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Feasibility of Intraoperative Nerve Monitoring in Preventing Thermal Damage to the "Nerve at Risk" During Image Guided Ablation of Tumors

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Abstract

Purpose—To assess feasibility of intraoperative neurophysiologic monitoring (IONM) during image-guided, percutaneous thermal ablation of tumors.

Materials and Methods—From February 2009 to October 2013, a retrospective review of all image-guided percutaneous thermal ablation interventions using IONM was performed and data was compiled using electronic medical records and imaging studies.

Results—Twelve patients were treated in 13 ablation interventions. In 4 patients, real-time feedback from the monitoring neurologist was used to adjust applicator placement and ablation settings. IONM was technically feasible in all procedures and there were no complications related to monitoring or ablation. All nerves at risk remained intact and of the 11 patients who could be followed, none developed new nerve deficit up to a minimum of 2 months after ablation.

Conclusion—IONM is safe and feasible for use during image guided thermal ablation of tumors in the vicinity of nerves. Outcomes in this study demonstrate its potential utility in image guided ablation interventions.

Introduction

Image guided thermal ablation of tumors is a minimally invasive treatment for tumors that is curative for some patients and can be used as a low risk, palliative procedure for others (1,2). Thermal ablation zone size depends on numerous factors and may be difficult to predict in vivo. Nerve damage during image guided thermal ablation is a well-recognized complication (3–5). Nerves adjacent to tumors are often poorly visualized and sedation or anesthesia can suppress a patient's ability to sense nerve injury during ablation. Intraoperative nerve monitoring (IONM) has been in use in the neurosurgical and orthopedic operating rooms for decades to recognize impending nerve injury and prevent permanent damage during deep sedation (6,7). The purpose of this manuscript is to review initial experience of IONM in an interventional oncology setting as an adjunct to the percutaneous thermal ablation

interventions in preventing damage to “nerve at risk” when it is adjacent to the intended ablation zone.

Materials and Methods

Institutional Review Board approval was obtained for retrospective review of patients treated with image guided thermal ablation interventions while undergoing IONM. Informed consent for procedures was obtained from all individual participants included in the study. For this type of study formal consent for inclusion is not required. Data was compiled and stored in database compliant with the Health Insurance Portability and Accountability Act.

Patient Selection

A database composed of all patients who had undergone IONM was searched for image guided thermal ablations. There were no patient exclusion criteria.

Intervention

Utilization of IONM during an ablation intervention was decided by an interventional radiologist when a nerve (nerve at risk), such as brachial plexus or sciatic nerve, was deemed high risk for damage due to the proximity of the intended ablation zone. IONM was scheduled with the neurology department. Electrode locations were chosen after a discussion by the interventional radiologist and monitoring neurologist. All ablations were performed under general anesthesia as per local standard of care. Setup of monitoring equipment was performed in parallel with standard setup for ablation interventions to prevent increase in procedure time. Criteria for abnormal neurotonic activity were those recommended by the American Society of Neuromonitoring⁸. Somatosensory evoked potential (SSEP) amplitude changes of greater than 50% or prolonged latency greater than 10% from baseline were considered significant. For electromyography, spontaneous neurotonic activity was considered abnormal. Decisions regarding change in anesthesia or change in procedure (ablation) were made after review by the monitoring neurologist, anesthesiologist and interventional radiologist.

Ablation method, approach, device settings and duration were determined by the interventional radiologist. Endocare (Endocare, Inc., Austin Texas) or Galil (Galil Medical Inc., Arden Hills, Minnesota) systems were used for cryoablation and non-tined Cool-Tip system (Covidien, Mansfield, Massachusetts) was used for radiofrequency ablation. Initially, cryoablation, radiofrequency and microwave ablation were considered for use with IONM. After experience with five radiofrequency ablations, only cryoablation was subsequently used because it does not interfere with IONM signals during treatment. Treatment margins were estimated using predicted ablation zones from manufacturers' tables, intraoperative imaging and operator's experience. Additional protective measures were used to protect adjacent tissues when deemed necessary by the interventional radiologist.

Available imaging guidance was computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET)/CT and ultrasound, although ablations are not

performed solely under ultrasound guidance at the author's institution. Sedation method was chosen by the interventional radiologist.

Post Intervention Follow Up

Clinical and imaging follow up was determined by the interventional radiologist and other physician members of the multidisciplinary treatment teams.

