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Effectiveness of Genicular Nerve Radiofrequency Ablation: A Case Series and Considerations for Future Research

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Background: Postherpetic neuralgia (PHN) is the most common complication of shingles and can be a significant burden to patients due to pain and disability. Currently, treatment options are limited. In refractory cases, neuromodulation using spinal cord stimulation (SCS) and peripheral nerve stimulation (PNS) have been used but is considered experimental due to limited evidence.

Case Report: We report 2 cases who experienced successful treatment of refractory PHN. Patients underwent dorsal root ganglion (DRG) stimulation at the thoracic level for the treatment of refractory PHN.

Conclusion: Both patients showed significant improvement in pain at 24 and 36 months after a DRG stimulation trial and implantation. We report the successful use of DRG stimulation for the treatment of PHN.

Key words: Knee, genicular, radiofrequency ablation, osteoarthritis, pain, block, cooled

BACKGROUND

Chronic knee pain due to osteoarthritis is one of the most common musculoskeletal conditions for which patients seek medical care. As an increasingly older population continues to remain active, it represents a significant source of disability as its prevalence continues to rise (1,2). Traditional management options include physical therapy, oral medications, and intraarticular injections, but these have limited efficacy. Total knee arthroplasty (TKA) is the gold standard for moderate to severe knee osteoarthritis, but elevated body mass index and a variety of comorbid medical conditions often preclude this treatment option. Within the last decade, radiofrequency ablation (RFA) of the genicular nerves has emerged as a promising treatment alternative in the management of chronic knee pain secondary to osteoarthritis. Prior literature has supported the efficacy of genicular nerve RFA, but high-quality randomized controlled trials and standardized treatment protocols have yet to be established.

Primary targets of knee RFA have traditionally included the superolateral, superomedial, and inferomedial genicular nerves, but anatomical and cadaver studies have demonstrated significant variability in the precise

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location and course of these nerves (3-5). To account for this complex anatomic variability, prior studies have used a wide range of anesthetic volume during genicular prognostic blocks, ranging anywhere from 0.5 mL to 2 mL of anesthetic (5-9). Studies have also suggested that the anatomic regions anesthetized during prognostic blocks and lesioned during RFA are often not congruent, and this discrepancy has both called into question the predictive value of prognostic blocks and created confusion regarding inconsistent results between prognostic blocks and RFA (8).

We present a case series that further demonstrates the therapeutic benefit of genicular nerve RFA, but also highlights several important considerations for future research. As radiofrequency technologies continue to evolve in the management of a variety of chronic pain syndromes, cooled RFA has emerged as a potential solution; theoretically it holds several advantages that not only account for the anatomical variability of genicular nerve innervation to the knee joint, but may also lessen inconsistent results between prognostic nerve blocks and subsequent RFA.

METHODS

Study Design

This is a retrospective case series involving patients who presented with chronic knee pain secondary to osteoarthritis and who underwent genicular nerve RFA. In order to be considered for the procedure, patients needed to have failed conservative management, which included physical therapy, nonopioid medications, and intraarticular knee corticosteroid injections; and who must not have been treated with genicular nerve RFA within the past 6 months. A search was completed for all patients who had a genicular nerve RFA completed at the West Penn Hospital Institute for Pain Medicine by a single attending physician between October 1, 2014 and March 31, 2016.

Procedure Description

Patients meeting the above criteria were taken to the fluoroscopy suite for an initial diagnostic genicular nerve block. The patient was placed in the supine position and the skin overlying the knee was prepped with antiseptic solution and draped in sterile fashion. Using fluoroscopy in the anteroposterior (AP) view, the needle entry sites were identified at the periosteum of the medial and lateral junctions at the distal femoral shaft and epicondyles, and at the medial junction of the proximal tibia and epicondyle. After local anesthesia was obtained, a 25-gauge 3.5-inch spinal needle was incrementally advanced until the periosteum was contacted at each targeted site. Under lateral x-ray view, the needles were confirmed to contact the periosteum at approximately 50% depth of the femoral and tibial shaft. After aspiration for heme was negative at each location, 1 mL of 1% lidocaine was injected at each of the 3 locations. If greater than 50% pain reduction was achieved, a confirmatory block was then performed in the same manner using 1 mL of 0.25% bupivacaine. If the second procedure again resulted in greater than 50% pain relief, the patient proceeded to genicular nerve RFA.

