UC San Diego
Department of Surgery

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Clinical Challenges

Rare Chest Mass Managed by Oncoplastic Approach to Treatment and Reconstruction

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Chest masses in female patients raise immediate consideration for breast cancer. Although very common, breast cancer is not the only pathology that can be encountered, with other entities requiring consideration. One such entity is granular cell tumor (GCT) of the breast. Here Drs. Chris Reid, Zach Collier, and Anne Wallace present the first reported case of recurrent breast GCT with malignant transformation and metastases in juxtaposition to an occipital nerve stimulator. A possible novel pathophysiologic mechanism was identified as well as reinforcement of importance of complete oncologic treatment for GCTs.

A 45-year-old female with a medical history significant for occipital neuralgia requiring implantation of a bilateral occipital impulse nerve stimulator (INS) was seen for an enlarging chest wall mass. Two years earlier, she had a small mass (**Figure 1**) in proximity to the INS excised and primarily closed by different surgeon. Final pathologic diagnosis was granular cell tumor (GCT) with focally positive margins. The patient opted for watchful observation rather than re-excision to negative margins.

Figure 1: Initial Resection Specimen

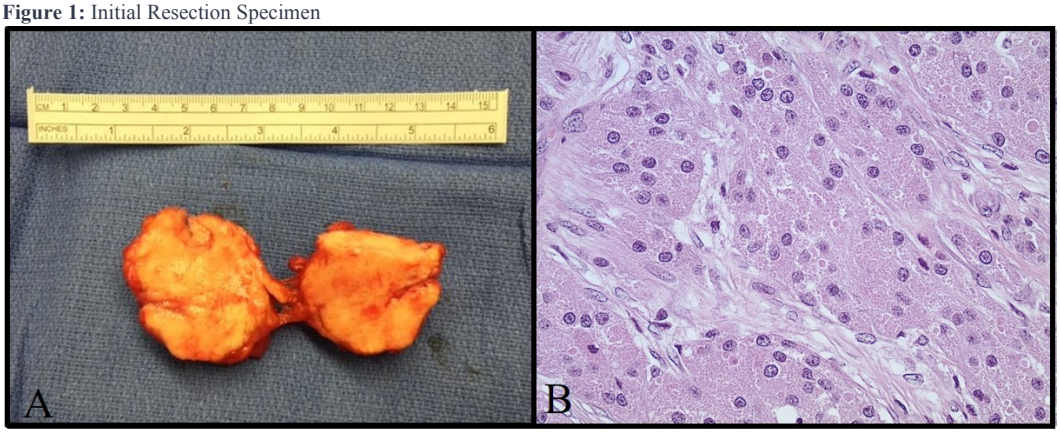

Figure 1. A) Depicted is the original mass that was resected in April 2016, which measured 4.9 x 4.5 x 3.2 cm. **B)** Histology showed an ill-defined tumor composed of sheets of large cells with a low nuclear to cytoplasmic ratio, granular cytoplasm, lack of mitotic figures, and no necrosis. (+ S-100 protein, - myogenin, - myoglobin, - desmin)

Figure 2: Appearance & Topography of Recurrent and Satellite Lesions

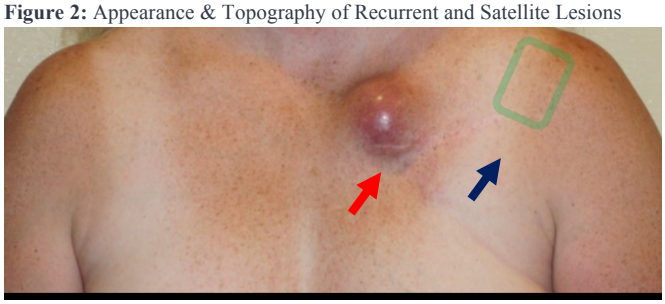

Figure 2. This image is from a July 2016 clinic visit in which a 7 cm hard, spherical, fixed mass just medial to the stimulator in the left supero-medial breast quadrant was appreciated (red arrow). The overlying skin was notably erythematous, atrophic, and significantly tense. A smaller, 1.5 cm mass (blue arrow) superficial to the stimulator battery pack (green square) was also noted.

She presented more recently with a protruding mass, adjacent to the stimulatory device in the left supero-medial quadrant of her breast, that was growing rapidly. She stated that the mass started growing back in the same location a few months after excision with an additional new mass of similar consistency but smaller size directly above the INS battery pack (**Figures 2** & **3**).