Data Collection

Each patient's imaging studies and electronic medical records including initial consultation, ablation intervention details, follow up visits and other specialists' notes were reviewed. Patient demographics, imaging modality, ablation modality and duration, intra-procedural changes based on IONM, follow up imaging and physical exams were recorded. In cases where a portion of the electronic medical record was not clearly documented, such as a statement of "no abnormalities" for a physical examination, specifics of the examination were confirmed by the author of the note in question at the time of data acquisition for this manuscript. IONM reports were reviewed by a board certified neurologist trained in neurophysiologic monitoring for procedure related and monitoring information including techniques, nerves surveyed, location of electrodes, changes in tracings and changes in the procedure as a result of tracing changes.

Results

From February, 2009, to October, 2013, 12 patients underwent IONM during image guided thermal ablation of tumors in the interventional radiology service. A second ablation was performed in one patient (patient number 3, Table 1) due to persistent symptoms making the total number of IONM-assisted ablation interventions 13. The patient population included 10 males and 2 females, age range 21–74 with a mean age of 47.2 and median age of 45. Treated lesions were lung cancer (n=1), osteoid osteoma (n=2), synovial sarcoma of the knee (n=1), renal cell carcinoma metastasis to the iliac bone (n=1), nasopharyngeal squamous cell carcinoma metastasis to the lung (n=1), desmoid tumor metastasis to the lung (n=1), small cell lung cancer metastasis to the femur (n=1), breast cancer metastasis to the chest wall (n=1), breast cancer metastasis to the glenoid (n=1), Ewing Sarcoma metastasis to the tibia (n=1) and a lesion that was inconclusive for malignancy based on intraoperative biopsy containing non-specific spindle cells but no mitoses (n=1). This lesion was considered benign based on correlation of pathology results with the imaging and clinical presentation.

The majority of cases were within musculoskeletal territory with the location of treatment sites including pectoral muscles/chest wall (n=1), the popliteal fossa (n=2), the glenoid (n=1), humerus (n=1), iliac bone (n=1), femur (n=1), tibia (n=3) and lung apex (n=3).

The average maximum tumor dimension was 22 mm (range 5–57 mm) and the average distance from tumor margin to nerve at risk was 9 mm (range 3–14 mm).

Five treatments were performed using radiofrequency ablation (RFA) and 8 treatments utilized cryoablation. In the five RFA interventions, CT was used as guidance. For

cryoablation interventions CT (n=5), MRI (n=1), PET/CT (n=1) and a combination of CT/ultrasound were used for imaging guidance. Protection of adjacent tissues was performed using hydrodissection to displace nerves (patient 5, Table 1), pneumodissection to displace and insulate nerves (patient 12, Table 1) and pneumodissection to displace and insulate the skin (patient 10, Table 1).

Procedure time ranged from 90 minutes to 210 minutes with a mean time of 172 minutes.

Anesthesiologists performed general anesthesia for ablations. Seven out of 13 cases included intra-procedural biopsies.

Before the start of ablation the neurologist and interventional radiologist discussed details of treatment planning so the electrodes could be positioned without interfering with the ablation intervention.

Electromyography (EMG) was performed in every case and somatosensory evoked potential (SSEP) was also performed in 10 of 13 cases (Figures 1–3).

Monitored nerves were the brachial plexus (n=4), brachial plexus and suprascapular nerve (n=1), median and axillary nerves (n=1), sciatic nerve (n=2), and the tibial and peroneal nerves (n=5) (Table 1).

Each patient was seen immediately following the intervention by an interventional radiologist attending, fellow or nurse practitioner. Twelve out of 13 patients were seen in follow up visits (8 patients at 1 month post procedure, 3 at 2 months post procedure and one at 4 months post procedure). One patient with a benign diagnosis (patient 11, Table 1) declined follow up visits due to conflicts with busy personal schedule. One patient (patient 8, Table 1) had documented tibioperoneal nerve deficits prior to ablation that were unchanged following the procedure.

Follow-up imaging was obtained in all patients except for one patient who declined follow up visits (Table 1).

