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IDEAS AND INNOVATIONS

Breast

Targeted Muscle Reinnervation following Breast Surgery: A Novel Technique

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Summary: Post-mastectomy pain syndrome is a prevalent chronic pain condition that affects numerous patients following breast surgery. The mechanism of this pain has been proposed to be neurogenic in nature. As such, we propose a novel surgical method for the prophylactic management of postsurgical breast pain: targeted muscle reinnervation of the breast. This article serves to review the relevant current literature of post-mastectomy pain syndrome and targeted muscle reinnervation, describe our current surgical technique for this operation, and present an initial cohort of patients to undergo this procedure. *(Plast Reconstr Surg Glob Open 2020;8:e2782; doi: 10.1097/GOX.0000000000002782; Published online 24 April 2020.)*

INTRODUCTION

Breast cancer is the most common cancer diagnosis among women in the United States, affecting over 200,000 patients each year.[1] The mainstay of treatment is surgical extirpation of the cancer and any affected lymph nodes via either mastectomy or lumpectomy with a sentinel lymph node biopsy and/or axillary lymph node dissection.[2]

Chronic pain after breast cancer surgery, otherwise known as "post-mastectomy pain syndrome" (PMPS), has become increasingly studied in recent times.[3–8] PMPS is defined as pain lasting >3 months after surgery, in accordance with the International Association for the Study of Pain guidelines for chronic pain.[9] PMPS has been shown to affect 25%–60% of patients after mastectomy.[8,10] Although it has not been precisely elucidated, many believe that PMPS is primarily neurogenic, stemming from nerve injury during surgery or neuroma formation.[4,5]

To date, very little has been described considering surgical options for PMPS in the breast patient[6]; however, numerous studies have described the treatment of neurogenic extremity pain after amputation by targeted muscle reinnervation (TMR).[11–14] There is significant evidence that TMR reduces pain after amputation.[14] By this same construct, we postulate that we may be able to treat postsurgical breast pain by performing TMR for the injured cutaneous intercostal nerves. The intercostal nerves have been well described as an important component of the cutaneous sensation to the breast and nipple-areolar complex.[15,16] Here, we highlight our technique for performing this procedure and review a preliminary cohort of patients who underwent breast TMR.

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OPERATIVE TECHNIQUE

We begin each operation by assessing the field and identifying any transected intercostal nerve branches. If present, residual nerve ends of the lateral cutaneous intercostal branches are identified emerging from one or more of the second through sixth intercostal spaces predictably along the midaxillary line (Fig. 1). Anterior cutaneous branches, if transected, are reliably found lateral to the sternal border (Fig. 1).

After identification, dissection of the nerve proceeds proximally within the external intercostal muscle to gain length of the residual nerve end (Fig. 2A). A nerve stimulator is used to identify nearby redundant motor nerve branches supplying adjacent intercostal muscles, serratus anterior muscle, or pectoralis minor muscle, with contraction of local muscle indicating an adjacent motor branch. These motor nerves are then transected sharply with straight microsurgical scissors, minimizing trauma to the recipient fascicles. Similarly, the distal end of the donor nerve is cut back to remove traumatized tissue and expose a healthy nerve ending. An end-to-end neurorrhaphy is then performed using 8-0 or 9-0 nylon suture in an interrupted fashion to approximate the epineurium. Approximately 2–3 interrupted sutures are placed between the epineurium of the opposing nerves with the goal of neatly approximating the 2 nerve endings and minimizing foreign bodies at the anastomosis (Fig. 2B). Successful coaptation is then evaluated by stimulating the proximal cutaneous nerve branch and observing contraction of the newly innervated muscle. Finally, the nerve coaptation is wrapped in surrounding muscle using 3-0 or 4-0 Vicryl sutures to protect the coaptation. We then proceed with the planned reconstruction, either autologous or implant based.

