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USE OF RADIOFREQUENCY ABLATION TO TREAT KNEE PAIN IN EARLY OSTEOARTHRITIS OF KNEE JOINT

Orthopaedics

Dr Bharat Soni	Senior Resident Gmers Medical College, Gotri Vadodara
Dr. Subham Verma*	Senior Resident Gmers Medical College, Gotri Vadodara *Corresponding Author
Dr. Tejashkumar Naik	Senior Resident Gmers Medical College, Gotri Vadodara
Dr. Chirag V Thakkar	Professor Gmers Medical College, Gotri Vadodara
Dr Shantanu Vijay	Junior Resident Gmers Medical College Vadodara
Dr Fenil Shah	Junior Resident Gmers Medical College Vadodara
Dr Jeevan Kishor Appala	Junior Resident Gmers Medical College Vadodara

ABSTRACT

Introduction: Knee osteoarthritis (OA), a very common degenerative joint disease, is characteristically the effect of wear and tear of the cartilage, menisci and finally bones of the knee. In our study we performed radio-frequency ablation of genicular nerves for treatment of early osteoarthritis and measured the method's outcomes by comparing visual Analog Score (VAS) and Knee Injury and Osteoarthritis Outcome Score (KOOS) pre-operatively and 6 months post-operatively. **Materials and Methods:** This study was a prospective study in department of orthopedics in GMERS medical college and hospital Vadodara from January 2021 to July 2022 **Results:** VAS and KOOS improved significantly at six months follow-up post radio-frequency (RFA) ablation procedure **Conclusion:** fluoroscopy-guided RFA of genicular nerves is a safe and effective intervention to reduce pain and disability in patients with OA who did not respond well with pharmacological treatment.

KEYWORDS

Knee Osteoarthritis Radiofrequency Ablation pain management

INTRODUCTION

Osteoarthritis of knee (OA) is usually an age-related degenerative disease which leads to progressive degeneration of articular cartilage[1].The prevalence of OA is mostly observed in elderly people and in due course might lead to disability.[1,2]

Common clinical symptoms include pain in the knee, which is gradual in onset and worsens with activity or prolonged rest intervals, stiffness, more so in the mornings and swelling of the knee[1]

The treatment of patients with OA includes conservative modalities like weight-loss[2,3,4], physical therapy[4] and anti-inflammatory drugs[5,6]. More invasive approaches include intra-articular viscosuppl ementation of hyaluronic acid [7,8] platelet rich plasma (PRP)[3] or depot steroid preparations[9]. Operative modalities for advanced OA include joint preserving surgery like high tibial osteotomy (HTO) and joint replacing surgeries like unicompartmental knee arthroplasty (UKA) and total knee arthroplasty (TKA)[3,4].

It is noticed that pain management options for OA range from conservative treatment to surgical procedures. However, pharmacological interventions are expensive, often ineffective, and may lead to serious adverse events[7,10]. Although corticosteroids and hyaluronic acid are the most frequently dispensed intra-articular therapies, their tolerability and clinical efficacy remains debated[7,8]. Also, these costly procedures are related to increased morbidity and the outcomes are highly variable based on patient-selection[11,12].

Despite these treatment options, patients with severe OA often suffer from refractory pain and look for modalities other than surgical intervention.

Interestingly, "radiofrequency ablation (RFA)" is a novel technique used for treatment of a wide variety of cancers, cardiac arrhythmias, and other numerous conditions[13,14], but it has recently gained popularity in alleviating chronic pain in patients with musculoskeletal disorders such as OA[12]. This minimally invasive technique involves a high temperature probe that targets specific nerves innervating the tissue of interest.

RFA was first introduced in 2011 by Choi et al as an option for management of pain in OA[15]. It was further explored in subsequent years. He investigated the efficacy of neurotomy with RFA. RFA was used to ablate articular nerve branches (genicular nerves) and he found it effective for relieving chronic OA pain[15]. In our study, we attempted to evaluate the efficacy of radio-frequency ablation for treating chronic pain in early osteoarthritis of knee joint in the patients who visited for conservative treatment. In addition to the conventional RFA method, other modes of RFA for OA include pulsed and cooled RFA[16].

MATERIALS AND METHODS

Study Area

This study is a prospective observational study. It was conducted in Department of Orthopedics, Gmers Medical College & Hospital, Vadodara from January 2022 to July 2021.

