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American Journal of Interventional Radiology

Original Research

A retrospective comparison of percutaneous radiofrequency ablation of osteoid osteoma using three anesthesia modalities

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Received : 26 May 2020
Accepted : 14 September 2020
Published : 06 October 2020

DOI
10.25259/AJIR_10_2020

Quick Response Code:

ABSTRACT

Objectives: The objectives of the study were to compare the safety and effectiveness of ultrasound-guided regional anesthesia (USGRA) with monitored anesthesia care (MAC) plus light sedation (MAC + LS) versus MAC with deep sedation (MAC + DS) versus general anesthesia (GA) for percutaneous radiofrequency ablation (PRFA) of lower extremity osteoid osteoma (OO).

Material and Methods: Patients who underwent PRFA of lower extremity OO from May 2016 to February 2020 were retrospectively reviewed. Three groups were constructed based on the primary anesthetic utilized: (i) USGRA with MAC + LS, (ii) MAC + DS, and (iii) GA. USGRA patients were administered sciatic or tibial nerve blocks using local anesthetic (LA) mixtures consisting of 1.5% mepivacaine ± 2% lidocaine or 2% chloroprocaine. Data were collected on the frequency of conversion to GA, post-procedure ambulatory falls, prolonged neurosensory blockade, technical success of the block, post-procedure visual analog pain scale (VAS), milligram morphine equivalent (MME) administered, procedure and recovery times, and time to resolution of the block. Data were also collected on patient age, sex, and the tumor size and location. Kruskal–Wallis and Pearson's Chi-squared tests were performed to compare outcomes in the three study groups.

Results: Nineteen patients (12 men; mean age 20.9 ± 5.9 years) with a median tumor volume of 66 mm^3 [IQR 36, 150] were included. Lesion locations included the tibia (10 cases), femur (4 cases), fibula (3 cases), and calcaneus (2 cases). Four patients were provided USGRA and MAC + LS, eight patients underwent MAC + DS, and seven patients received GA. There were no significant differences in patient demographic characteristics between the three study groups. Technical success was achieved in all four patients receiving USGRA. None required conversion to GA, had post-procedure ambulation difficulty, or prolonged neurosensory deficits. Post-procedure VAS score was 0 at all measured time intervals, and no USGRA patients required opioids. Conversely, patients receiving MAC + DS or GA had varying mean VAS scores (GA: 1.8 ± 0.9; MAC + DS: 1.7 ± 1.7) and opioid requirements (median [IQR]) (GA: 0 [0, 0] MME; MAC + DS: 0 [0, 3.75] MME). Tumor volumes >100 mm^3 frequently required opioid analgesia. VAS scores were significantly lower in USGRA patients at 30 min post-recovery area arrival ($P = 0.027$) and on average over 0–120 min post-recovery area arrival ($P = 0.016$). Procedure duration was similar between the three anesthesia groups ($P = 0.939$). There was no significant difference in mean recovery times in the USGRA group (230 ± 111 min) compared to the MAC + DS (136 ± 71 min) or GA (113 ± 34 min) groups ($P = 0.305$). Of note, both time to USGRA resolution (254 min) and recovery time (70 min) were quickest in the patient who received a mixture of 1.5% mepivacaine and 2% chloroprocaine.

Conclusion: USGRA can be implemented safely and effectively for PRFA of OO as an alternative primary anesthetic technique. It decreases post-procedural discomfort without ambulation difficulty, prolonged

neurosensory deficit, or recovery time. The potential for prolonged block duration may be addressed using a mepivacaine/chloroprocaine LA mixture for periprocedural analgesia with quick resolution.

