

Fluorescence Imaging to Identify and Preserve Fifth Intercostal Sensory Nerves during Bilateral Nipple-sparing Mastectomies

Alberto O. Rancati, MD, PhD*

Claudio Angrigiani, MD*

Maurice Y. Nahabedian, MD†

Agustin Rancati, MD*

Kevin P. White, MD, PhD‡

Summary: The use of nipple-sparing mastectomies has increased steadily over the past 10–15 years. However, one major source of patient dissatisfaction with both skin- and nipple-sparing mastectomies is lost skin and/or nipple sensation postoperatively due to intraoperative, iatrogenic sensory nerve injury. We summarize the case of a 41-year-old woman with BRCA(+) breast cancer who underwent bilateral, risk-reducing nipple-sparing mastectomies, immediately followed by bilateral, direct-to-implant breast reconstruction, in whom a prototype fluorescent imaging camera was used to facilitate sensory nerve identification and preservation. Preoperatively, tactile and thermal quantitative sensory testing were performed using a 30-gauge needle to determine baseline sensory function over both breasts. Then, nipple-sparing mastectomies and direct-to-implant reconstruction were performed. Using a laterally-displaced submammary approach, the anterior intercostal artery perforator neurovascular pedicle was preserved. Then a prototype camera, which emits near-ultraviolet light, was used to detect nerve autofluorescence. Intraoperatively under near-ultraviolet light, both the fifth intercostal nerve and its sensory branches auto-fluoresced clearly, so that surgery was completed without apparent injury to the fifth intercostal nerve or any of its branches. Postoperatively, the patient reported full sensory function throughout both breasts and both nipple–areolar complexes, which was confirmed on both tactile and thermal sensory testing at 3-month follow-up. The patient experienced no complications and rated her overall satisfaction with surgery on both breasts as 10 out of 10. To our knowledge, this is the first time sensory nerve auto-fluorescence has been reported to reduce the likelihood of intraoperative, iatrogenic nerve injury and preserve sensory function. (*Plast Reconstr Surg Glob Open* 2023; 11:e5048; doi: [10.1097/GOX.0000000000005048](https://doi.org/10.1097/GOX.0000000000005048); Published online 16 June 2023.)

INTRODUCTION

The use of nipple-sparing mastectomies (NSM) has been steadily increasing.^{1–3} Advantages include improved patient body image, satisfaction, life quality, and psychological adjustment,^{2,4} and reduced need for multiple and/or more complex breast-reconstruction procedures.⁴

From the *Hospital de Clinicas Jose de San Martin School of Medicine, Universidad de Buenos Aires, Argentina; †National Center for Plastic Surgery, McLean, Va.; and ‡ScienceRight International Health Research Consulting (SCI-HRC), London, Ontario, Canada.

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Sensory loss of the nipple–areolar complex (NAC) following NSM remains problematic, with sensation rated poor to fair or from nonexistent to markedly-reduced, relative to preoperative sensation, up to six years postoperatively.^{2,5,6} One obstacle to preventing iatrogenic intraoperative injury to sensory nerves is that they are generally smaller than motor nerves⁷; hence, even more difficult to visualize and avoid. We describe a patient undergoing NSM and direct-to-implant breast reconstruction in whom the intercostal sensory branches were clearly visualized under near-ultraviolet light (NUVL), facilitating preservation of both the nerve and postoperative sensation of the NAC and surrounding skin.

CASE

Following tactile and thermal quantitative sensory testing with a 30-gauge needle, a 41-year-old woman with

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BRCA(+) breast cancer underwent bilateral, risk-reducing NSM followed by immediate bilateral direct to implant (DTI). Preoperatively, 60-ml Klein solution was injected subcutaneously into each breast quadrant to reduce bleeding and enhance Cooper's ligament identification. Bilateral NSM was performed using a 9-cm laterally-based infra-mammary fold incision to preserve the anterior intercostal artery perforator (AICAP) pedicle and fifth intercostal nerve, which has its origin in the 6 o'clock position along the meridian line (Fig. 1)^{8,9}

A fluorescence imaging camera (Dendrite Imaging, Germany; Fig. 2) was used to identify the fifth intercostal nerve and its sensory branches within the AICAP pedicle. All AICAP manipulation throughout surgery was performed using surgical scissors to avoid thermal damage. Electrocoagulation was used only to control bleeding. After each mastectomy, an anatomical implant (Mentor 322 CPG, 295 ml) was inserted for immediate prepectoral reconstruction while visualizing the AICAP pedicle and fifth intercostal nerve and its sensory branches under NUVL. Drains were placed before skin closure. Full sensory recovery, again with formal tactile and thermal quantitative sensory testing, was confirmed 1 and 3 months postoperatively.