Study Population consists of Patients with Knee Osteoarthritis satisfying inclusion criteria admitted in indoor ward of Department of Orthopedics.

All patients satisfying inclusion criteria were evaluated clinically and radiologically.

Criteria Of Selection Of Patients

Inclusion criteria

40-60 years patient with early osteoarthritis (grade 1 and 2) and symptoms of joint pain in one or both knee joints who did not respond to conservative management for at least 3 months.

Exclusion Criteria

OA GRADE-III or more, acute knee injury, chronic knee infection, previously operated knee, neurological pain, congenital deformity of Knee, ipsilateral limb fractures, psychological overlay, unstable knee joint.

Those who met the inclusion criteria were recruited into the study. After explaining the procedure and methodology of the research and obtaining written informed consent. Preoperative Evaluation was done with Standard radiographs in Anteroposterior Standing and Lateral

views were taken for confirmation of the diagnosis and also to classify the Osteoarthritis.

The demographic status and pain measurement were done by using visual analogue scale (VAS) as per the study of Huskisson[17] and Knee Injury and Osteoarthritis Outcome Score (KOOS) to predict Knee Osteoarthritis as per Roos et al[18], baseline evaluation was done followed by 3weeks, 6 weeks and 6 months of Radio frequency Ablation.

Procedure

The patient was placed supine on a table with the symptomatic knee(s) at 30° flexion. After a skin wheal was created with 1–2 ml of 2% lidocaine for superficial local anaesthesia, cannula was introduced at sites to block the superolateral, superomedial and inferomedial genicular nerves. The superolateral and superomedial genicular nerves course through the respective concave transitions of the femoral meta-diaphysis and femoral condyles. The inferomedial genicular nerve site is found at the concave transition between the tibial plateau and adjacent meta-diaphyseal shaft.

We used a fluoroscopic anteroposterior image to target the superior lateral genicular nerve by advancing the 20-gauge, 3.5-in (8.9-cm) cannula with a 10-mm active tip, percutaneously down to the junction of the femoral shaft and lateral epicondyle, contacting the bone.

Similarly using the fluoroscopic AP image, superomedial genicular nerve is targeted, percutaneously advancing the cannula to the medial aspect of the distal femoral diaphysis approximately 1 cm anterior to the adductor tubercle until the bone is contacted. Using the fluoroscopic AP view, we targeted the inferomedial genicular nerve by advancing the cannula percutaneously to the proximal tibial diaphysis, along the margin of the medial tibial condyle, until the needle contacted the bone. Obtained a fluoroscopic true lateral image to confirm cannula placement at the midpoint of the diaphysis in both the tibia and the femur. If cannula placement is beyond the mid-point of the diaphysis, each cannula was withdrawn 3 to 5 mm.

To ensure correct placement. Fasciculations were looked for to avoid ablating motor nerves. If there is motor activation during motor stimulation, the radiofrequency ablation needle should be repositioned and retested. Radiofrequency electrode is inserted through the cannula, temperature increased to 80°C for 2 minutes, and then the cannulas are advanced and repeated ablation is done. The cannulas were advanced 3 to 5 mm at each site to achieve a slight increase in the lesion volume in anteroposterior dimension.

RESULTS

In our study, majority of patients observed grade 2 (N = 43, 67.2%) while minimum patients observed grade 1 (N = 21, 32.8%) of OA grade and majority of patients were males (N = 36, 56.3%) while minimum patients were females (N =28, 43.8%).

Mean VAS SCORE at pre-operative and follow up-

Table1- Mean VAS Score

	Minimum	Maximum	Mean	Median	SD
Pre- Op	6.0	9.0	7.859	8.000	.8139
3 Week	4.0	8.0	4.844	5.000	.8768
6 Week	3.0	7.0	4.391	4.000	.7892
6 Month	3.0	7.0	3.703	3.000	.9374

Table describes the mean ± SD value of pre-operative VAS (7.859 ± 0.8139 cm; range of 6- 9 cm), follow up 3 weeks VAS (4.844 ± 0.8768 cm; range of 4-8 cm), 6 weeks VAS (4.391 ± 0.7892 cm; range of 3-7 cm) and 6 months VAS (3.703 ± 0.9374 cm; range of 3-7 cm). in which statistically significant (P<0.0001) reduction was observed.