Keywords: General anesthesia, Monitored anesthesia care, Osteoid osteoma, Radiofrequency ablation, Regional anesthesia

INTRODUCTION

Osteoid osteoma (OO) is a benign bone tumor most common in adolescence or young adulthood. These lesions account for 10–12% of all benign bone tumors and 2–3% of primary bone tumors with a predilection for the long bones of the lower extremities.[1,2] Historically, surgical excision has served as the principle treatment for OO, but in recent years, percutaneous radiofrequency ablation (PRFA) has emerged as the treatment of choice and boasts superior long-term efficacy at lower cost.[3,4]

Anesthetic management during PRFA of OO has presented several critical challenges. Periprocedural pain is often exquisite in these patients as the periosteum and marrow display increased nociceptive sensitivity in comparison to other tissues,[5] as does the tumor itself and the non-neoplastic reactive tissues that surround the tumor.[6,7] As such, patients typically require a general anesthetic (GA) or monitored anesthesia care (MAC) with deep sedation (DS).[8] Unpleasant side effects from these types of anesthetics include nausea, vomiting, delayed wakeup, and sore throat.[8] At our institution, these cases are associated with post-procedural opioids.

Regional anesthesia (RA) is a technique that has been gaining popularity in the interventional radiology (IR) suite. Specifically, it has been used by interventional oncology for renal, hepatic, and uterine tumor ablations with studies showing increased patient satisfaction with decreased periprocedural pain and opioid utilization.[9-11]

The purpose of this study was to evaluate the safety and effectiveness of ultrasound-guided RA (USGRA) with MAC plus light sedation (LS) versus GA versus MAC with DS for PRFA of lower extremity OO.

MATERIAL AND METHODS

Inclusion and exclusion criteria

This retrospective study received Institutional Review Board approval and is HIPAA compliant. All patients with OO diagnosed through CT and referred for treatment with PRFA at a single tertiary care academic medical center between May 2016 and February 2020 were reviewed. Twenty-one cases were identified by this initial screening. Inclusion criteria were age ≥14 years and lesions of the mid-to-distal femur, leg, and foot. Younger patients were excluded as they typically receive GA for procedures due to inability to cooperate. Nineteen patients were identified by these criteria [Figure 1]. Collected demographic data included age, gender, tumor location, and tumor volume. Tumor volume was obtained by measuring tumor nidus on CT in three dimensions and calculating volume as a rectangular prism.

Anesthesia groups and technique

Three anesthesia groups were comprised as follows: Patients given (i) USGRA plus MAC with LS, (ii) MAC with DS, or (iii) GA. The attending anesthesiologist selected the type of anesthesia based on the patient's history, a discussion with the IR physician performing the case and patient preference. Of note, based on the review, none of the patients included in the current study had contraindications for regional anesthesia.

All patients were premedicated with fentanyl and midazolam. Preprocedure multimodal analgesia, with celecoxib, tramadol, and/or acetaminophen, intraprocedural analgesics such as ketorolac and long acting opiates, and adjuvants such as dexamethasone, was at the discretion of the anesthesia provider.

MAC with DS

Using standard American Society of Anesthesiologists (ASA) monitoring, a propofol bolus of 1.5–2 mg/kg was administered, followed by an infusion rate of 200–250 mcg/kg/min and titrated to a level where there was an absence of motor response to painful stimulus but preserved respiratory drive.

General anesthesia (GA)

GA was induced using standard ASA monitors with propofol ± rocuronium. Sevoflurane was used for maintenance. The airway was secured with either an endotracheal tube or laryngeal mask airway.

Regional anesthesia

Target nerves (sciatic or tibial) were selected based on lesion location in relation to sclerotomes. A single shot sciatic or tibial nerve block was performed at the level of the popliteal fossa using the GE Logiq E ultrasound (General Electric, Boston, MA, USA) with a linear transducer and an 80 mm 22 g SonoPlex needle (Pajunk Medical Systems L.P., Norcross, GA, USA). The blocks