Figure 3: Secondary Presentation of Recurrent Mass

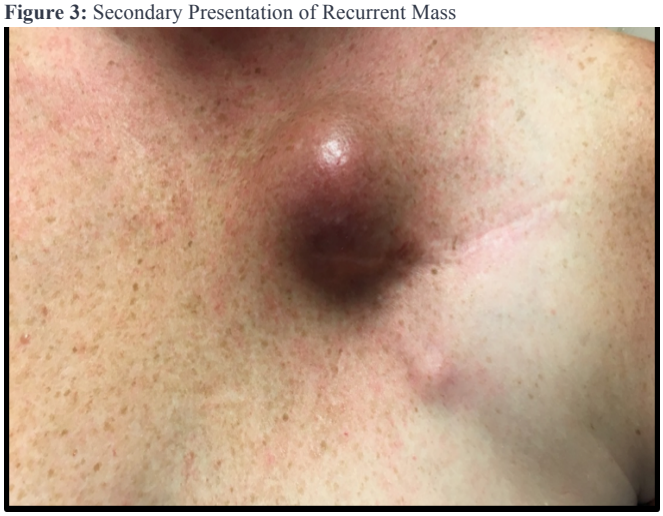

Figure 3. This close-up image of the recurrent mass was taken at the time of the patient's presentation for surgical resection. The second presentation raised concerns for malignancy due to the clinically significant increase in growth rate relative to the initial presentation and the involvement of overlying skin with erythema, tense inelasticity, and dermal atrophy. The scar from the initial resection is also visible on the inferior border of the mass. The smaller satellite lesion is also visible infero-lateral to the primary lesion.

Computed tomography imaging displayed a locally invasive tumor with regional lymphadenopathy (**Figure 4**). Wide surgical resection with immediate flap reconstruction was planned (**Figure 5**). Intraoperatively, careful dissection revealed that the medial branch of the supraclavicular nerve was penetrating into the tumor with a resulting defect, 20cm x 15cm (**Figure 6**). A pedicled latissimus dorsi myocutaneous flap and breast advancement flap were employed to cover the defect and recruit healthy durable tissue given the anticipated need for adjuvant radiation therapy (**Figure 7**). At 1 year post-operation she is healthy with no evidence of disease.

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Granular cell tumors (GCTs), or Abrikossoff tumors, are rare soft-tissue neoplasms that originate from Schwann cells (SCs).[1,2] Although GCTs are typically slow growing, benign tumors, they can be locally invasive.[3] The majority of GCTs develop in the head and neck region (>50%) with significant localization to the tongue (40%) while lesions of the breast account for 5-15% of all cases.[4–6] Around 2% of GCTs are malignant[7] (MGCT) and carry a poor prognosis due to their high rates of local recurrence (32%) and metastasis (50%).[3,4,8]

In contrast to benign lesions, malignant GCTs grow at appreciably greater rates to sizes greater than 4 cm and are more likely to result in ulceration, hemorrhage, or atrophy of the overlying skin.[9] Furthermore, in the absence of malignant histological features such as necrosis, high cellularity, atypia, and mitotic figures (>2/high-powered field), morphologically benign MGCTs may be phenotypically defined as malignant by the presence of metastases to regional lymph nodes or distant sites.[4,8,9]