Mean KOOS at 0 week and 6 month follow up

Table 2 – Mean KOOS

	Minimum	Maximum	Mean	Median	Std. Deviation
KOOS (0wk)	34.6	48.3	42.334	42.050	2.8418
KOOS (6mon)	54.2	80.2	73.827	75.700	5.6052

Table describes the mean ± SD value of 0-week KOOS (42.334 ± 2.8418; range of 34.6- 48.3) and follow up 6 months KOOS (73.827 ± 5.6052; range of 54.3-80.2) which observed statistically significant (P<0.0001) increasing trend.

DISCUSSION

KOA is well known degenerative joint disorder, which can occur in single knee joint and/or both knee joints and observes progressive degeneration of articular cartilage.[1] The prevalence of KOA was majorly found in the elder people, which lead to disability and hampered quality of life due to severe pain.[1,2,19,20.]

KOA management is basically relief of pain amongst patients. Moreover, the pain management decisions for KOA range from conservative therapies to surgical interventions. On the other hand, pharmacological interventions can be achieved but they are expensive, sometimes ineffective, and may lead to severe adverse side-effects such as GI bleeding, renal impairment, hypersensitivity reactions, and peptic ulcer disease.[21,22]

To provide symptomatic relief, intra-articular steroid injections are used but it has been observed that their clinical benefits tend to diminish after 2 years of repeated injections[23]. Moreover, steroid injections have been associated with numerous long-term complications such as crystal-induced synovitis, fat necrosis, deterioration of the cartilage and sepsis[24,25,26,27.]

In short, steroid injections provide immediate, clinically significant relief, but are not a long- term solution for symptomatic control in patients with KOA.

Chondroitin and glucosamine, are also used but their efficacy is largely controversial[28]. Numerous large study trials have shown minimal or no evidence of meaningful benefit, while other trials that suggest benefit have been considerably criticized on their methodologies.[21,22,28,29,30,31]

In the context of surgical approaches, evidenced from earlier randomized trial did not support arthroscopy for addressing the arthritic joint surface.[29] Whereas, knee replacement might be recommended to report final stage KOA for relieving pain and restoring functional ability.[29,30] However, these expensive surgical procedures are associated with increased mortality and morbidity, and the outcomes are highly contingent on patient selection.[31,32] Some studies have shown that 20 % of patients who underwent knee replacement still had persistant pain.[6]

Radiofrequency ablation (RFA) has recently found to potential for treatment of chronic pain in patients with degenerative disorders like KOA.[12] The minimally invasive conventional technique entails a high temperature probe that targets specific nerves innervating the tissue of interest. As per historical perspective, pain management in KOA, RFA was first introduced in 2011 by Choi et al.[15] which was found to be effective for neurotomy after applying it to articular nerve branches (genicular nerves) to reduce chronic KOA pain.

RFA helps patients who are unresponsive to conservative treatment or are unsuitable candidates for total knee arthroplasty. In the context of KOA, RFA is applied to the sensory innervation surrounding the knee, specifically the genicular nerves (GNs).[15]

It acts by ablating nociceptive (A-δ and C-fibers) without destroying sensory A beta and motor fibres. It causes localised thermocoagulation of neuronal tissue over 3 weeks post procedure. It has been observed that threshold of neuronal tissue is 45 degrees therefore heat more than 45 degrees is required.[33,34,35]

Moreover, several clinical studies have confirmed that RF modalities could be a potentially feasible and efficacious therapeutic option for the treatment of chronic KOA related pain.[9,15,36] However, due to its uniqueness and the lack of standardization in procedural techniques across published studies[9],uncertainty remains with using RF, and to date, no treatment guidelines recommend using RF in KOA[9].

It is not yet rich concept in which imaging method is superior as a guide to perform thermal radiofrequency of genicular nerve (TRFGN), but in 2019, Kim et al. reported that ultrasound might be the optimum tool.[37] This study observed no difference in the efficacy of genicular nerve block (GNB) when performed in an ultrasound-guided or fluoroscopic-guided manner.[37] The researchers confined the genicular nerves in an ultrasound-guided manner and then performed images

with fluoroscopy and contrast, it showed that targets for GNB were located similarly irrespective of the imaging method used. It was found that pain relief, functional stability and protection using the Western Ontario and McMaster's Universities Osteoarthritis Index (WOMAC) scale, were similar in both groups.[37]