Radiofrequency ablation causes electrical artifact such that IONM is not possible during active ablation. Setting up electrodes and monitoring devices for IONM were done parallel to the standard setup of ablation interventions and had no discernible effect on the total length of ablation interventions. In four cases, there were changes in IONM signals as indicated by increased neurotonic activity (EMG) and in each instance, this information from the on-site neurologist resulted in an active change in technique by the interventional radiologist. In patient 7 (Table 1), the freeze cycle was stopped and a probe was repositioned leading to cessation of neurotonic activity. In patient 8 (Table 1), freezing was discontinued and the thaw cycle commenced, leading to cessation in neurotonic activity. In patient 9 (Table 1), there was neurotonic activity during an attempt to place the fifth cryoablation probe in close proximity to the brachial plexus. Probe placement could not be accomplished without neurotonic activity and therefore ablation was performed with four probes without neurotonic activity. In patient 11 (Table 1), neurotonic activity led to discontinuation of freezing after 5 minutes of a planned 8 minute cycle. All nerves at risk remained intact

during and after ablation interventions. No new nerve deficits were found in any patient during post procedure interviews and examinations. There were no complications directly related to IONM in this series. There were no cases in which IONM was not feasible due to technical reasons and it did not directly interfere with the operator's ability to perform or complete the ablation intervention.

Imaging demonstrated stability or resolution of ablation targets in 8 patients (Table 1). Persistence of inflammatory change in and around an osteoid osteoma 2 months post procedure prompted re-treatment (patient 3, Table 1). Progression of disease with diffuse bony metastases were present 6 months after treatment in a patient with a Ewing sarcoma lesion of the femur (patient 10, Table 1). A pathologic fracture occurred following treatment in a patient with a breast cancer metastasis to the glenoid (patient 12, Table 1). This was treated conservatively with medical management including pain medications, activity restriction and systemic chemotherapy. The fracture has remained stable for 12 months (until the time of data collection).

Discussion

Thermal ablation has become a commonly used tool in both the operating room and interventional radiology setting ⁽⁹⁾. Evidence supporting treatment success for thermal ablation is abundant and some reports have proven it to be as effective as surgery in select scenarios ^(10–13). Percutaneous thermal ablation can be offered to more patients than surgical resection due to its minimally invasive approach and low risk profile ⁽¹⁴⁾. Additionally, it has become a useful tool for palliation of painful metastases ⁽¹⁵⁾. Numerous case reports and series have cited nerve damage as a complication of thermal ablation techniques ^(3,5,16–22). Nerves adjacent to ablation zones are susceptible to both hot and cold thermal damage ⁽²³⁾. Animal studies have shown transient nerve dysfunction during heating may begin at temperatures as low as 40 degrees Celsius ⁽²⁴⁾ and permanent nerve damage occurs at 51 degrees Celsius ⁽⁴⁾. Nerve injury during cryoablation is thought to begin at 10 degrees Celsius ⁽²³⁾. Given these findings, a critical nerve does not necessarily need to be included within an active ablation zone to sustain damage. Furthermore, the vast majority of heat based ablations (and in the case of the authors' institution this includes all ablations) are performed under general anesthesia, eliminating any feedback that might be given from the patient to the operator about imminent nerve damage.

Ablation approach is affected by structures along the path of the applicator and ablation zone margin is often limited by adjacent critical structures that may be damaged by thermal changes. Nerve damage can occur in the context of image guided ablation by two mechanisms: trauma or thermal injury. Traumatic injury can be induced by stretching of the nerve (such as raising of the arms above the head during a lung or liver ablation, a position that has been abandoned by the author's institution due to risk of brachial plexus injury) or disruption of the nerve during applicator probe placement (patient 9, Table 1). Thermal injury can involve nerves near the target lesion as well as those outside of the intended ablation zone by both active and passive thermal energy transfer.

Attempts have been made to protect and monitor nerves from thermal damage during ablations including injection of saline, dextrose solution, dilute iodinated contrast, air and carbon dioxide (25,26) as well as measurement of temperatures using thermocouples (27,28). Injection of buffers is difficult to control and may not remain in the intended location throughout the procedure. Thermocouple utility depends on placement near critical structures (29) and accurate positioning along nerves may be difficult using landmarks or even imaging guidance.