Figure 4: Pre-Operative CT Imaging

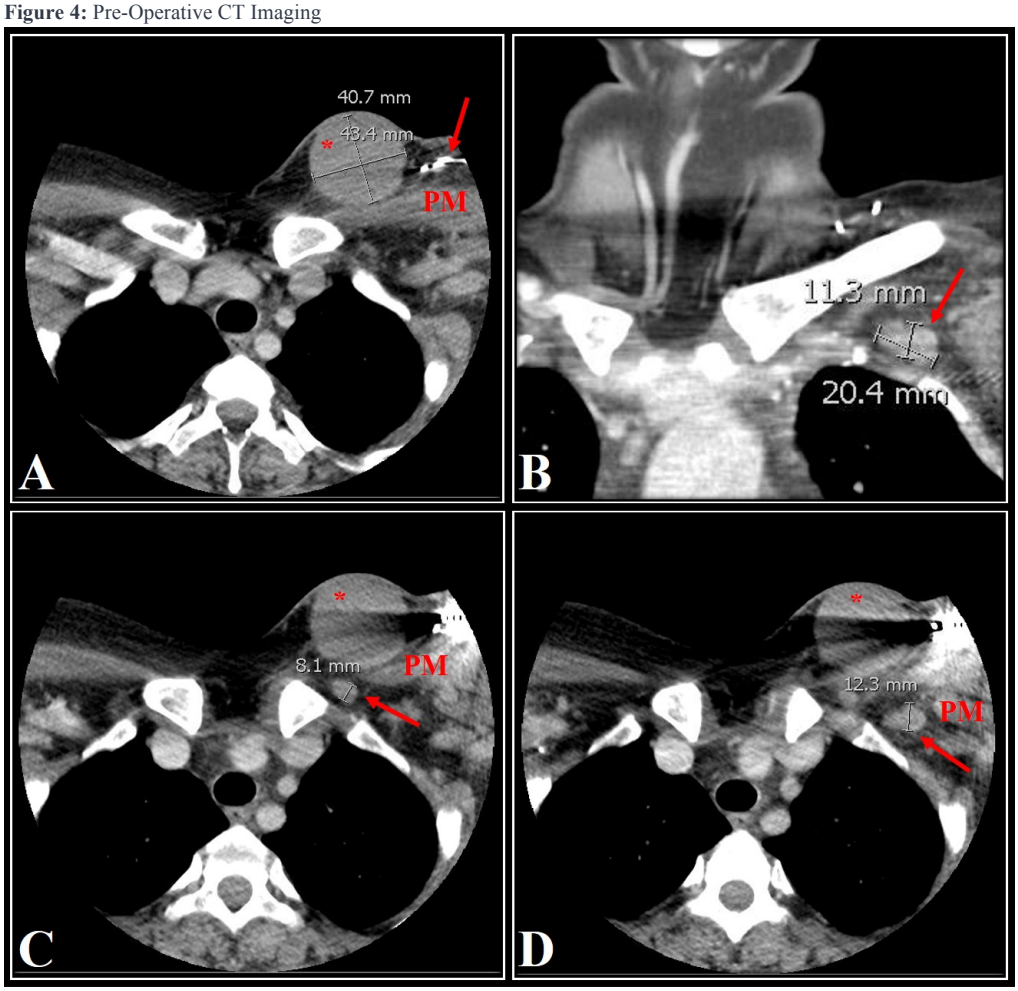


Figure 4. A) Primary lesion measuring 43.4mm x 40.7mm x 44mm shown superficial to pectoralis major (PM) and medial to the battery pack (red arrow). **B)** Large subpectoral node (red arrow) measuring 11.3mm x 20.4mm. **C)** Enlarged Rotter's node (red arrow) measuring 8.1mm x 10mm. **D)** Second Rotter's node (red arrow) measuring 12.3mm x 9mm. PM = Pectoralis major muscle; * = primary lesion.

Following diagnosis of GCTs, benign lesions are optimally treated with wide surgical resection to ***clear margins*** in order to reduce recurrence rates (2-8%).[3,7,9-11] While chemotherapy and radiotherapy have been employed in varying intensities for the treatment of MGCTs, they have failed to provide any statistically detectable survival benefit and wide surgical excision is the only curative treatment for MGCTs at this time.[9]

Diagnosing granular cell tumors in the breast is complicated by the fact that, clinically, grossly, and microscopically they mimic breast carcinomas. Clinically, breast GCTs often present as small, indolent, and firm solitary nodules located in the supero-medial quadrant of the breast parenchyma.[6,12,13] The quadrant localization is hypothesized to be a sequelae of the pathophysiologic derivation of the tumor from Schwan cells of the medial or intermediate branches of the supraclavicular nerve.[6,14-17]