The procedure with regards to achieving an accurate location of anatomical landmarks by ultrasound, the placing of the patient should be in supine position with the knee flexed and a pillow under the popliteal fossa.[36,37,38]

Interestingly, decrease in the pain scale is an important parameter, which is observed as an efficacy of TRFGN. Moreover, the effectiveness of ablation of genicular nerves viz. improved functional capacity, good patient satisfaction, and decreased analgesic use.[39]

Recently there has been advances is radiofrequency techniques such as Pulsed radio frequency (PRF) and coolif technique. The advantages of PRF compared to conventional RFA are that PRF tends to be less neuro-destructive, patients experience less pain with the procedure, and there is minimized tissue destruction. Furthermore, PRF poses less risk for development of deafferentation pain.40

Cooled Radiofrequency Ablation is similar to conventional RFA, that utilizes thermal ablative mechanisms; however, it creates a greater local neuronal lesion.[15]

Two large Level I randomized clinical studies have demonstrated extended clinical durability of CRFA and its superiority to intraarticular steroid and hyaluronic acid in the management of knee OA. It is a safe, effective and consistent treatment, one which fills the treatment gap between short term pain relief solutions and replacement surgeries.[41,42]

CONCLUSIONS

In conclusion, the present study is a first-time investigation to evaluate the efficacy of radiofrequency ablation for treating chronic pain in early osteoarthritis of knee joint in patients of Western part of India. Our findings indicated that fluoroscopy guided RFA for genicular nerves blockade is suitable to be considered as a safe and effective intervention to reduce pain and disability among 50-60 years older patients who were affected by KOA, who did not improve after conservative treatment of 3 months**.**

Limitation

1) Larger number of sample size or a multicentric study would have been more conclusive with respect to the conducted study.