Nerve damage can have a profound effect on patients both mentally and physically, including limitation of activities of daily living, anxiety and depression (30). This may be more pronounced when life expectancy is limited. The cost of iatrogenic nerve injury related to image guided thermal ablation interventions is both mental and financial and varies based on the degree of injury, the nerve affected, functional status of the individual and life expectancy, among other aspects. Depending upon the injury, associated costs may potentially be very high and include rehabilitation, assistance with activities of daily living, and further injury of the affected limb in the setting of persistent anesthesia, misuse and paralysis. Avoiding such complications often means not performing ablations considered to be high risk, or limiting the techniques to lower procedure risk at the cost of creating a desired ablation margin. These decisions are based on subjective estimations of what tissues may or may not be affected by thermal damage. Scientists have been unable to sufficiently quantify heat transfer in vivo based on current preoperative imaging and ablation tools. For these reasons, the authors use intraoperative nerve monitoring as an effective measure to prevent traumatic and thermal nerve damage during percutaneous image guided tumor ablation interventions.

IONM has been established as a standard of care in some surgical procedures including facial nerve sparing surgeries and has been used in the operative rooms since the early 1960's (31–33). Some of its use includes monitoring of the spinal cord (33), spinal nerves³⁴ and recurrent laryngeal nerve (35). The monitoring neurophysiologist uses several techniques to obtain real time feedback from monitored nerves to assess functional status and impending injury in the case of thermal ablation. Two commonly used techniques in neurophysiologic monitoring are assessment of somatosensory evoked potentials (SSEP) of sensory nerves and electromyographic (EMG) potentials of motor nerves. Both techniques can be performed using a single monitoring unit specifically designed for multimodality, simultaneous, real time monitoring that provides quantitative information and graphical displays, as well as printed copies of information. Setup of monitoring equipment in parallel with standard ablation procedure setup prevents this additional step from lengthening procedure time.

In monitoring of EMG potentials, needle electrodes are placed within a muscle innervated by the nerve at risk, peripheral to the ablation zone (relative to the central nervous system). Electrodes can be placed at a distance from the operative field as long as they are within a structure innervated by the nerve at risk. Thermal or mechanical irritation of the motor nerve elicits an action potential that is propagated into the muscle and the electrodes can detect this “neurotonic” activity. The motor nerve may also be electrically stimulated and compound

muscle action potentials can be quantified for latency (speed) and amplitude (strength). Changes in latency or amplitude suggest a possible nerve injury.

SSEP monitoring is done by placing adhesive stimulation electrodes on the skin based on a particular sensory nerve distribution (dermatome). Needle electrodes are placed on the scalp which record transmitted action potentials from the stimulated nerve to the brain. Latency and amplitude can be quantified and compared to readings obtained prior to the ablation (pre-procedure).

Neurophysiologic monitoring requires real time interpretation of data and correlation of confounding variables including other forms of nerve stimulation, nerve suppression from medications, and electrical interference from other equipment such as radiofrequency energy from ablation equipment, among other factors (³⁶). Radiofrequency energy can produce electrical interference and inhibit accurate monitoring of latencies or neurotonic activity and, therefore, radiofrequency ablations must be paused in order to record IONM signals. This series of cases included five treatments with RFA and, in each of these interventions, ablations were paused momentarily to allow recording of IONM signals. Time intervals were typically every 3 to 5 minutes, however, these were based on best estimates during the procedure and there is no data available on optimal sampling intervals. As the main purpose of IONM is provision of real time feedback about the integrity of the nerve at risk to the operating interventional radiologist, RFA precludes optimal utilization of IONM with current technology. Although microwave ablation was not used, it is the author's opinion that similar interference is expected.

Cryoablation is the only modality that does not produce nerve monitoring artifact during active ablation. The compatibility of cryoablation with continuous real time nerve monitoring is why this became and remains the technique of choice at the author's institution when IONM is considered. Monitoring can be performed continuously as long as interference from other variables is not present. For example, MRI was used for guidance during one cryoablation and IONM was performed only while radiofrequency energy was not being transmitted (it was not performed while images were acquired).

In four cases, there were treatment changes based on real time monitoring feedback. In three of these cases, cryoablation was stopped when changes in neurophysiologic activity were recognized and there were no permanent deficits. In the remaining case, probe placement was not possible without neurotonic activity suggesting the probe was very close to the nerve at risk (brachial plexus). All of these instances highlight the potential for nerve damage during thermal ablation that might not be apparent even by experienced operators. Previously irradiated animal nerves are known to be more susceptible to heat damage and this is thought to be related to changes in the vasculature supplying the nerves (³⁷). In this series, there were four patients treated with thermal ablation in previously irradiated zones and in two of these patients, feedback from the monitoring neurophysiologist resulted in active changes in treatment. No patient who received prior radiation experienced transient or permanent nerve injury following their procedures.