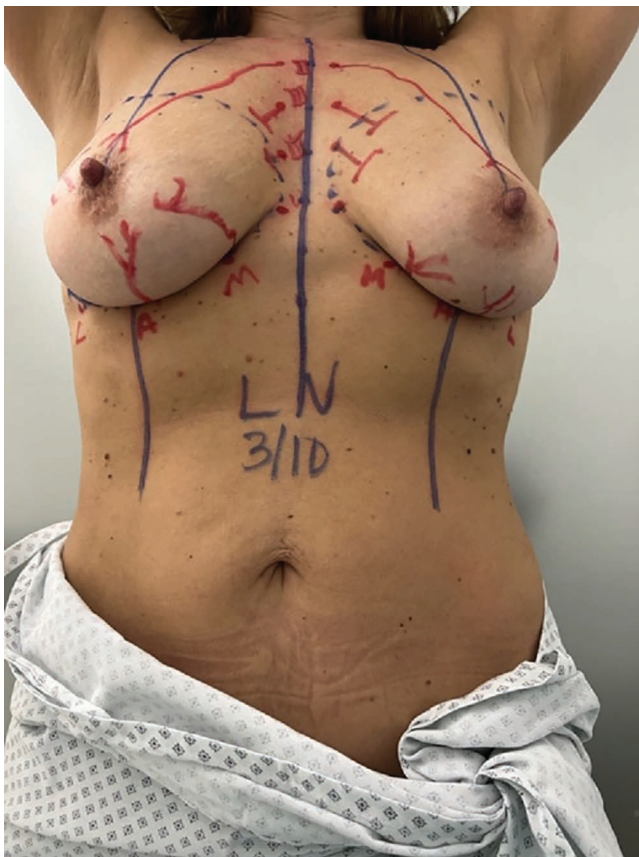


Fig. 1. Mapping the three intercostal artery perforators and the intended incision. (LICAP and MICAP = lateral and medial intercostal artery perforator, respectively) in both breasts. The fifth intercostal nerve was selected for preservation in our patient because of its consistent location within the AICAP in the 6 o'clock position within breasts.

Takeaways

Question: Is it possible to preserve an intercostal nerve to retain sensation of the nipple–areolar complex following mastectomy?

Findings: Fluorescence imaging can visualize the intercostal nerve during mastectomy.

Meaning: The likelihood of preserving sensation to the NAC is increased.



Fig. 2. The prototype Dendrite fluorescence imaging system (Axon Imaging Technologies, Germany). The Dendrite camera used to assist nerve visualization has a light-emission system that includes nearultraviolet and other interposed wavelengths of light to achieve excitation of nerve fascicles. Once switched on, the filter system and software are activated to read specific wavelengths emitted by neural tissue, and the image is projected real-time, in magnified form, onto a high-definition monitor. During each procedure, images also were taken and preserved, as high-definition jpeg files, for later analysis.

RESULTS

Under NUVL, sensory branches of the fifth intercostal nerve were visualized throughout their length and easily identified and avoided (compare Figs. 3 and 4).

Postoperatively, the patient experienced no complications and was discharged home within 24 hours, with follow-up 72 hours postoperatively, then weekly. At 72-hour follow-up, the patient reported full sensation throughout both breasts, and formal testing revealed full sensation throughout the breast and NAC at 1- and 3-month follow-up. She also had no complications and rated her satisfaction with the surgical results 10 out of 10.

DISCUSSION

Intraoperative use of fluorescence imaging has increased in recent decades. During breast surgery, its effectiveness is well supported as a tool to guide axillary lymph node biopsies,^{10–15} as is its clear noninferiority to the current gold standard of technetium-99m (99m-Tc).^{10–17} Published research also supports its use assessing



Fig. 3. Locating the fifth intercostal nerve and its sensory branches under white light. Surgical incision to identify the AICAP pedicle and Fifth intercostal nerve under standard operating room (white) light.