REFERENCES

1. Hsu H, Siwiec RM. Knee Osteoarthritis. 2021 Jul 25. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan–.
2. Manlapaz DG, Sole G, Jayakaran P, Chapple CM. Risk factors for falls in adults with knee osteoarthritis: A systematic review. PM & R. 2019 Jul;11(7):745-57.
3. Li JS, Tsai TY, Clancy MM, Li G, Lewis CL, Felson DT. Weight loss changed gait kinematics in individuals with obesity and knee pain. Gait Posture. 2019 Feb;68:461-5.
4. Alrushud AS, Rushton AB, Bhogal G, Pressdee F, Greig CA. Effect of a combined programme of dietary restriction and physical activity on the physical function and body composition of obese middle-aged and older adults with knee OA (DRPA): protocol for a feasibility study. BMJ Open. 2018 Dec 14;8(12):e021051
5. Bjordal JM, Ljunggren AE, Klovning A, Slørdal L. Non-steroidal anti-inflammatory drugs, including cyclo-oxygenase-2 inhibitors, in osteoarthritic knee pain: meta-analysis of randomised placebo controlled trials. BMJ. 2004 Dec 4;329(7478):1317.
6. Hochberg MC, Altman RD, April KT, Benkhalti M, Guyatt G, McGowan J, et al. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. Arthritis Care Res (Hoboken). 2012 Apr;64(4):465-74.
7. Arrich J, Piribauer F, Mad P, Schmid D, Klaushofer K, Mu¨llner M. Intra-articular hyaluronic acid for the treatment of osteoarthritis of the knee: Systematic review and meta- analysis. CMAJ. 2005 Apr 12;172(8):1039-43.
8. Bannuru RR, Natov NS, Dasi UR, Schmid CH, McAlindon TE. Therapeutic trajectory following intra-articular hyaluronic acid injection in knee osteoarthritis—meta-analysis. Osteoarthritis Cartilage 2011 Jun;19(6):611-9.
9. Davis T, Loudermilk E, DePalma M, Hunter C, Lindley D, Patel N, et al. Prospective, multicenter, randomized, crossover clinical trial comparing the safety and effectiveness of cooled radiofrequency ablation with corticosteroid injection in the management of knee pain from osteoarthritis. Reg Anesth Pain Med. 2018 Jan;43(1):84-91.
10. Bjordal JM, Ljunggren AE, Klovning A, Slørdal L. Non-steroidal anti-inflammatory drugs, including cyclo-oxygenase-2 inhibitors, in osteoarthritic knee pain: meta-analysis of randomised placebo controlled trials. BMJ. 2004 Dec 4;329(7478):1317.
11. Howells N, Murray J, Wylde V, Dieppe P, Blom A. Persistent pain after knee replacement: Do factors associated with pain vary with degree of patient dissatisfaction? Osteoarthritis Cartilage 2016 Dec;24 (12):2061-8.
12. Ajrawat P, Kin HB, Radomski L, Bhatia A, Peng P, Nath N, et al. Radiofrequency procedures for the treatment of symptomatic knee osteoarthritis: A systematic review. Pain Medicine, 0(0), 2019 Sep 17, 1-16.
13. Calkins H, Epstein A, Packer D, Arria AM, Hummel J, Gilligan DM, et al. Catheter ablation of ventricular tachycardia in patients with structural heart disease using cooled radiofrequency energy: results of a prospective multicenter study. Cooled RF Multi Center Investigators Group. J Am Coll Cardiol. 2000 Jun;35(7):1905-14.
14. Friedman M, Mikityansky I, Kam A, Libutti SK, Walther MM, Neeman Z, Locklin JK, Wood BJ. Radiofrequency ablation of cancer. Cardiovasc Intervent Radiol. 2004 Sep-Oct;27(5):427-34.
15. Choi WJ, Hwang SJ, Song JG, Leem JG, Kang YU, Park PH, Shin JW. Radiofrequency treatment relieves chronic knee osteoarthritis pain: a double-blind randomized controlled trial. Pain. 2011 Mar;152(3):481-7.
16. Gupta A, Huettner DP, Dukewich M. Comparative effectiveness review of cooled versus pulsed radiofrequency ablation for the treatment of knee osteoarthritis: A systematic review. Pain Physician. 2017 Mar;20(3):155-171.
17. Huskisson EC. Measurement of pain. Lancet. 1974 Nov 9;2(7889):1127-31.
18. Netter FH. Atlas of human anatomy. 2nd ed., Stuttgart (GER): Thieme, 2000.
19. Mannoni A, Briganti MP, Di Bari M, Ferrucci L, Costanzo S, Serni U, et al. Epidemiological profile of symptomatic osteoarthritis in older adults: a population based study in Dicomano, Italy. Ann Rheum Dis. 2003 Jun;62(6):576-8.
20. 17.Michael JW, Schlüter-Brust KU, Eysel P. The epidemiology, etiology, diagnosis, and treatment of osteoarthritis of the knee. Dtsch Arztebl Int. 2010 Mar;107(9):152-62.
21. Gutthann SP, García Rodríguez LA, Raiford DS. Individual nonsteroidal antiinflammatory drugs and other risk factors for upper gastrointestinal bleeding and perforation. Epidemiology. 1997 Jan;8(1):18-24.
22. Bjordal JM, Ljunggren AE, Klovning A, Slordal L. Non-steroidal anti-inflammatory drugs, including cyclo-oxygenase-2 inhibitors, in osteoarthritic knee pain: Meta-analysis of randomised placebo controlled trials. BMJ. 2004 Dec 4;329(7478):1317.
23. Jensen LK, Mikkelsen S, Loft IP, Eenberg W, Bergmann I, Løgager V. Radiographic knee osteoarthritis in floorlayers and carpenters. Scand J Work Environ Health. 2000 Jun;26(3):257- 62.