Figure 5: Pre-Operative Markings

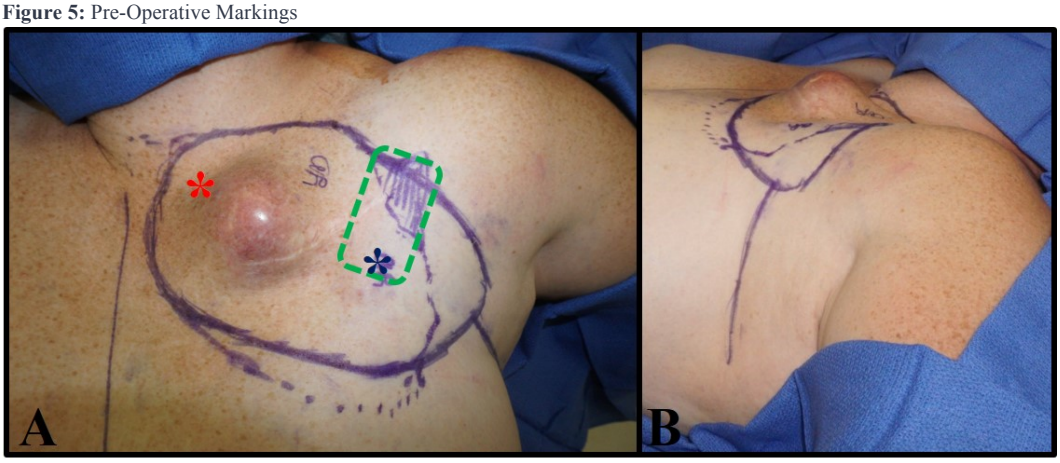


Figure 5. A) A-P view of left chest wall containing the primary (red *) and secondary (blue *) lesions as well as outline of the battery pack (green box) and planned resection using 5 cm margins. **B)** Left lateral view showing 5 cm projection of primary lesion.

While *de novo* GCTs of the breast consistently present in a supero-medial quadrant distribution pattern that correlates with the supraclavicular nerve branches, they are often solitary as well as benign in nature. This is a unique case of GCT with malignant transformation in close proximity to an occipital impulse nerve stimulator, which was charged on a daily basis with an electromagnetic field-emitting device. While the juxtaposition of a neoplasm and an implantable device may not always raise concerns for iatrogenic influences, the mounting body of literature supporting the ability of electromagnetic fields to induce proliferation, increase survival, and enhance/hasten migrational capacity of SCs has pertinent implications for this particular case.

Figure 6: *En Bloc* Resection with Resultant Defect & Specimen

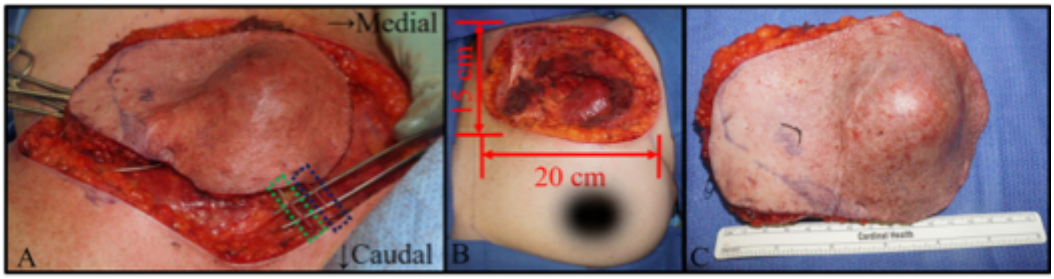


Figure 6. A) Completely incised *en bloc* resection highlighting the medial branch of the supraclavicular nerve (blue box) heading towards the tumor and the impulse nerve stimulator lead (green box) immediately adjacent to the nerve traveling in the same vector. **B)** Final defect was 20 x 15 cm and involved the underlying sternal and costal fascia (medial & inferior) and abutted the clavicle and subclavian vein superiorly. **C)** Final pathology specimen containing both lesions as well as the battery pack and capsule.

To date, six studies have directly examined the effects of electromagnetic fields (EMFs) on SCs as they relate to proliferation, migration, and cell survival.[18-23] Following exposure to these EMFs, SCs exhibited numerous phenotypic transformations consistent with neoplastic behavior, the first being increased gene expression and up regulation in SC growth factor production and secretion.[18,22,23] Second, EMFs augment SC alignment and motility following brief periods of EMF exposure. [21,24-29,] Another study found that SC exposure to EMFs of 50 Hz and 100 mT resulted in suppression of tumor suppressor activity.[22] The studied EMF parameters are condemningly similar to the transcutaneous EMF battery pack charger the patient had implanted.