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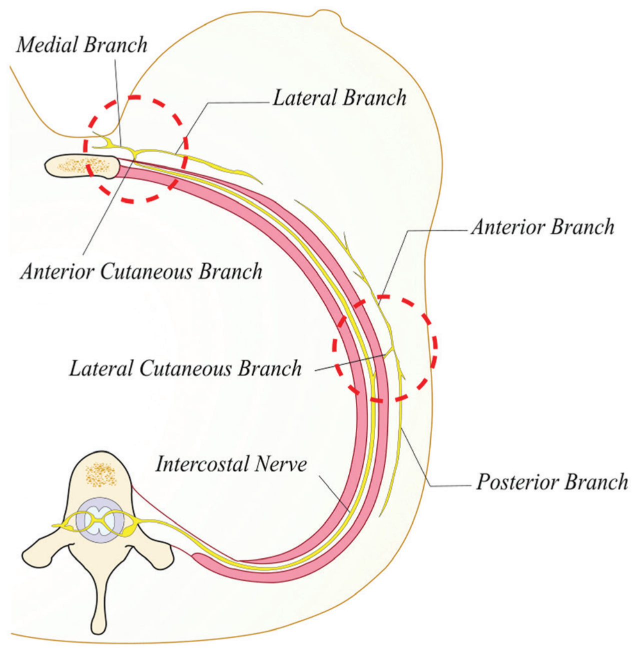

Fig. 1. Anatomy of intercostal nerve. Lateral cutaneous branch pierces intercostal muscle at midaxillary line, giving off anterior and posterior branches. Anterior cutaneous branch emerges medial to sternal border and diverges into medal and lateral branches. Red circles indicate common sites of iatrogenic transection; these may also occur anywhere along the branches.

Table 1. Patient Demographics and Surgical Characteristics

Patient Demographics	Average (Range)
Age (y)	47.4 (30–70)
Average follow-up time (mo)	5.1 (0.4–10.8)
Surgical characteristics	Count (%)
Indication for breast surgery	
Invasive ductal carcinoma	8 (89)
Prophylactic	1 (11)
Breast surgery	
Bilateral mastectomy	7 (77.8)
Unilateral mastectomy	2 (22.2)
Lymph node surgery	
None	1 (22.2)
Sentinel lymph node biopsy	4 (44.4)
Axillary lymph node dissection	4 (44.4)
Breast reconstruction	
Primary closure of mastectomy incision	1 (11.1)
2-stage implant based	6 (66.7)
Direct-to-implant	2 (22.2)
Implant plane	
Total submuscular	2 (25)
Prepectoral with ADM	6 (75)

ADM, accellular dermal matrix.

Table 2. Average Coaptations, Common Target Muscles, and Surgical Outcomes

	Count (%)	Average (Range)
Total no. coaptations	30 (100)	—
Average per patient	—	2.7 (1–5)
Average per side	—	1.8 (1–4)
Muscular targets		
Serratus anterior	11 (37)	—
Intercostalis	9 (30)	—
Pectoralis minor	7 (23)	—
Pectoralis major	3 (10)	—
Complications		
30-d readmissions	0 (0)	—
Minor complication	0 (0)	—
Major complication	0 (0)	—

RESULTS

Eleven patients who underwent TMR at the time of mastectomy are identified; the patient demographics, oncologic indications, and subsequent reconstructions are represented in Table 1. Within these patients, a total of 30 intercostal nerves are identified as injured or transected immediately following mastectomy, with an average of 1.8 nerves identified per unilateral breast surgery. The most common target muscle is the serratus anterior (11), followed by an adjacent intercostal muscle (9), pectoralis minor (7), and pectoralis major (3). Within our cohort, there are no readmissions within 30 days of surgery, no minor complications, and no major complications requiring reoperation (Table 2). One patient developed a superficial wound from subsequent radiation therapy 5 months following her operation.