Of the 3 patients who were able to be followed and in whom IONM feedback resulted in an intra-procedure alteration of treatment, all had stable imaging appearances at the time of this analysis at 5, 15 and 22 months post treatment. While these results are insufficient to accurately state the utility of IONM in improving tumor control, there is promise in the fact that there were treatment successes within this group without a single nerve injury.

The most common complications directly related to intraoperative nerve monitoring are skin burn, infection and rarely seizures (^{38,39}). There were no complications directly related to IONM in this series, illustrating the safety of this technique that has been well proven in open operative procedures. There were no cases in which IONM was not feasible due to technical reasons and it did not directly interfere with the operator's ability to perform or complete the procedure.

This study is limited by its retrospective, non-standardized nature, which makes comparison of individual procedure techniques and outcomes difficult. The number of treatments in this series is low; however, data obtained indicates IONM is safe and feasible, even in situations with interference from radiofrequency energy. Data also indicate there were multiple situations in this small group (4 of 13 procedures) in which real-time feedback from IONM detected a change in nerve activity, raising the possibility of nerve injury and resulting in a change in treatment to preserve nerve function.

Conclusion

In this study IONM was safe and feasible for use during image guided ablation procedures, requiring minimal added time and providing real time feedback leading to treatment changes. It can potentially improve outcomes of image guided thermal ablations by preventing damage to nerves at risk. Based on the authors' experience, the ideal setting for IONM is cryoablation under CT guidance.

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Figure 1.

Cryoablation of a slowly growing soft tissue nodule in the lateral head of the left gastrocnemius muscle with intra operative nerve monitoring in a patient who declined surgical resection: (A) Stimulating electrodes are placed in the left gastrocnemius (arrow) and tibialis anterior (not shown) muscles. Sequential compressive device could be worn only on the non treatment contra lateral leg (arrowhead). (B) Recording electrodes (arrows) are placed on the skull to record cortical evoked potentials. (C) An applicator for cryoablation (arrow) and a 5 French catheter (arrowhead) for infusion of saline buffer are placed. (D) The neurologist monitors SSEP and EMG in real-time during the ablation inside the operating room. (E) Contrast enhanced T2 fat suppressed MR and (F) noncontrast pre-procedure CT shows a nodule (asterisks) within the lateral head of the left gastrocnemius muscle, only 1.5 cm from tibial nerve (arrowheads). (G) An applicator for cryoablation (arrow) and a 5

French catheter (arrowhead) for infusion of saline buffer are placed. The 5 French catheter is placed between the soft tissue nodule and the tibial nerve and popliteal vessels. During cryoablation, the low attenuation ice ball approaches, but does not contact the tibial nerve.

(H) Post procedure imaging demonstrates normal morphology of the tibial nerve (arrowheads) and the location of treated soft tissue nodule (asterisks).

Figure 2.

Somatosensory evoked potentials measured during lower extremity cryoablation. The tibial nerve is stimulated at 0 ms, and evoked potentials were measured in the lumbar (28 ms), thalamic (42 ms), and cortical (42 ms) regions. There is no change in somatosensory evoked potentials obtained pre-ablation (blue arrows) and post-ablation. Electrode locations on scalp CZ-central; FZ-forntal/central; CP3-left central/parietal; peripheral location IC-iliac crest

Figure 3.

Free run electromyography during image guided cryoablation of lower extremity. Increases in small motor unit potentials (black arrows) were seen during cryoablation, which may represent a surrogate marker for impending nerve injury. (LTA+ LTA: 2 needles placed at the left tibialis anterior muscle. LEDB + LEDB: 2 needles placed at the left extensor digitorum brevis muscle.)

Table 1

Procedure related data and follow up information for all patients treated.

