SPY Imaging: Benefits in Breast Reconstruction

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INTRODUCTION
During my plastic surgery rotation this year, I had the opportunity to learn about the fascinating use of the SPY imaging system (Lifecell Corporation, Branchburg, NJ), a novel technology that is available in El Paso, Texas. The SPY imaging system presents a new advantage in breast reconstruction and other fields by allowing the surgeon to determine the percentage of tissue perfusion during surgery. Using near-infrared angiography with intravenous indocyanine green (ICG) dye, the vasculature of the tissue can be visualized during tissue expansion or flap reconstruction. Benefits include improved judgment of tissue perfusion intraoperatively, removal of distal tissue prone to necrosis, and decreased long-term complications and need for further surgeries.

BACKGROUND
Breast cancer is the most common malignancy in women and the second leading cause of death due to cancer.1 Survivors often seek various breast reconstruction procedures, with immediate reconstruction often preferred at the time of initial surgery.1 Immediate reconstruction options include direct to implant reconstruction, tissue expanders with later placement of silicone implants, and autologous breast reconstruction. The most common autologous site is the abdomen; utilizing the pedicled transverse rectus abdominis myocutaneous (TRAM) flap.1 The latissimus dorsi myocutaneous flap is often used as a second choice.1 Microvascular flap reconstruction with tissue from the abdomen or buttocks is also available in specialized centers. Both tissue expanders and flap reconstruction are prone to many complications, including arterial or venous occlusion, tissue necrosis, infection, and flap failure.1,2 Reducing both intraoperative and postoperative complications is critical to breast reconstruction surgery.

CURRENT LITERATURE
The use of fluorescent angiography imaging has been used for decades in other surgeries such as coronary artery bypass grafts and gastrointestinal surgery where vascular supply is critical.3,4 When using the SPY system, after ICG dye is injected intravenously, the 805-nm laser causes the ICG dye to fluoresce and the intensity is recorded by a digital video camera using an infrared filter.3 It allows for superior visualization of subdermal vessels 1-2 cm from the skin’s surface.3,4 Recent clinical trials and literature reviews have focused on the use of SPY imaging in breast reconstruction.

Liu et al conducted a comprehensive literature review of ICG angiography in various plastic surgery procedures, including 17 case series and 386 patients.2 These included free flaps, pedicled skin flaps, and breast reconstruction procedures such as tissue expanders and autologous flaps. It was noted in breast reconstruction procedures that SPY imaging significantly predicted areas of poor perfusion and led to decreased morbidity and better patient outcomes.2 Gurtner et al also performed a literature review along with 7 experts in SPY technology, including 6 plastic surgeons and one general surgeon.8 This review included mainly case series, with a total of almost 140 patients who underwent breast reconstruction using SPY technology. Final recommendations for SPY imaging included free flaps, pedicled flaps, skin flaps, and mastectomy flaps. SPY imaging should be used in pedicled flaps, such as the TRAM flap, to identify the perforator perfusion zone and design the flap, as well as to confirm arterial and venous supply both before and after transfer and inset of the flap.6 It is also recommended following mastectomy, both when selecting either implants or tissue expanders and after inserting either device.6 Since ICG dye has a very short half-life and is not nephrotoxic, it can be used multiple times during the same operative procedure.6 SPY imaging is superior to previously used methods, such as fluorescein dye or clinical judgment alone.4,5

Recently, Phillips et al conducted a prospective clinical trial of 51 tissue expander breast reconstructions in 32 patients, with intraoperative evaluation of skin flaps by clinical assessment, ICG, and fluorescein.4 Areas of poor perfusion were excised based on clinical assessment only, leading to a 41.2 percent total necrosis rate within four weeks. After reviewing saved intraoperative videos, the researchers found clinical assessment resulted in gross underprediction of ischemia and necrosis intraoperatively compared to dye angiography. ICG was more accurate than fluorescein dye angiography in prediction of skin necrosis, with similar sensitivity (90 percent), but increased specificity (50 vs. 30 percent), positive predictive value (56 vs. 48 percent), and negative predictive value (88 vs. 82 percent). ICG angiography overpredicted poor perfusion by 72 percent vs. 88 percent by fluorescein angiography (p=0.002). ICG had nearly 3 times the predictive accuracy in preserving viable tissue. This study proves the use of fluorescein dye leads to excision of larger areas of viable skin. In addition, active smoking, obesity, and breast weight >1000 g were significantly associated with necrosis.