Utilizing the same setup and technique as the prognostic blocks described above, a 20-gauge 10-cm introducer needle with a 15-mm curved active tip electrode was placed at each target location (see Fig. 1 for final needle placement in the AP and lateral views, respectively). Next, motor stimulation was performed at 2 Hz and confirmed no muscular contractions. One mL of 2% lidocaine was instilled at each of the indwelling needles. After a period of 60 seconds, each needle site was lesioned at 85°C for 90 seconds. Needles at each target location were then repositioned and motor stimulation was repeated. A second lesion was created at 85°C for 90 seconds. A third round of needle repositioning, nerve stimulation, and ablation completed the treatment course.

Data Collection

Patients were evaluated using the Numeric Rating Scale (scored 0 to 10) with zero indicating no pain and 10 indicating the worst pain they have ever experienced. This scale was used before and after each prognostic block and RFA procedure. The primary outcome measure was the percentage of pain relief in the immediate hours following each nerve block and the percentage of pain relief following the RFA at 3 weeks and again at the subsequent follow-up office visit.

RESULTS

A total of 8 RFA cases were found involving 6 patients. Each patient involved in the study underwent a prior knee surgery, with 5 of these cases consisting of total knee arthroplasty. The remaining surgeries included internal fixation of a proximal medial tibial plateau fracture (case 1) and a left and right knee plica excision (cases 2 and 3, respectively). Results are summarized in

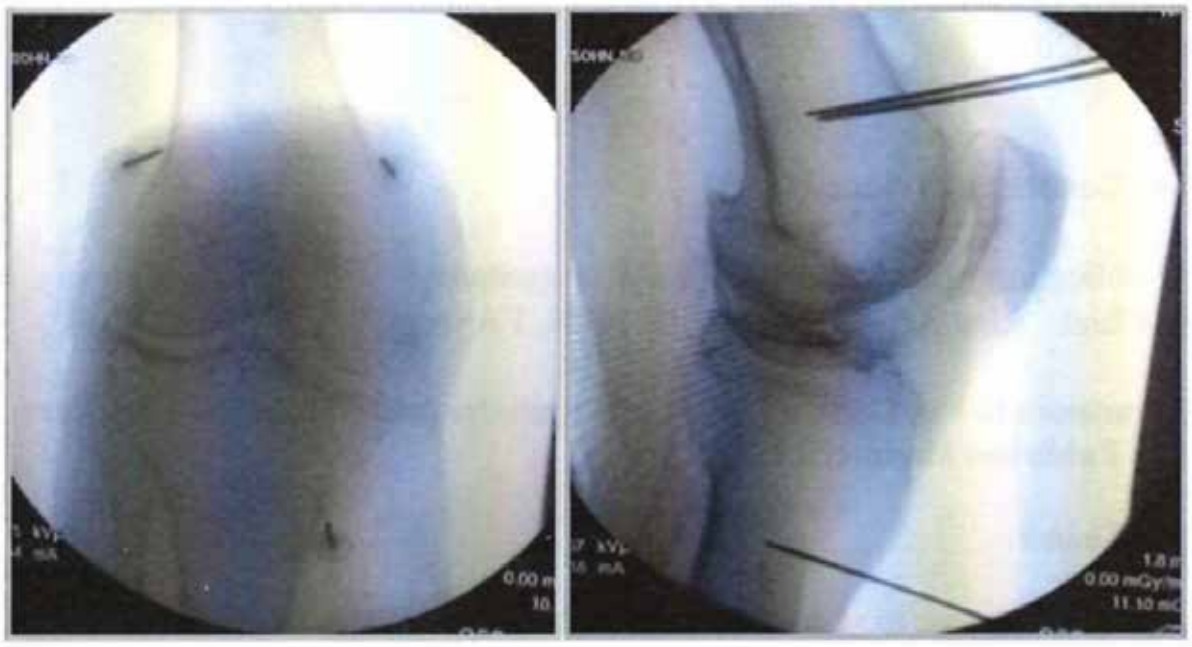

Fig. 1. Fluoroscopic AP (anteroposterior) and lateral views of radiofrequency ablation needle placement.