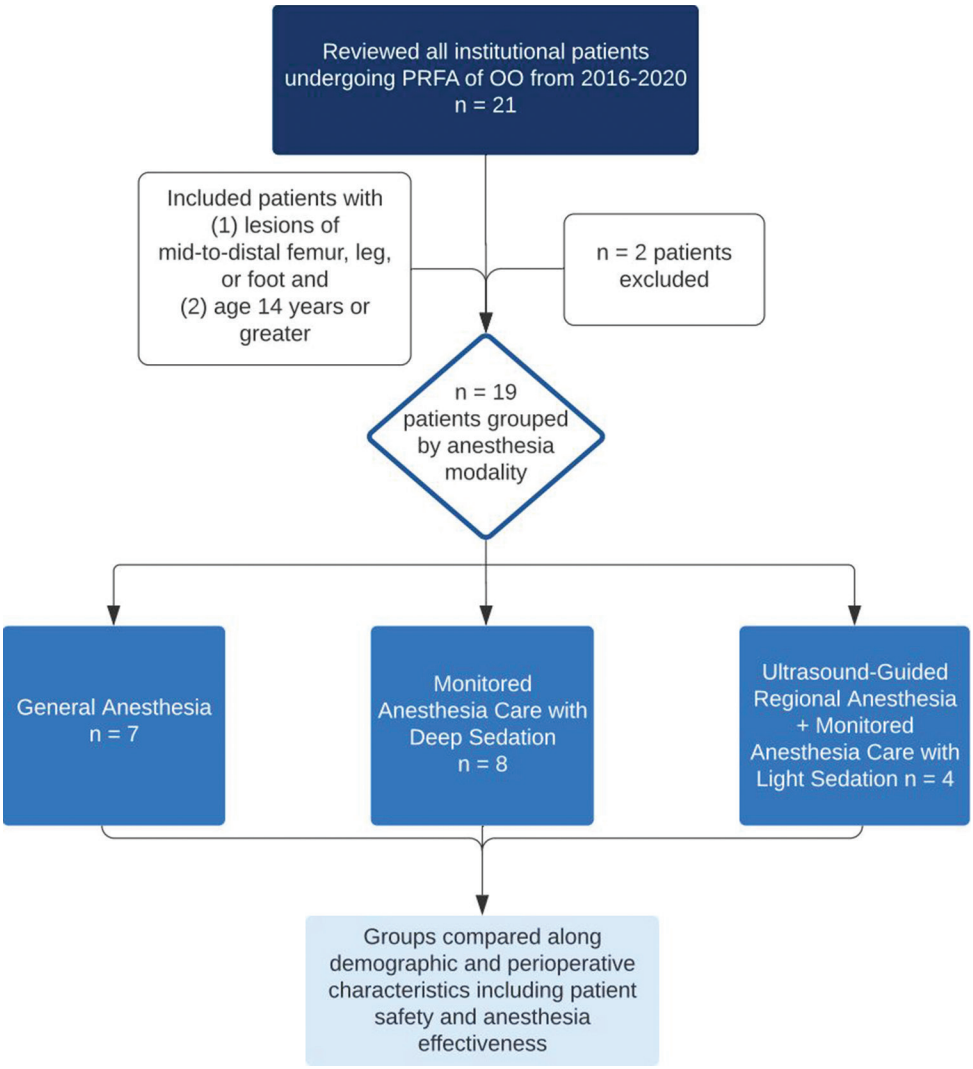

Figure 1: Visual representation of study design with inclusion and exclusion criteria.

were performed with the patient in the supine position and using sterile technique. The lower extremity with the lesion was elevated on a leg holder, supporting the leg at the level of the calf. In this position, the knee was slightly flexed, to facilitate placement of the ultrasound transducer at the popliteal fossa. The posterior and lateral aspects of the lower thigh were prepped with 2% chlorhexidine and a sterile sleeve was used for the transducer. The bifurcation of the sciatic nerve was identified by placing the transducer in a transverse orientation at the popliteal fossa and scanning cephalad. Once the nerve of interest was identified, the SonoPlex needle was introduced from the lateral aspect of the thigh perpendicular to the probe for an in-plane approach. Before insertion of the block needle, the area was anesthetized with 2 cc of 1% lidocaine through a 25 g 1.5 inch needle. The needle tip was advanced toward the sciatic nerve traversing the epineural layer just between the tibial and peroneal nerve bifurcation to achieve subparaneural spread of the local anesthetic (LA). Once adequate location of the tip was confirmed using hydrodissection with normal saline, between 20 and 30 cc of a LA mixture containing either 1.5% mepivacaine with epinephrine 1:400,000 ± 2% lidocaine or 2% chloroprocaine which was injected at the level of the bifurcation of the sciatic nerve. The tibial block was performed in a similar fashion. In this case, the nerve was identified by scanning caudal from the bifurcation of the sciatic nerve at the popliteal fossa. Once the tibial nerve was identified, the needle tip advanced to proximal to the epineurium of the tibial nerve and 20 cc of LA were injected to achieve circumferential spread. The injections were performed gradually with intermittent aspiration, to avoid inadvertent intravascular injection of LA. At the time of PRFA, a propofol infusion at 40–80 mcg/kg/min was initiated to provide light procedural sedation.