24. Magnusson K, Turkiewicz A, Englund M. Nature vs nurture in knee osteoarthritis - the importance of age, sex and body mass index. Osteoarthritis Cartilage. 2019 Apr;27(4):586-92.
25. Li JS, Tsai TY, Clancy MM, Li G, Lewis CL, Felson DT. Weight loss changed gait kinematics in individuals with obesity and knee pain. Gait Posture. 2019 Feb;68:461-5.
26. Alrushud AS, Rushton AB, Bhogal G, Pressdee F, Greig CA. Effect of a combined programme of dietary restriction and physical activity on the physical function and body composition of obese middle-aged and older adults with knee OA (DRPA): protocol for a feasibility study. BMJ Open. 2018 Dec 14;8(12):e021051.
27. Bastick AN, Runhaar J, Belo JN, Bierma-Zeinstra SM. Prognostic factors for progression of clinical osteoarthritis of the knee: a systematic review of observational studies. Arthritis Res Ther. 2015 Jun 08;17:152.
28. Rivero-Santana A, Torrente-Jiménez RS, Perestelo-Pérez L, Torres-Castaño A, Ramos-García V, Bilbao A, et al. Effectiveness of a decision aid for patients with knee osteoarthritis: a randomized controlled trial. Osteoarthritis Cartilage. 2021 Sep;29(9):1265-1274.
29. Kirkley A, Birmingham TB, Litchfield RB, Giffin JR, Willits KR, Wong CJ, et al. A randomized trial of arthroscopic surgery for osteoarthritis of the knee. N Engl J Med. 2008 Sep 11;359(11):1097-107.
30. 27.Mantilla CB, Horlocker T, Schroeder DR, Berry DJ, Brown DL. Frequency of myocardial infarction, pulmonary embolism, deep venous thrombosis, and death following primary hip or knee arthroplasty. Anesthesiology. 2002 May;96(5):1140-6
31. 28.Beswick AD, Wylde V, Gooberman-Hill R, Blom A, Dieppe P. What proportion of patients report longterm pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients. BMJ Open. 2012 Feb 22;2(1):e000435.
32. Howells N, Murray J, Wylde V, Dieppe P, Blom A. Persistent pain after knee replacement: Do factors associated with pain vary with degree of patient dissatisfaction? Osteoarthritis Cartilage. 2016 Dec;24(12):2061-8.
33. Liu J, Wang T, Zhu ZH. Efficacy and safety of radiofrequency treatment for improving knee pain and function in knee osteoarthritis: a meta-analysis of randomized controlled trials. J Orthop Surg Res. 2022 Jan 15;17(1):21.
34. 32.Kirdemir P, Çatav S, Alkaya Solmaz F. The genicular nerve: radiofrequency lesion application for chronic knee pain. Turk J Med Sci. 2017 Feb 27;47(01):268-72.
35. de Sire A, Lippi L, Curci C, Calafiore D, Cisari C, Ammendolia A, et al. Effectiveness of combined treatment using physical exercise and ultrasound-guided radiofrequency ablation of genicular nerves in patients with knee osteoarthritis. Appl Sci. 2021 May 12;11:4338.
36. Pineda MMS, Vanlinthout LE, Moreno Martín A, van Zundert J, Rodriguez Huertas F, Novalbos Ruiz JP. Analgesic effect and functional improvement caused by radiofrequency treatment of genicular nerves in patients with advanced osteoarthritis of the knee until 1 year following treatment. Reg Anesth Pain Med. 2017 Jan-Feb;42(1):62-8.
37. Kim DH, Lee MS, Lee S, Yoon SH, Shin JW, Choi SS. A prospective randomized comparison of the efficacy of ultrasound vs fluoroscopy-guided genicular nerve block for chronic knee osteoarthritis. Pain Physician. 2019 Mar;22(2):139-46.
38. Lash D, Frantz E, Hurdle MF. Ultrasound-guided cooled radiofrequency ablation of the genicular nerves: a technique paper. Pain Manag. 2020 May;10(3):147-57
39. Pérez Moreno JC, Nájera Losada DC, Herrero Trujillano M, Gálvez Mateos R, Sánchez García MA, Vela de Toro A et al. Genicular nerve radiofrequency in osteoarthritis-related chronic knee pain. Rev Soc Esp Dolor. 2021 May-Jun;28(3):157-68
40. Bellamy N, Campbell J, Robinson V, Gee T, Bourne R, Wells G. Intraarticular corticosteroid for treatment of osteoarthri- tis of the knee. Cochrane Database Syst Rev 2006; 19:CD005328.
41. Chen AF, Khalouf F, Zora K, et al. Cooled radiofrequency ablation provides extended clinical utility in the management of knee osteoarthritis: 12-month results from a prospective, multi-center, randomized, cross-over trial comparing cooled radiofrequency ablation to a single hyaluronic acid injection. BMC Musculoskelet Disord. 2020;21(1):363. Published 2020 Jun 9.
42. Davis, T., Loudermilk, E., DePalma, M., Hunter. C., Lindley, D., Patel, N., Choi, D., Soloman. M. Gupta. A., Desai. M., Buvanendran, A.. & Kapural, L. (2018). Prospective. Multicenter, Randomized. Crossover Clinical Trial Comparing the Safety and Effectiveness of Cooled Radiofrequency Ablation With Corticosteroid Injection in the Management of Knee Pain From Osteoarthritis. Regional anesthesia and pain medicine, 43(1). 84-91.