

Long Term Outcomes of Genicular Radiofrequency Ablation for Chronic Knee Pain

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Introduction: Knee osteoarthritis (OA) affects over 600 million individuals worldwide and costs the United States over \$5 billion to treat annually. The main treatment for refractive chronic pain from knee OA is total knee arthroplasty (TKA). Genicular nerve radiofrequency ablation (GNRFA) is a minimally invasive option for those who are unable to undergo TKA and for the 44% of TKA patients that experience persistent post-surgical pain. GNRFA selectively lesions the sensory nerves of the knee to provide pain relief without harming motor function. Current literature lacks data about long-term pain relief for this procedure. In this study, we aimed to test the hypothesis that GNRFA is effective beyond 12-months, and that its effectiveness varies based on clinical factors.

Methods: 57 patients that underwent a GNRFA at the University of Cincinnati outpatient pain clinics between 6/2/2017 and 6/2/2022 were enrolled in a retrospective cohort study. Medical records were reviewed for duration of benefit, pain scores, demographics, medications, surgeries, patient-defined percent relief, other medical conditions, and procedural details. Duration of benefit was calculated as the time until the patient reported termination of relief, a second intervention was performed, or until the most recent UC Health visit for patients that continued to report ongoing relief. Survival curve analyses were performed to demonstrate duration of benefit overall and between various clinical factors. A Cox proportional hazards regression model was generated to determine possible factors predictive of a better or worse outcome.

Results: Of the 82 treated knees initially identified in 57 subjects, 45 knees (25 left, 20 right) were included in our final analysis. 37 knees were excluded for being from a vulnerable population (n=4), having a GNRFA outside of the study time frame (n=23), and lack of follow-up (n=10). Survival curve analyses indicate longer duration of benefit with history of other pain conditions (p=0.015), mild (vs. severe) degeneration on XR (p=0.027), and smoking status: current or former (vs. never) (p=0.024). The Cox proportional hazards regression model shows increased duration of benefit with smoking status: current (HR = 0.26, 95% CI = 0.07-0.70, p = 0.016), history of diabetes (HR = 0.50, 95% CI = 0.23-1.03, p = 0.070), and history of other pain conditions (HR = 0.47, 95% CI = 0.21-1.12, p = 0.071). 14/45 (31%) of the knees were “non-responders,” experiencing improvement of symptoms for < 30 days following the GNRFA. Average duration of benefit in responders was 330.0 ± 394.5 days, with an average decrease in pain score of -1.75 ± 2.44 on the visual analog scale.

Conclusion: GNRFA is effective beyond 12-months for 13% of patients. Clinical factors may be used to estimate outcomes. More investigation is needed to determine why some knees do not respond to GNRFA.

Key Words: osteoarthritis, chronic pain, radiofrequency ablation, genicular nerves, total knee arthroplasty

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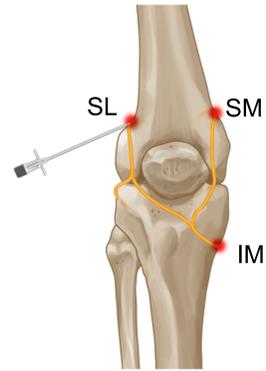
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Introduction

Osteoarthritis (OA) is the most common joint disorder in the world, with the knee being the most common site of degeneration (Zhang, Onishi). The main treatment for refractive chronic pain caused by knee OA is total knee arthroplasty (TKA), but age and other contraindications preclude many patients from being candidates for surgery (Onishi). Even with TKA, some patients experience post-surgical refractive knee pain (Wylde, Lewis). A less invasive treatment option is needed for those in which TKA is inaccessible or ineffective.

Radiofrequency ablation (RFA) of genicular nerves is a safe, minimally invasive procedure that targets the sensory nerves of the knee (Figure 1). Utilizing the heat generated by radiofrequency waves at the tip of an RF probe, the knee's sensory nerves are ablated, and pain relief is achieved—without harming motor function (Choi).