Follow-up

Patient safety was reviewed by examining complications such as conversion to GA, post-procedure ambulation difficulty, or prolonged neurosensory deficits. Conversion to GA represents a safety issue as these procedures take place in a CT scanner with patient positioning non-optimal for mid-procedural anesthesia adjustments. Effectiveness was assessed by block technical success, post-procedure opioid burden (in milligram morphine equivalent [MME]), and visual analog pain scale (VAS) at post-procedure recovery area arrival, and again at 30, 60, and 120 min after recovery area arrival. Block technical success was defined by lack of patient movement as the needle approached and traversed the tumor bed. Times to block resolution, procedure times, and recovery times were recorded for comparison. MAC with DS and GA patients was discharged once they met institutional discharge criteria from the radiology recovery suite, which included assessment of adequate oral intake and pain control. There was no protocol in place to discharge patients with nerve blocks from the radiology recovery area, thus patients receiving USGRA were not discharged until baseline motor strength had returned per the patient's judgment.

Statistical analysis

Statistical analyses were conducted using SPSS Statistics software package (IBM, Armonk, NY, USA). Patient demographic data and endpoints are reported with descriptive statistics such as frequency, range, mean, and standard deviation for continuous, normally distributed data. Not normally distributed data were reported with median and interquartile range. Kruskal–Wallis tests and Pearson's Chi-squared tests were performed to compare demographic and procedural outcomes in the three study groups.

RESULTS

Population

The study population included 12 men and 7 women with a mean age of 20.9 ± 5.9 years (range 14–35 years). Median tumor volume was 66 mm^3 [IQR 36, 150]. The most common lesion location was the tibia (10 cases), followed by the femur (4 cases), fibula (3 cases), and calcaneus (2 cases). Four patients were given pre-procedure USGRA and MAC with LS, eight patients underwent the procedure using MAC with DS, and seven were provided GA. No significant differences were observed in patient demographic or tumor characteristics between the three study groups [Table 1]. A full report of patient data is listed in Figure 2.

Effectiveness

In the USGRA group, block technical success was achieved in all four patients. None required opioids post-procedure or reported pain at measured time intervals [Table 2].

Patients receiving MAC with DS or GA displayed variable VAS scores and opioid requirements. In the MAC with DS group, three patients required post-procedural opioids (median MME 0 mg and IQR [0,3.75]) while one GA patient requested opioids for pain and was given 9.1 mg MME (median 0 and IQR [0,0]). Of the four patients that received opioids, three had tumor volumes >100 mm^3. Seven of seven in the GA group and seven of eight in the MAC with DS group experienced post-procedure pain (in at least one of the measured time intervals) compared to 0 of 4 in the USGRA group, with a significant difference observed in VAS scores at 30 min post-recovery area arrival ($P = 0.027$) and average VAS scores from 0 to 120 min post-recovery area arrival ($P = 0.016$).

Table 1: Patient characteristics in the three anesthesia groups.

