medical Center institutional review board study approval, patient data were collected from our electronic medical records. Data collection sheets included a patient identifier; date of birth/age; gender, body mass index (BMI); baseline visual analog scale (VAS) lateral obturator and lateral femoral nerve block (one or 2 diagnostic blocks and VAS after the block/blocks); daily total opioid usage at baseline (morphine milligram equivalents [MME]); total daily use of opioids in MME at approximately 6 and 12 months after the cooled RF procedure; other sources of chronic pain; the number of additional chronic pain sources; opioid dependency/abuse susceptibility (opioid risk assessment during follow-ups); VAS approximately 3, 6, and 12 months after the procedure; number of repeated lateral femoral and lateral obturator nerve denervations using cooled radiofrequency ablation (CRFA); VAS 6-12 months after the repeated procedure; and the time interval of satisfactory (> 50%) pain relief after the first procedure and each repeat (15).

Statistical Analysis

Data were summarized using descriptive statistics for continuous variables. We used Student's t-test and, when needed, Mann-Whitney U rank sum test to determine whether the VAS pain scores reported following RF denervation of the affected hip using a CRFA system was significantly different than prior to cooled RF denervation. A similar analysis was carried out to determine changes in the VAS before and after the blocks and daily opioid use from before and after RF denervation. We calculated the percentage of patients who maintained pain relief following CRFA. All analyses were completed using Sigma Plot for Windows Version 14 (SYSTAT Software, San Jose, CA).

Procedures completed

All patients were required to have 2 lateral obturator and femoral articular branches nerve blocks (LFLONB) with at least 50% improvement in pain scores to qualify for the RF ablation. Blocks were completed under fluoroscopic guidance using 25-guage, 3.5-in spinal needles. Anteroposterior (AP) views were used for the lateral articular obturator branches blocks with the needle directed to the bottom of the fluoroscopic

landmark called the incisura acetabuli. The outer upper pole (at the 10 or 2 o'clock position) of the joint approximately one cm outside of the joint was used as the landmark for the lateral articular femoral branches blocks. The needles were advanced under fluoroscopy to the target site until a bony endpoint was met, and aspiration performed to ensure no blood return. Later, 2 cc of 0.5% bupivacaine was injected at each of the 2 sites.

CRFA was completed in sedated but responsive patients. It was completed with the patient supine and under sterile prep and drape. The Halyard CooliefTM (Halyard Health, Inc., Alpharetta, GA) RF probe with introducers, in combination with the RF generator, was used for RF lesioning in nervous tissue at 80°C (20).

A 17-guage trocar was passed through the skin to the lateral aspect of the upper joint edge after 2 cc of 0.5% lidocaine was administered for skin infiltration. Advancing the trocar's position in relationship to the femoral vein, artery, and nerve was guided using ultrasound imaging. It was advanced until the tip of the trocar contacted a fluoroscopically identified bony landmark. This was followed by the placement of a second trocar. It was passed medial to the femoral vein under ultrasound guidance with the tip of the trocar directed to the bottom of a fluoroscopic landmark, the incisura acetabuli. The femoral vein, artery, and nerve were in close proximity of the introducing trocar when ultrasound was applied. However, real-time ultrasound guidance provided safe passage of the trocar in all cases conducted. There were no cases of vascular or nerve puncture.

Using AP fluoroscopy, the target sites were identified: the first landmark was at the bottom of the incisura acetabuli, this fluoroscopic landmark appearing as a teardrop shape, to denervate the lateral obturator articular branches. Another lesion was completed at the outer edge of the femoral joint to denervate the lateral articular femoral branches. A second obturator articular branches denervation was completed at the anterior ischial location, just below the incisura acetabuli by slightly changing the angle of the RF electrode from the incisura acetabuli toward the highest position at the anterior ischium.

Results

We completed 235 consecutive CRFAs for chronic hip pain in 136 patients (Figs. 1-3). Out of those 235 CRFAs, 178 were performed in 84 consecutive patients who had 12 or more months follow-up; we were able to retrieve a complete set of collected data. Data from those patients who had a minimum of 12 months follow-up after the first procedure were analyzed below. Twelve patients out of those 84 received bilateral CRFA. The total number of initial procedures was 96 and there were 82 repeats (Fig. 3).