- RF probe and RFA targets of superolateral (SL), superomedial (SM), and inferomedial (IM) genicular nerves

While RFA is becoming a popular intervention for those with chronic knee pain, the current literature lacks data about long-term pain relief. Although conventional RFA is more common among proceduralists, the only study examining outcomes at times greater than 12-months analyzes cases in which cooled RFA was utilized (Lyman, Adb-Elseyed). Additionally, few studies evaluate clinical factors that may affect outcomes. We hypothesize that genicular RFA is effective beyond 12-months, and that its effectiveness may vary based on clinical variables.

Methods

Study design

- Retrospective cohort study
- Data pulled from University of Cincinnati outpatient pain clinics
- Inclusion criteria:
 - Over the age of 18
 - Knee genicular RFA within 5 years ending 1 year before the study begins, indicated for the management of chronic knee pain
- Exclusion criteria:
 - Under the age of 18
 - Vulnerable populations
 - Previous RFA before start date
 - First RFA after end date (within last year)
 - Lack of follow-up

Data Collection

- Electronic query of existing Epic anesthesia and procedure notes
- Stored in encrypted password-protected Excel spreadsheets

Statistical Analysis

- Graphpad Prism software
- Survival curve analyzed using next intervention as endpoint for RFA relief duration
- Cox proportional hazards regression model generated analyzing factors including diabetes status, history of depression, previous physical therapy/injections to determine possible factors predicting duration of benefit

Results

Inclusion and Exclusion

	Left Knee	Right Knee
Initially identified	43	39
Vulnerable population	2	2
Prior RFA within 1 year before start date	3	3
First RFA after end date (within last year)	9	8
Lack of follow-up	4	6
Included	25	20

Simple demographic variables do not predict responders vs. non-responders

		Responders	Non-responders	P-value
Age	Mean ±SD, years	58.74 ±16.09	66.57 ±15.38	0.1329
BMI	Mean ±SD, kg/m ²	34.69 ±9.48	33.83 ±8.77	0.9084
Pre-Procedure Pain Score	Mean ±SD, NRS	5.84 ±1.90	6.5 ±1.99	0.1529
Post-Procedure Pain Score	Mean ±SD, NRS	4.11 ±2.35	5.85 ±3.36	0.0623
Change in Pain Score	Mean ±SD, NRS	-1.75 ±2.44	-0.62 ±2.22	0.1629
% Improvement Follow-up	Mean ±SD, %	72.67 ±18.23	30.71 ±38.72	<0.0001****
Duration of Benefit	Mean ±SD, days	330.0 ±394.5	3.00 ±4.32	<0.0001****
Race				0.4022
	Caucasian	24	13	
	African American	7	1	
Sex				0.7171
	Female	24	10	
	Male	7	4	
Tobacco Use				0.5717
	Current	6	1	
	Former smoker	9	5	
	Never Smoker	16	8	
Prior TKA				0.3262
	Yes	10	7	
	No	21	7	
Total		31	14	

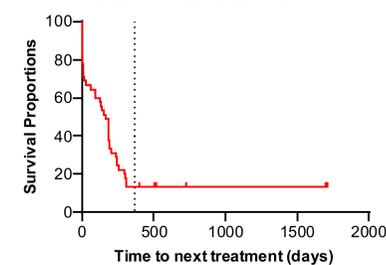
- Subjects were split into two groups for further analysis: responders and non-responders. Non-responders are defined by improvement of symptoms lasting <30 days following the procedure. There is no significant difference between the groups in race, sex, tobacco use, prior TKA, age, BMI, pre-procedure pain score, post-procedure pain score, and change in pain score. The percent improvement reported at follow-up is significantly higher in the responders group (p<0.0001), and the duration of benefit is significantly longer in the responders group (p<0.001). Of the 14 non-responders, 8 reported no benefit at all (0 days), 5 reported <10 days, and 1 reported a duration of benefit of 14 days.