Patient	Lesion Type	Location	Primary vs. metastatic	Lesion maximum size (mm)	Nerve at Risk Minimum distance between (mm)	Pre-treatment Radiation to Ablation Zone?	Image Guidance	Monitoring Type	Intra-procedural Flap	Ablation Type	Time (minutes)	Did RNM affect procedure?	Complication	Notes on effect on nerve post procedure	Number of Probe and System	Ablation Cycles	Thermal couple	Follow Up (months)	Other
1	Basal Cell Carcinoma	L Thigh	Metastatic	57	Sciatic (S1)	Yes	CT	SSFP EMG	Yes	RFA	210	No	None	No (1)	3, Cool-dip	4 (12 overlapping) (random)	Yes	Stable at 30 mos (PET)	
2	Adenocarcinoma	L Lung apex	Primary	12	Brachial plexus	No	CT	SSFP EMG	No	RFA	175	No	None	No (1)	1, Cool-dip	2 (random)	No	Stable at 31 mos (CT)	
3	Ovarian Ovarian	R Thigh	Primary	10	Tibial	No	CT	EMG	Yes	RFA	180	No	None	No (2)	1, Cool-dip	1 (empty mode)	No	Pre-treatment pain and numbness at 2 mos (MRI)	Ablation was paused twice to allow numbness to subside
3	Ovarian Ovarian	R Thigh	Primary	10	Tibial	No	CT	EMG	No	RFA	175	No	None	No (4)	1, Cool-dip	2 (empty mode)	No	Re-treatment of previous procedure at 4 mos (MRI)	Ablation was paused three times to allow numbness to subside
4	Ovarian Ovarian	R Humerus	Primary	5	Medial n	No	CT	SSFP EMG	Yes	RFA	175	No	None	No (2)	1, Cool-dip	1 (empty mode)	No	Asymptomatic, Stable at 2 mos (MRI)	Ablation was paused twice to allow numbness to subside
5	Desmoid tumor	L Chest wall	Primary	30	Brachial plexus	No	CT	SSFP EMG	No	Cryo	205	No	None	No (1)	3, Endocare	2 freeze cycles (random)	No	Stable at 30 mos (MRI)	Hydro-dissection used
6	Adenocarcinoma	L Lung apex	Primary	10	Brachial plexus	No	CT	SSFP EMG	No	Cryo	175	No	None	No (2)	1, Endocare	2 freeze cycles (random)	No	Stable at 17 mos (CT)	
7	Small Cell Lung Cancer	L Femur	Metastatic	55	Sciatic	Yes	MRI	EMG	No	Cryo	205	Yes	None	No (1)	5, Gall	2 freeze cycles (random)	No	Stable at 15 mos (MRI)	Other unable to report numbness due to RNM only possible outside of the target.
8	Synovial Cell Sarcoma	L Knee	Primary	12	Tibial and Peroneal	Yes	CT	SSFP EMG	No	Cryo	175	Yes	None	No (1)	2, Endocare	2 freeze cycles (random)	No	Stable at 6 mos (MRI)	Neurosensory activity, second cryo cycle stopped early.
9	Breast Cancer	R Pectoralis muscle	Metastatic	35	Brachial Plexus	No	PET CT	SSFP EMG	Yes	Cryo	90	Yes	None	No (1)	3, Endocare	2 freeze cycles (random)	No	Stable at 22 mos (PET CT)	Neurosensory activity when probe was in a 1 cm radius of target area. No hyper-contraction was observed.
10	Esophageal Sarcoma	R Thigh	Metastatic	21	Tibial and Peroneal	Yes	CT	SSFP EMG	Yes	Cryo	150	No	None	No (1)	2, Endocare	2 freeze cycles (random)	No	Endoneurotomy at 6 mos (PET CT)	Proximal dissection to prevent flare up.
11	Neurofibrosarcoma, non-malignant, diffuse neurofibroma	L Gastrocnemius muscle	Primary	51	Tibial	No	US CT	SSFP EMG	Yes	Cryo	120	Yes	None	Declined follow up (a flare of numbness)	1, Endocare	2 freeze cycles (random)	No	Declined imaging	Hyper-contraction. 2nd freeze cycle initiated due to numbness due to proximal dissection.
12	Breast Cancer	L Glenohumeral	Metastatic	19	Spino radicular nerve (radial plexus)	No	CT	SSFP EMG	Yes	Cryo	200	No	Post procedure fracture	No (1)	3, Endocare	2 probes, 2 freeze cycles (random), 1 probe 2 freeze cycles, 1 probe 2 freeze cycles, 1 probe 2 freeze cycles (random)	No	Stable at 12 mos (CT)	Proximal dissection to prevent flare up.