Fig. 4. Locating the fifth intercostal nerve and its sensory branches under NUVL. Fifth intercostal nerve and sensory branches (clear arrow) visualized using the fluorescent imaging camera.

tissue perfusion during reconstructive breast surgery.^{18–24} For both above-mentioned uses, fluorescence imaging relies on viewing the surgical field in the near-infrared spectrum after injecting the fluorescent dye indocyanine green. However, such imaging has not been documented to enhance nerve visualization.

Recent studies have demonstrated that nerves can auto-fluoresce in NUVL,^{25–27} including a diverse case series of 17 patients in whom the nerves clearly auto-fluoresced during parotid resections, thyroid resections, resection of various peripheral nerve and spinal tumors, and neonatal brachial plexus injury repair.²⁷ The current case differs from these others in that it is the first time when purely sensory nerve branches have been visualized and preserved during breast surgery.

Published data are virtually nonexistent on the relative frequency of iatrogenic sensory versus motor nerve injuries. However, sensory nerves tend to be smaller than

motor nerves and, hence, more difficult to see and avoid intraoperatively.⁷ Furthermore, iatrogenic nerve injury may occur not just by sectioning a nerve, but by stretching, crushing, tying off, or thermally damaging it, and such damage can lead not only to lost or altered sensation, but to potentially chronic and severe neurogenic pain.²⁸ Moreover, although nerve grafting to repair iatrogenic nerve injuries has recently gained some popularity, the results of nerve repair may be inferior with sensory versus motor nerves, especially associated with suboptimal fine-touch results,²⁹ for various reasons that include their smaller caliber.²⁸

Nipple-sparing mastectomy is performed to enhance aesthetic outcomes while minimizing the risk of residual cancer within breast tissue. Unfortunately, breast sensation is usually forfeited during NSM.^{2,5,6} In a recent survey of 131 women who underwent either bilateral ($n = 101$) or unilateral ($n = 30$) breast reconstruction, of which 99 were direct-to-implant and 32, tissue-expander reconstructions, 106 (80.9%) claimed their reconstructed breasts remained either totally numb ($n = 47$, 35.9%) or had less sensation ($n = 59$, 45.0%) than preoperatively at a median follow-up of six years.² Similarly, 67 (51.1%) and 37 (28.2%) said their nipples were either totally numb or considerably less sensitive, respectively, than before surgery. Total breast numbness was associated with significantly-reduced physical well-being ($P = 0.048$), whereas total numbness in a nipple was linked to significantly reduced physical ($P = 0.007$), psychosocial ($P = 0.041$), and sexual ($P = 0.002$) well-being.² In an earlier study of 48 women who underwent bilateral nipple-sparing ($n = 33$) or skin-sparing ($n = 15$) mastectomies, nipple sensation was lost in one or both breasts in 74% and 32% of patients, respectively, and overall satisfaction with postoperative sexual arousal was poor with both procedures.⁵

For these reasons, surgeons performing NSM should do everything possible to avoid iatrogenic nerve injury. Based upon prior research documenting the importance of the inferior pedicle to preserving NAC sensation,^{30,31} we hypothesized that preserving the sensory nerves within the fifth anterior intercostal pedicle during NSM might be crucial to preserve NAC sensation. The excellent sensory results we achieved bilaterally suggest this might be true. Our case further suggests that fluorescence imaging warrants ongoing investigation as a tool to enhance sensory nerve visualization and potentially reduce the incidence of such injuries in larger patient samples, thereby enhancing patient outcomes and reducing the need for subsequent nerve grafting procedures. Potential limitations that also must be explored include the limited tissue penetration depth of NUVL and possible impact of factors like increased adiposity and bleeding on nerve visualization.

Alberto O. Rancati, MD, PhD

Director Oncoplastic Program
Htal de Clinicas Jose de San Martin
University of Buenos Aires, Argentina
Av. Cordoba 2351 (1425) CABA
E-mail: rancati@ubaoncoplastic.com

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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