Cox Hazards analysis implies smoking prolongs benefit

Variable	β	Std. Error	P-value	Hazard Ratio (HR)	Lower HR	Upper HR
Smoking Status [Former]	-0.2997	0.3818	0.4324	0.7410	0.3410	1.545
Smoking Status [Current]	-1.3470	0.5569	0.0155	0.2599	0.0746	0.7008
Diabetic [yes]	-0.6921	0.3816	0.0697	0.5005	0.2271	1.027
Other Pain Conditions [yes]	-0.7621	0.4221	0.0710	0.4667	0.2102	1.121

- The model demonstrates increased duration of benefit with smoking status: current (HR=0.26, 95% CI=0.07-0.70, p=0.016), with a trend for history of diabetes (HR=0.50, 95% CI=0.23-1.03, p=0.070), and history of other pain conditions (HR=0.47, 95% CI=0.21-1.12, p=0.071). With this model, current smokers have a 3.85x increased duration of benefit (p=0.016), a history of other pain conditions increases duration of benefit by 2.14x (p=0.071), and a history of diabetes increases duration of benefit by 2.00x (p=0.070).

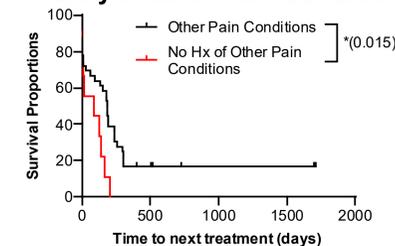
Survival Curve



- Survival curve of all subjects. Here, "survival" refers to the time until the RFA stopped working as indicated by subject receiving a geniculate block, additional RFA, or total knee replacement. Those with 0-day duration of benefit were adjusted to 0.00001 for analysis. The subjects without a specific time for end of benefit are marked as censored (represented by the dashes along the graph). These include the subjects that report ongoing benefit and continue to visit UC Health offices. The minimum known duration of benefit as time between procedure and most recent UC Health visit was estimated; they may continue to have benefit into the future. Dotted line indicates 1 year time point.

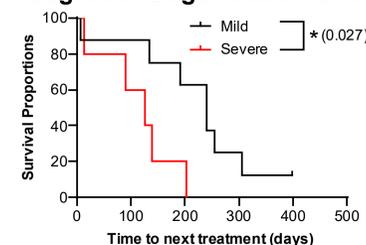
Clinical variables with significant effect in survival curve analysis

History of Other Pain Conditions



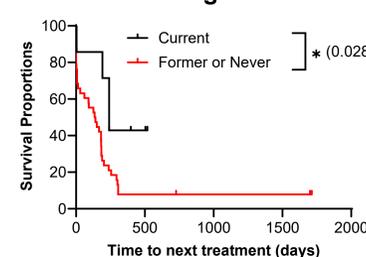
- Patients with a history of other pain conditions experience a longer duration of benefit than patients with no history of other pain conditions (p=0.015).

Degree of Degeneration on XR



- A mild (vs. severe) degree of degeneration visible on x-ray prior to the procedure corresponds to a longer duration of benefit (p=0.027).

Smoking Status



- A smoking status of current (vs. former or never) corresponds to a longer duration of benefit (p=0.028).

Conclusions

- Genicular RFA is effective beyond 12-months for 13% of patients, and its effectiveness varies based on clinical variables including history of other pain conditions, degree of degeneration on XR, smoking status, and history of diabetes.
- A significant portion of patients experienced little to no benefit (non-responders, n=14) following the genicular RFA procedure. Future research may involve investigating factors that contribute to procedure responsiveness, including central vs peripheral pain treatments and duration of pain prior to procedure.
- A history of other pain conditions may contribute to an increased duration of benefit due to more frequent appointments at the pain clinic, concomitant pain prescriptions, or the development of some degree of pain tolerance.
- Current smoking status and a history of diabetes may contribute to an increased duration of benefit because of these factors' roles in wound healing; The longer it takes for the nerve lesion to heal, the longer duration of benefit the patient experiences as the genicular sensation remains ablated.
- Some limitations of this study are its small sample size (n=45) and that the study was performed retrospectively. The research timeline did not allow for a prospective study; this retrospective study can only show correlations, not causal relationships.

Clinical Relevance

- We propose that clinical variables—especially a history of other pain conditions, smoking status, degree of degeneration on XR, and a history of diabetes—be taken into consideration when estimating the duration of benefit that a patient will experience following a genicular nerve RFA for the treatment of chronic knee pain.

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