	General anesthesia	MAC with deep sedation	RA with MAC plus light sedation	*P*-value[a]
n	7	8	4	
Age (years)				
Mean (±SD)	20.7 (5.8)	21.9 (7.3)	19.5 (3.9)	0.940
Gender (male)				
Frequency (% group)	4/7 (57%)	6/8 (75%)	2/4 (50%)	0.641
Tumor location				
Frequency	Femur 3/7 Tibia 4/7 Fibula 0/7 Calcaneus 0/7	Femur 1/8 Tibia 2/8 Fibula 3/8 Calcaneus 2/8	Femur 0/4 Tibia 4/4 Fibula 0/4 Calcaneus 0/4	0.128
Tumor volume (mm^3)				
Median [IQR]	80 [36,120]	102 [29,357]	57 [39,354]	0.852

SD: Standard deviation, IQR: Interquartile range, MAC: Monitored anesthesia care, RA: Regional anesthesia. [a]Kruskal–Wallis test used to compare interval data and Pearson's Chi-squared test used to compare proportions

Patient	*Age (yrs)*	*Sex*	*Tumor Location*	*Tumor Volume (mm^3)*	*Regional Anesthetic*	*Local Anesthetic*	*Local Dose (mL)*	*Type of Anesthesia*	*VAS at multiple intervals post procedure starting at Recovery arrival (min)*				*Procedure duration (min)*	*Block Duration (min)*	*Recovery Time (min)*	*Post-Procedure MME (mg)*
									0	30	60	>120				
1	24	F	Mid tibia	66	Sciatic	Mepivacaine 1.5% with epinephrine 1:400,000	20	RA/MAC	0	0	0	0	97	436	326	0
2	21	M	Tibial plateau	48	Sciatic	Lidocaine 2% and mepivacaine 1.5% with epinephrine 1:400,000	30/10	RA/MAC	0	0	0	0	74	354	261	0
3	15	M	Tibial plateau	36	Sciatic	Mepivacaine 1.5% with epinephrine 1:400,000	20	RA/MAC	0	0	0	0	65	345	261	0
4	18	F	Proximal tibia	450	Tibial	2% Chloroprocaine, mepivacaine 1.5% with epinephrine 1:400,000	10/10	RA/MAC	0	0	0	0	145	254	70	0
5	20	F	Tibia	112	NA	NA	NA	GA	0	3	0	0	86	NA	86	0
6	16	F	Distal Femur	36	NA	NA	NA	GA	0	9	0	5	75	NA	123	9.1
7	19	F	Proximal Tibia	140	NA	NA	NA	GA	3	3	0	0	97	NA	182	0
8	14	M	Tibia	20	NA	NA	NA	GA	0	0	3	5	182	NA	85	0
9	27	M	Proximal Tibia	120	NA	NA	NA	GA	0	4	3	2	79	NA	94	0
10	30	M	Distal Femur	80	NA	NA	NA	GA	0	4	0	0	89	NA	99	0
11	19	M	Medial Femur	45	NA	NA	NA	GA	0	0	3	0	95	NA	121	0
12	31	M	Distal Tibia	648	Sciatic	Mepivacaine 1.5% with epinephrine 1:400,000	20	MAC + Deep Sedation*	8	2	10	0	124	243	292	4
13	17	F	Mid Femur	165	NA	NA	NA	MAC + Deep Sedation	0	0	7	0	103	NA	97	7.5
14	18	M	Distal Fibula	421	NA	NA	NA	MAC + Deep Sedation	7	2	6	0	113	NA	117	3
15	16	M	Lateral Calcaneus	36	NA	NA	NA	MAC + Deep Sedation	0	0	0	3	61	NA	152	0
16	15	M	Proximal Tibia	20	NA	NA	NA	MAC + Deep Sedation	0	0	0	4	151	NA	114	0
17	35	M	Fibula	54	NA	NA	NA	MAC + Deep Sedation	1	1	0	0	77	NA	121	0
18	21	F	Calcaneus	27	NA	NA	NA	MAC + Deep Sedation	0	0	0	0	61	NA	45	0
19	22	M	Fibula	150	NA	NA	NA	MAC + Deep Sedation	0	0	4	0	95	NA	152	0

Abbreviations: MAC-Monitored Anesthesia Care; RA-Regional Anesthesia; GA-General Anesthesia; M-Male; F-Female; NA-Not Applicable
* RA performed Post-Procedure as Rescue for Severe Pain

Figure 2: Patient-specific demographic, tumor, anesthetic, and periprocedural outcomes data.