Figure 7: Defect Closure with Latissimus Dorsi Myocutaneous Flap & Breast Rotational Flap

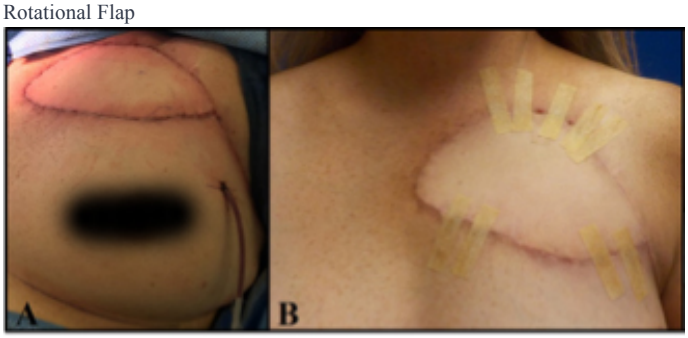
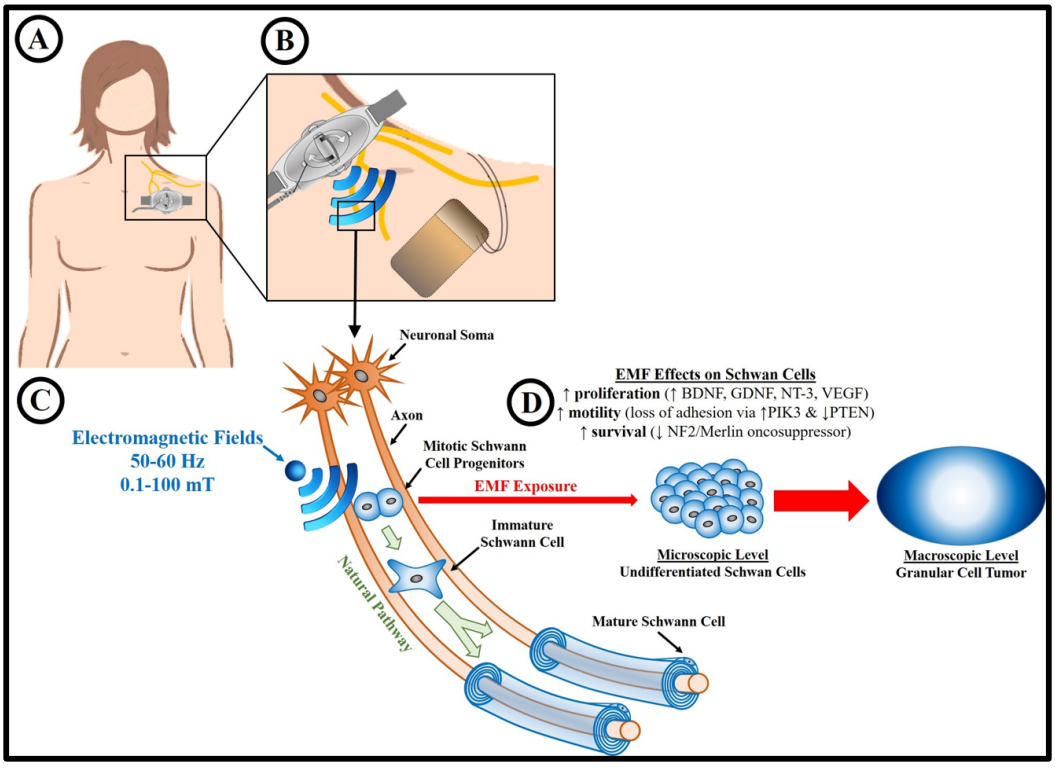


Figure 7. A) The defect was closed with a transposition latissimus dorsi myocutaneous flap based on a thoracodorsal vascular pedicle with a 9 cm x 20 cm skin paddle in conjunction with a breast rotational flap. **B)** Post-operative picture of the latissimus myocutaneous flap shows a well-healing flap inset without any flap loss

These studies strongly suggest that EMFs can induce SC reprogramming towards an undifferentiated state that ultimately results in increased proliferation, cell motility, and survival—all key elements for promoting malignant and metastatic behaviors. We similarly hypothesize in this case that the daily application of an EMF-generating charger to the INS site resulted in a clinically significant increase in the growth rate of the tumor due to neurotrophic growth factor upregulation with the additional effect of augmented cell motility and autocrine responsivity (**Figure 8**). These EMF effects are therefore thought to have substantially contributed to the extensive regional lymph node invasion observed in this case. Though it is uncertain whether the GCT developed *de novo* and was malignant prior to EMF exposure, it is reasonable to conclude that an iatrogenically induced or augmented malignant GCT conversion was secondary to the long-term, high-intensity transcutaneous EMF exposure.

This case depicts the importance of complete surgical resection is critical in the management of GCT, and sparked new insight in to a pathophysiologic pathway for malignant transformation of SCs, which may lead to future discoveries.

Figure 8: Proposed Pathophysiological Pathway of Malignant Degeneration Secondary to Electromagnetic Field Stimulation.



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