Each of the CRFA candidates received LFLONB and a total of 204 patients were trialed for CRFA (Fig. 3). Blocks were completed under fluoroscopy as described in Methods, above. Fifty patients had no relief after the

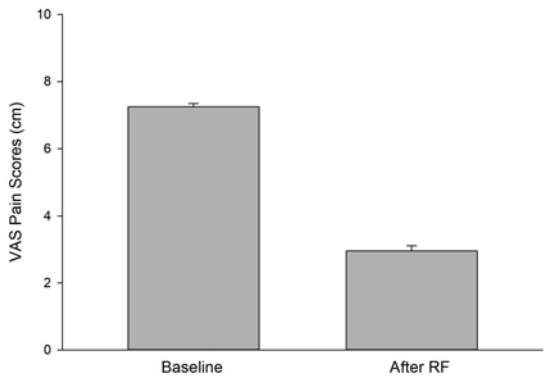

Fig. 1. *Overall short-term success of all CRFA of LFLO nerves in patients who underwent procedure. There were 178 CRFAs completed and improvements in pain scores were significant ($P < 0.001$).*

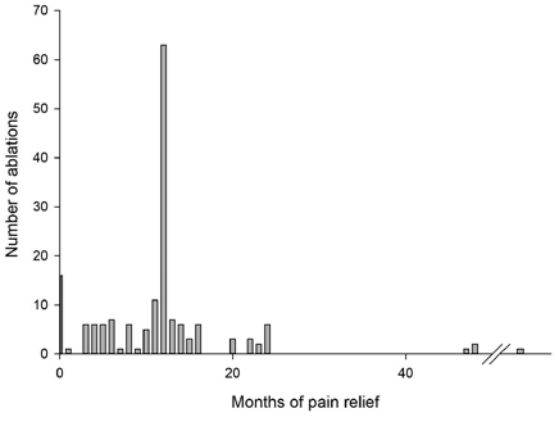

Fig. 2. *Distribution of pain relief time intervals for 178 CRFAs in 84 patients who had a minimum of 12 months follow-up. Median longevity of more than 50% pain relief was 12 months after most procedures (n = 62). Time interval of > 50% pain relief ranged from 0-72 months.*

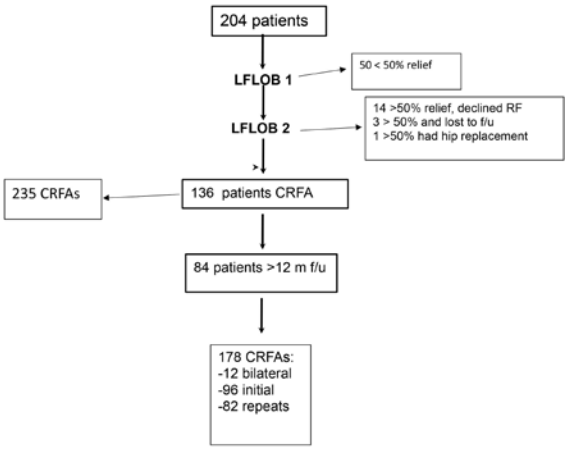

Fig. 3. *Disposition of 204 patients who underwent LFLONB and an algorithm of retrospective chart review. From 204 patients who underwent the block, 136 received CRFA and complete records from at least 12 months follow-up were obtained from 84 patients who underwent 178 CRFAs.*
HA, hip arthroplasty; LFLONB, lateral femoral, lateral obturator nerve block; CRFA, cooled radiofrequency ablation

first block and never pursued a second block. Eighteen patients either received long-term pain relief, and by the time we collected this data did not return for CRFA (14 patients), had a hip replacement (one patient) or were lost to follow-up (3 patients) (Fig. 3).

Exactly 178 CRFAs were performed in 63 women and 21 men who had more than 12 months follow-up. They had an average age of 57 years (range 26-97 years) and a BMI of 31.2 (range 18-58). The average VAS pain score in those 84 patients was recorded before and after each of the 178 CRFAs, and decreased from 7.3 ± 1.3 cm to 3.0 ± 1.9 cm (Fig. 1) achieving statistical significance ($P < 0.001$). There were 141 out of 178 procedures where the pain score decreased > 50% at the first follow-up (79% of the patients). There were 16 CRFAs after which patients had no pain relief. Furthermore, a median number of months with > 50 % of pain relief was 12 months, (n = 62 procedures). The time interval of pain relief varied from 0-72 months (n= 178; Fig. 2).

We also analyzed long-term improvement in pain scores for each individual hip denervation procedure. Eighty-four patients who underwent successful LFLONB with > 50% pain relief were followed for a minimum of 12 months after the CRFA. The average decrease of the VAS pain scores was from 7.3 ± 1.3 to 2.3 ± 1.5 and 2.48 ± 1.5, respectively, for the first and second block, and was statistically significant ($P < 0.001$). Similarly, a decrease in VAS pain scores was noted for CRFA at 6 and 12 months after denervation (3.44 ± 2.5 and 4.23 ± 2.5, respectively; $P < 0.001$).

Out of 96 initial procedures in 84 patients, 66 (69%) provided > 50% relief at 6 months and 50 (52%) at 12 months.