One patient scheduled to receive MAC with DS reported 8/10 pain on arriving at the post-procedure recovery area. A total of 1.0 mg of hydromorphone was administered without improvement, and by 60 min, his pain escalated to 10/10. After obtaining informed consent, this patient received an ultrasound-guided tibial nerve block as a rescue procedure with 20 mL of 1.5% mepivacaine with epinephrine 1:400,000. Soon after, his pain decreased to 0/10.

Safety

Procedure durations were similar between the three groups. Mean recovery times were generally longer for USGRA patients when compared to those receiving MAC with DS or GA, but this relationship was not significant ($P = 0.305$). Among the four USGRA patients, block duration (range 254–436 min) and recovery time (range 70–326 min) varied depending on the LA mixture used. However, duration and recovery time were quickest in the patient that received a 2% chloroprocaine and 1.5% mepivacaine with epinephrine 1:400,000 mixture [Table 3].

DISCUSSION

The growth of RA techniques has provided opportunity to avoid GA, minimize opioid utilization, and decrease

Table 2: Outcomes of patients receiving GA, MAC + DS, and RA with MAC + LS for PRFA of OO.

	General anesthesia	MAC with deep sedation	RA with MAC plus light sedation	p-value[a]
n	7	8	4	
VAS at post-procedure recovery area arrival				
Mean (SD)	0.4 (1.1)	2 (3.4)	0 (0)	0.283
VAS at 30 min				
Mean (SD)	3.3 (3)	0.6 (0.9)	0 (0)	0.027*
VAS at 60 min				
Mean (SD)	1.5 (1.6)	3.4 (3.9)	0 (0)	0.178
VAS at 120 min				
mean (SD)	2 (2.4)	0.9 (1.6)	0 (0)	0.297
Average VAS 0–120 min				
Mean (SD)	1.8 (0.9)	1.7 (1.7)	0 (0)	0.016*
Post-procedure MME (mg)				
Median [IQR]	0 [0,0]	0 [0,3.75]	0 [0,0]	0.366
Procedure duration (min)				
Mean (SD)	100 (37)	98 (31)	95 (36)	0.939
Recovery time (min)				
Mean (SD)	113 (34)	136 (71)	230 (111)	0.305
Ambulatory falls				
Frequency	0/7	0/8	0/4	-
Conversion to GA				
Frequency	NA	0/8	0/4	-
Unexpected residual nerve paresthesia				
Frequency	NA	NA	0/4	-

SD: Standard deviation, IQR: Interquartile range, MAC: Monitored anesthesia care, RA: Regional anesthesia. [a]Kruskal–Wallis test used to compare interval data and Chi-squared test used to compare proportions. *Significant values with $\alpha<0.05$

Table 3: Local anesthetic and duration and recovery.

Patient	Target nerve	Local anesthetic	Dose (mL)	Block duration (min)	Recovery time (min)
1	Sciatic	1.5% mepivacaine with epinephrine 1:400,000	20	436	326
2	Sciatic	2% lidocaine and 1.5% mepivacaine with epinephrine 1:400,000	30/10	354	261
3	Sciatic	1.5% mepivacaine with epinephrine 1:400,000	20	345	261
4	Tibial	2% chloroprocaine and 1.5% mepivacaine with epinephrine 1:400,000	10/10	254	70

periprocedural pain. In the interventional space, phrenic nerve, brachial plexus, femoral and sciatic nerve, intercostal, transversus abdominus plane, and stellate ganglion blocks have been widely adopted for these purposes.[9] Within the realm of interventional oncology, the application of RA has been limited. Although the use of RA has been studied in the ablation of renal, hepatic, and uterine fibroid tumors, implementation of RA for lower extremity musculoskeletal IR procedures has not yet been explored.[10,12,13] Lower extremity blocks are routinely used during orthopedic surgeries and percutaneous endovascular laser ablations for venous insufficiency, but not during IR or interventional oncology musculoskeletal procedures.[14-18]

In this study, USGRA with sciatic and tibial nerve blocks plus MAC with LS was utilized as an alternative to GA and MAC with DS for the treatment of PRFA of lower extremity OO. Conventionally, GA or MAC with DS is required as patients experience exquisite periprocedural pain, especially during ablation. As reported by Rosenthal *et al.*, OO is a bone tumor uniquely interlaced with nerve fibers.[6,7] This feature is thought to be responsible for the abrupt onset of pain and hemodynamic response on entering the tumor with a needle and possibly for the early post-procedural pain as well. In this analysis, the acute post-procedural pain from PRFA resolved within 2 h. The use of USGRA may be an effective means of circumventing this phenomenon, and therefore, USGRA is well positioned to serve as an alternate primary anesthetic.