With respect to pain outcomes, 4 of the 11 patients had completed the Physical Well-Being: Chest Scale (PWBC) of the BREAST-Q survey. The average score was 77.5 of 100, with individual scores of 85, 85, 80, and 60 and an

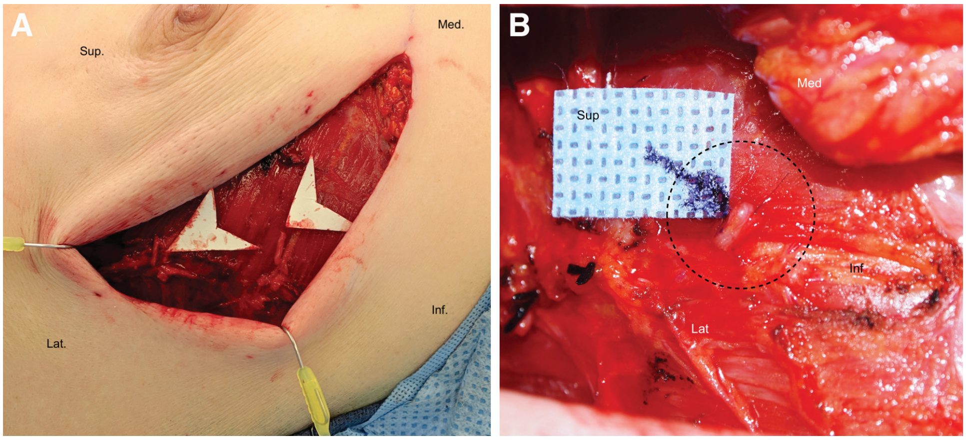

Fig. 2. Representative example of TMR after coaptation has been performed. A, Identified transection of lateral cutaneous intercostal branch immediately following mastectomy. B, Coaptation of the intercostal nerve to the target motor end plate (circle encloses coaptation).

average follow-up time of 8.5 months (range, 7.9–9.5). The notable outlier developed clinically appreciable skin changes and capsular contracture following radiation to her affected breast.

DISCUSSION

Although not fully understood, the mechanism of phantom limb pain in the extremity is believed to result from peripheral nerve aberrancy, leading to centralized cortical changes in the amputee.[17–20] In addition, neuroma pain has been described as a prevalent source of chronic residual limb pain in amputees.[21] It has been proposed that similar neurally oriented mechanisms also serve as drivers of PMPS.[4] By this same construct, we propose TMR of transected and injured sensory intercostal cutaneous nerves for the prevention of PMPS.

TMR is a technique first described to enhance control of myoelectric prosthetics in limb amputations.[22] Shortly thereafter, TMR was shown to reduce residual and phantom limb pain when performed months-to-years after the amputation.[11,13] More recently, TMR was demonstrated to be an effective method for reducing such pain when performed at the time of amputation.[14] In this multi-institutional case-control study, patients who underwent TMR were found to have a reduction in pain severity, outward pain behaviors, and less interference of pain on their daily living. In these publications, TMR for the treatment of pain is performed on sensory, and mixed sensory-motor nerves exclusively, similar to the cutaneous sensory nerves commonly damaged iatrogenically during breast surgery.[11,14] Although not fully elucidated, it has been previously hypothesized that TMR reestablishes the continuity of afferent signals in transected sensory nerves with those of proprioception and motor end plates; it is believed that this restoration of an end-target receptor for these nerves is responsible for reducing pain. With respect to our patient cohort, we observed an average BREAST-Q PWBC of 77.5, compared with an observed score 71 in previously published data among patients who underwent a mastectomy.[23] Furthermore, if the outlying patient in our cohort was excluded, the average PWBC score becomes 83.3, approaching the normative score of 93 in those without a previous history of breast cancer or surgery.[23]

Given this mounting evidence supporting TMR for the control of extremity pain, and the parallel mechanisms for pain in the breast patient, we postulate that TMR may be able to play an important role in the management of breast pain following surgery. To our knowledge, with the exception of autologous fat grafting, no other surgical techniques have been proposed as treatment to PMPS.[7,24] This preliminary study is not without limitations, namely its small sample size, paucity of controls, and lack of a specific method for identifying PMPS and its associated pain. However, we believe that TMR in the breast patient is safe, and ongoing efforts toward a prospective, comparative investigation with a more directed pain measurement tool are underway.

CONCLUSIONS

PMPS is a widely prevalent burden among breast surgery patients, and although complex and poorly elucidated, the mechanism of such has been attributed to iatrogenic peripheral nerve injury and neurogenic dysregulation. As such, we propose a novel technique of TMR for the breast as prophylactic management of peripheral sensory nerves and potentially PMPS in the surgical breast patient.

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