Table 1 (patients who had a prior knee operation other than a total knee arthroplasty) and Table 2 (patients who had a prior total knee arthroplasty). The average age was 54 (range, 30-67) years. Of the 6 patients, 4 were women and 2 were men. Two of the patients (cases 2-3 and cases 5-6, respectively) had bilateral genicular knee RFAs at separate times. In case 8, a 5-mm active tip electrode was initially used, which resulted in 0% pain relief. Subsequently, a 15-mm active tip was then utilized during the repeat procedure, which yielded 85% pain relief at the 3-month follow-up.

Sixteen diagnostic and confirmatory blocks were performed, which subsequently resulted in 8 genicular nerve RFA procedures. Nine out of 16 blocks resulted in 100% pain relief with the remaining results varying between 50% to 85% of pain relief. Regarding RFA, clinically significant improvements were made in the majority of subjects. At 3 months, 4 of the cases (2,4,7,8) reported greater than 50% pain relief and case 1 reported 40% pain relief. Case 3 reported 45% improvement at 3 weeks but 0% relief at 3 months. One of the patients who underwent bilateral genicular nerve RFA (cases 5 and 6) reported 0% pain relief at 3 weeks, and thus was not reevaluated.

DISCUSSION

Consistent with prior research, our study revealed clinically significant improvements in the majority of patients who underwent genicular nerve RFA for symptomatic knee osteoarthritis. An interesting observation is that patients who had undergone prior knee surgery (other than total knee arthroplasty) experienced superior overall pain reductions in comparison to patients who were status post knee arthroplasty, at least with respect to the diagnostic block procedures. The reasons for this finding are not entirely clear, but likely secondary to significantly altered postoperative neuroanatomy of the genicular nerves following total knee arthroplasty. Aberrant regeneration and collateral sprouting subsequently results in a variable course of the genicular nerve supply, rendering typical bony landmarks used in genicular nerve procedures less reliable.

In regard to both total knee arthroplasty and nontotal knee arthroplasty groups, genicular nerve RFA outcomes were not as favorable as the corresponding prognostic blocks. The potential reasons for this finding are numerous, and while recent literature has suggested that prognostic blocks are inaccurate and have little utility for predicting success with genicular nerve RFA, efforts

Table 1. Percentage of post-procedure pain relief (non-total knee arthroplasty).

Case Number	Case Description	Block 1 % Pain Relief	Block 2 % Pain Relief	RFA % Pain Relief
Case 1	64 M right tibial plateau repair	100%	100%	3 weeks: 40% 3 months: 40%
Case 2	30 F left plica excision	100%	100%	3 weeks: 66% 3 months: 66%
Case 3	30 F right plica excision	100%	100%	3 weeks: 50% 3 months: 0%

M = male, F = female. Numbers indicate patient age

Table 2. Percentage of post-procedure pain relief (total knee arthroplasty).

Case Number	Case Description	Block 1 % Pain Relief	Block 2 % Pain Relief	RFA % Pain Relief
Case 4	61 F left TKA	100%	100%	3 weeks: 33% 5 months: 100% at rest, 66% with ambulation
Case 5	64 M left TKA	60%	50%	3 weeks: 0%
Case 6	64 M right TKA	65%	75%	3 weeks: 0%
Case 7	67 F left TKA	80%	50%	3 weeks: 50% 3 months: 80%
Case 8	58 F left TKA	70%	80%	3 weeks: 50% 3 months: 85%

M = male, F = female. Numbers indicate patient age

need to be made to standardize procedures so that more meaningful conclusions can be made (8).