Despite the fact that a significant percentage of patients did not achieve more than 50% pain relief, overall improvements were significant throughout 12 months ($P < 0.001$ at 6 and 12 months; Fig. 4).

Change in opioid use from baseline to 12 months after CRFA of the LFLO nerves was not significant (Fig. 5; $P = 0.739$). It decreased from 56.4 ± 80 MME to 53 ± 68 MME at 6 months and to 46.2 ± 58 MME at 12 months. Patients were not intentionally weaned off their opioids after denervation; this patient population had an average of 2 other chronic pain sources (ranging from 0-7) in addition to their chronic hip pain.

There were 82 repeat CRFAs in 36 patients. The number of repeated procedures in individual patients varied from 1 to 9. Repeated procedures in the same patients provided similar pain relief and on average there was no statistically significant difference in the median values of pain scores (2.8 ± 2.1 cm vs 3.1 ± 1.7 cm; $P = 0.197$) or the time interval of pain relief (12.7 ± 10.9 vs 10.3 ± 4.7; $P = 0.508$). We plotted all 36 individual patient's data who underwent one or more repeat of CRFA for chronic hip pain (Fig. 6). Despite the fact that most of the patients had only one repeat CRFA up to the moment when we collected our data, consistent responses are illustrated.

We could not find a clear relationship between multiple chronic pain sources or BMI to short-term or long-term outcomes of the CRFA.

As far as complications, we recorded 2 cases of groin pain that resolved within a week after the procedure, and one case of neuritis that resolved within 2 weeks after the procedure. There were no vascular punctures either to the femoral artery or vein or femoral nerve palsies.

Discussion

This large retrospective study confirmed our previous notion from a smaller case series (18,19) that by using CRFA of the lateral femoral and lateral obturator sensory branches we can provide a significant, clinically meaningful (> 2 point change on a pain scale) pain relief over an extended time period in most patients and that the procedure is safe. Only 13 patients received

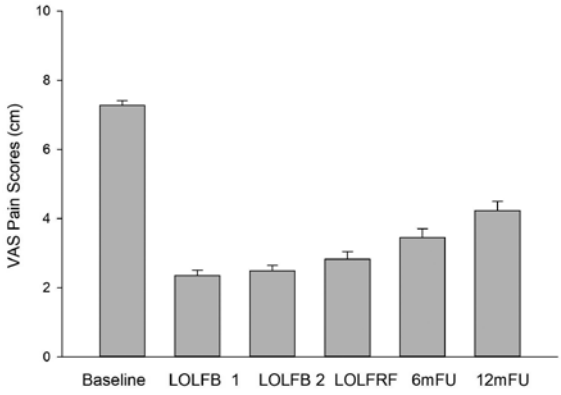

Fig. 4. *Overall long-term improvement in pain scores in an individual hip denervation procedure for those patients who underwent successful LFLONB with > 50 % pain relief and had CRFA of LFLO nerves after which they were followed for the minimum of 12 months. Overall improvements were significant throughout 12 months (P < 0.001 at 6 and 12 months).*

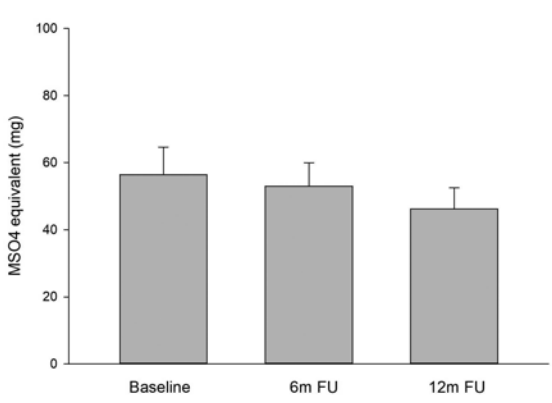

Fig. 5. *Change in opioid use from baseline to 12 months in patients who underwent LOLFRF. Improvements in opioid usage as measured by calculated daily morphine milligram equivalents (MME). Despite the fact that there was a tendency to decrease opioid usage from an average of 56.4 MME to 46.2 MME, the difference was not significant (I = 0.739).*

no pain relief after the CRFA of LFLO nerves. Improvements in pain scores lasted for an impressive median of 12 months (Fig. 2), and 52% of patients maintained at least 50% pain relief at one year.

The internal cooling in CRFA systems allows for the delivery of substantially more RF energy, as well as distal projection from the probe tip which results in larger, spherical lesions compared to standard RF probes. This can help successfully ablate target nerves given the complexity and variability of the nerve course in this anatomical location. Additionally, distal projection from the probe tip allows flexibility in probe placement which may also assist in the capturing of nerve targets (20). It is hypothesized that these may be key factors in providing more substantial and longer relief of pain than previously observed using smaller diameter, conventional RF probes (8-19,21). At this time, it is not clear how extensive RF denervation should be in order to provide the best possible long-term outcome and still maintain procedural safety free from any serious side effects.