The present study demonstrates that tumor ablations larger than 100 mm^3 frequently required opioid analgesics. We hypothesize that tumor volume is positively associated with

both periprocedural opioid administration and immediate post-procedural discomfort, but a larger cohort is needed to assess this relationship. In addition, future studies involving USGRA for PRFA of OO should utilize conscious sedation without propofol to assess blunting of the intraprocedural pain and hemodynamic response to ablation.

OO lends itself for selective nerve blockade. Nerve targeting with ultrasound guidance decreases the amount of LA needed, decreases the risk LA toxicity, and results in faster block onset and resolution.[19] As the primary nociceptive stimulus in these procedures involves manipulation of the periosteum, marrow, tumor body, and surrounding reactive tissues, lower extremity sclerotomes should be utilized for optimal target nerve selection.[19,20] In our retrospective review, this technique was successful in all patients. None required conversion to GA, and all blocks had complete post-procedure sensorimotor resolution.

Fall risk is temporarily elevated following delivery of lower extremity RA. This relationship is well documented in RA for orthopedics surgeries, but has not been explored in RA for IR musculoskeletal procedures.[21,22] In the present study, no patients experienced a fall. Short-acting LAs pose a lower overall fall risk due to rapid return of sensorimotor function and should serve as first-line agents.

The main limitation of RA in the cases reviewed was a trend toward increased recovery time in the post-procedure recovery area compared to the other two groups, though non-inferior compared to the other two groups. This can be addressed with the use of short-acting agents, such as chloroprocaine and mepivacaine, which provide periprocedural analgesia with quick block resolution, thereby minimizing recovery time from anesthesia.[23] In addition, a protocol can be put in place to have patients use a lower extremity soft brace with a wheelchair escort to expedite discharge. Of note, RA may not be suitable for young children as they routinely need GA for ablative procedures due to not being able to tolerate laying immobile for a relatively prolonged period of time and the need for a secured airway.

An inherent limitation of this study is its retrospective nature and small number of patients. We acknowledge that three of the four USGRA patients had relatively small tumor volumes in comparison to the other two groups; however, one RA patient had a very large tumor measuring 450 mm^3 and experienced no immediate post-procedure pain or need for opioid analgesia. In addition, there were four different short-acting mixtures of LA for each of the patients. Future studies should aim to use one standard LA mixture for a better homogenous comparison. Moreover, patients were not evaluated in the days following PRFA. As such, the present study is unable to evaluate for differences in patient discomfort following the immediate post-procedural period. However, in our experience, we have observed that pain is most apparent immediately following PRFA and rapidly subsides within a few hours.[24] In addition, given the duration of anesthetic effects, we do not predict that anesthetic choice would influence patient discomfort in the days following ablation.

CONCLUSION

Lower extremity USGRA with light procedural sedation can be a safe and effective primary anesthetic for PRFA of OO with non-inferior recovery time as an alternative to either GA or MAC with DS. Future studies should include more patients to show its statistical superiority.

Acknowledgments

We would like to thank Dr. Joseph L. McDowell, Dr. Brinda B. Kamdar, Dr. Peter Stefanovich, and Dr. Ambrose Huang for their guidance and support.

Declaration of patient consent

Institutional Review Board permission obtained for the study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Di Capua CA, Cabarcas JC, Di Capua JF, Low S, Chang CY, Gilman AJ, *et al*. A retrospective comparison of percutaneous radiofrequency ablation of osteoid osteoma using three anesthesia modalities. Am J Interv Radiol 2020;4:11.