Contrary to genicular nerve procedures, research has shown the utility of prognostic blocks in predicting RFA success in the lumbar spine (11,12). A likely reason for this finding is because there is a well-documented and consistent location of lumbar medial branches that can be easily identified with fluoroscopic imaging. The precise location of lumbar medial branches allows for a small volume of medication to reliably anesthetize their corresponding facet joints. Because there are many pain generators located within a very small anatomical region (intervertebral discs, nerve roots, ligaments, and muscle layers), using a larger amount of local anesthetic will likely spread to these adjacent structures. Consequently, this will decrease the specificity of the procedure and lead to false positive prognostic blocks, resulting in suboptimal RFA outcomes. For this reason, authors have greatly emphasized the importance of using a small volume of anesthetic when performing lumbar medial branch blocks (13).

Innervation to the knee joint is significantly more complex and we do not have the luxury of precise bony landmarks when performing genicular nerve procedures. Multiple cadaver and sonographic studies have described variability in the course of genicular nerves as they travel along bony landmarks traditionally used in genicular nerve procedures (3,5). In patients who have previously undergone knee surgery, this neuroanatomy may be even further altered. To account for this variability, using a larger amount of anesthetic is likely necessary to ensure the genicular nerves are properly anesthetized. As previously discussed, using a larger volume of anesthetic in the lumbar spine can lead to false positive results. This is less of a concern in the knee where the clinical history of osteoarthritic knee pain is more straightforward and the differential diagnosis of intraarticular knee pain is smaller as compared to the lower back region; thus a larger anatomic region anesthetized should not significantly increase false positive results.

If a larger volume of anesthetic is used during genicular prognostic blocks, it is important to maintain congruency between the anatomic regions that are both anesthetized during the blocks and lesioned during RFA. Studies in the cervical and lumbar spine have shown that a volume of 0.25 mL will anesthetize the region of a thermal lesion created by a conventional 18-gauge

RFA needle (13,14). The authors concluded that if 0.5 mL or greater of anesthetic is used, the anesthetic will spread beyond the distribution area of a conventional RFA lesion (13,14). If RFA lesions are significantly smaller than anesthetic spread, it is not surprising that this incongruence leads to incomplete lesioning, resulting in suboptimal results which may be inaccurately labeled as false positive prognostic blocks.

Many methods are utilized to create larger and more complete lesions with conventional RFA. These include using radiofrequency probes with larger cannula diameter sizes, electrode temperature, and duration of lesion time. Prior research has also shown that longer active tip lengths result in a larger lesion size, and our study notably used 15-mm curved active tip electrodes as opposed to a 5- or 10-mm curved active tip (15). Utilizing double or triple lesion techniques may also create larger lesions, but this method is challenging to standardize among different interventionalists. These techniques may not account for the complex knee innervation nor be as effective as cooled RFA.

In order to maintain congruency between a larger anesthetic region and ablation size, several distinct features of cooled RFA theoretically hold advantages compared to conventional RFA (16-18). An internally cooled probe creates a significantly larger spherical lesion with cooled RFA compared to the smaller elliptical shape created by conventional RFA. Not only is the spherical lesion larger, but a significant amount of thermal damage is created beyond the electrode probe tip, which is not the case with a conventional RF probe. Finally, the lesion created by a cooled RF probe does not rely on precise parallel placement relative to the target nerve. Because genicular nerves do not reliably course directly over the periosteum at the traditional bony landmarks used in knee RFA, these unique features of cooled RFA carry significant advantages.

CONCLUSION

Genicular nerve ablation is increasingly being utilized in the management of chronic knee pain secondary to osteoarthritis, and we describe a case series further supporting the efficacy of this relatively new procedure. To date, there is limited data discussing many procedural aspects of genicular nerve RFA. Defining the appropriate anesthetic volume to be used during prognostic blocks, maintaining congruency between prognostic blocks and subsequent ablation, and comparison between conventional and cooled genicular nerve RFA have not been sufficiently evaluated. There is significant opportunity to build upon an already proven innovative procedure, and standardization of these protocols will result in improved reliability and efficacy of genicular nerve ablation.

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