Our CRFA introducer placement approach was lateral and 75° oblique for the lateral femoral nerve denervations, and medial over the pubic bone and with the trocar directed laterally for the lateral obturator nerves. In order to avoid bleeding or nerve damage from the femoral neurovascular bundle puncture, we performed the procedure with ultrasound assistance. As we described previously (18,19), despite the prox-

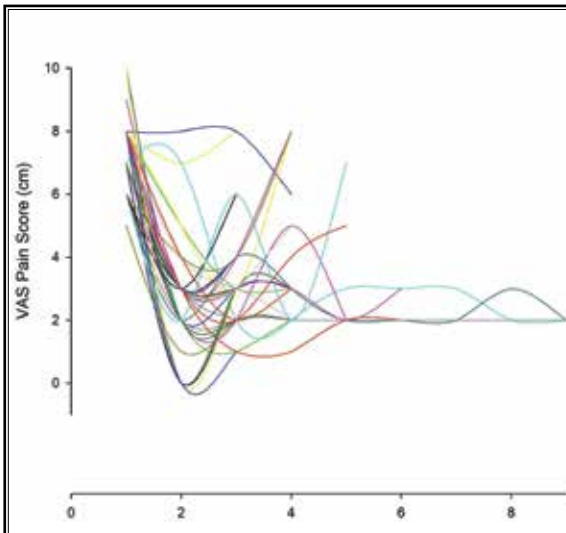

Fig. 6. *Individual VAS Pain Scores in patients who received repeated CRFA. Baseline score is shown as the first point (1) of axis and colored lines represent each of 36 patient's data who underwent at least one repeated CRFA. Axis numbers show the number of repeated procedures for each treated patient. As shown, there was a profound improvement in pain scores reproducible when the procedure was repeated. Unfortunately, most of the patients up to this date underwent only a single repeat.*

imity of the trocar to the femoral vein, we were very comfortable in placing the trocar under ultrasound guidance.

We used CRFA for various causes of chronic hip pain in this large case series, including osteoarthritis, labral tears of the acetabulum, posttraumatic arthritis, avascular necrosis, and persistent pain following total hip arthroplasty. We could not find any differences in outcomes when it comes to causes of chronic pain. In this study we had more patients with avascular necrosis who failed initial LFLONB and never went for CRFA, but the numbers are small and could be just be due to chance.

Previous evidence on the effectiveness of repeated RFA for hip denervation was negative or at least inconclusive and based on individual case-reports (16,22). Here we report no significant difference in VAS pain score improvements when CRFA was repeated. Not only that there was no statistical difference between initial denervation in 36 patients who received 82 repeated CRFAs, but also there was no difference in the time interval of pain relief (see Results and Fig. 6). And again, no additional complications were seen when patients received up to 9 repeated CRFAs.

We were unable to show a reduction in opioid requirements following CRFA of the LFLO nerves (Fig. 5), which is consistent with our previous findings (18). A likely explanation may be that the treated population of patients here had multiple sources of chronic pain, averaging 2 chronic pain sources in addition to the primary chronic pain from their hip. Although there was a tendency to decrease overall opioid use, it may be that we could be more aggressive in weaning their opioid medication once their primary chronic pain from the hip was reduced.

Similar to other studies (9-19) we used 50 Hz and 2 Hz stimulation via an active tip CRF probe. Acceptable threshold for patient to experience concordant pain/paresthesia was 0.5 V for sensory stimulation and up to 1.2 V for 2 Hz ruling out motor stimulation. Motor contractions were mainly observed when the tip of the probe was positioned as confirmed by fluoroscopy at the anterior ischium/lower part of incisura acetabuli. A simple repositioning of the probe laterally would eliminate muscle contractions in the obturator distribution. We had one case of painful neuritis that resolved within 2 weeks after the procedure. There were no motor weaknesses recorded.

Conclusions

Lateral femoral and lateral obturator sensory nerves CRFA provided a significant, clinically meaningful long-term (months) improvement in pain scores. It seems to be an effective therapy for patients with advanced osteoarthritis, avascular necrosis, or even previous arthroplasty of the hip joint. Using a large lesion of CRFA and closest medial approach by combining ultrasound for passage by the femoral vein and in combination with fluoroscopy for the landmark's electrode placement, we were able to facilitate this procedure and made it minimally painful to our patients. We were also able to eliminate the concern of puncture of the femoral neurovascular bundle. This procedure is deemed safe with only 3 minor complications recorded.

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