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When utilizing the SPY imaging system, it is vital to determine an objective value for tissue viability. In a prospective study of 118 patients, Moyer et al determined a cutoff perfusion score of 33 percent to determine tissue viability. This cutoff point had a sensitivity of nearly 84.6 percent and a specificity of 87.5 percent. Smoking shifted the cutoff point to 5 percent higher, while hypertension and African American race shifted the cutoff point slightly lower. This may be considered in determining tissue viability for breast reconstruction procedures.

Preventing skin flap necrosis is one of the most valuable and cost effective ways to reduced morbidity after breast reconstruction. Necrosis may occur in up to 20 percent of implant-based breast reconstructions and can lead to infection and reoperation. In a study of 24 consecutive breast reconstructions using ICG technology and SPY imaging, there was only a 4 percent complication rate after 90 days. Mastectomy flap areas which were not viable with ICG dye were resected and perfusion checked once more after tissue expanders were filled. In autologous flaps, ICG dye was used to design the flap and to check perfusion intraoperatively before final inset. Again, nonviable areas were excised. The researchers compared this method to a retrospective analysis of 206 reconstructions without SPY imaging; the complication rate was 15.1 percent. Excising skin that is nonviable may significantly reduce morbidity and postoperative complications.

Failing to remove poorly perfused skin leads to a high incidence of necrosis, infection, and implant loss. Inpatient and outpatient costs of treating these complications ranges from $15,000 to $21,000 per patient. Major costs include reoperaton and increased length of stay (LOS). In one study of 949 breast surgeries, mean LOS was 4.9 days longer in patients who suffered from surgical site infections. The cost of SPY imaging is currently about $1,200 per procedure. Considering a conservative estimate of 10% reduction in complications with SPY imaging and the average cost per complication, using SPY imaging for every case would save $30,000-$90,000 per 100 patients. The Federal Women’s Health and Cancer Rights Act of 1998 mandated all major insurance companies cover breast reconstruction after mastectomy, including the cost of surgery, implants, and complications. Since 1998, breast reconstruction rates have been exponentially increasing. Albornoz et al recently published a study analyzing the Nationwide Inpatient Sample database from 1998-2008, including 178,603 total mastectomies and 51,410 immediate breast reconstruction procedures. They found immediate breast reconstruction rates increased an average of 5% each year and implant use increased an average of 11% per year. Assuming these trends continue, SPY imaging could potentially save millions of dollars per year in complications related to breast reconstruction. Improving the patient’s recovery time and restoring body image is immeasurable.

CASE REPORTS
Case 1: A 45 year old female underwent immediate reconstruction after bilateral mastectomy with placement of tissue expanders and acellular dermal matrix. SPY imaging was performed after expanders were filled with 150 cc of saline each and wound edges were loosely approximated. Areas shown in white represent vessels and zones with the most perfusion on the right and left breasts.

Case 2: A 55 year old female with history of right breast invasive ductal carcinoma, previously treated with chemotherapy and radiation, underwent delayed breast reconstruction with a latissimus dorsi myocutaneous flap and tissue expander. The image shows the flap at its recipient site. Again, highlighted in white are perforating vessels and areas of perfusion.

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Case 3: A 30 year old female with history of invasive ductal carcinoma, previously treated with mastectomy and chemoradiation, underwent delayed left breast reconstruction using a transverse rectus abdominus myocutaneous flap. Note vascularity of the flap intraoperatively which aids in removing poorly perfused tissue.

Case 4: A 24 year old female with history of left breast mastectomy for invasive ductal carcinoma underwent right nipple-sparing prophylactic mastectomy with bilateral expander reconstruction. Note excellent perfusion to the nipple areola complex (white).

CONCLUSION
The SPY imaging system should be used to prevent complications and increase surgical accuracy in many types of breast reconstruction procedures and to assess perfusion of pedicled or free flaps, mastectomy flaps, and the nipple-areolar complex during nipple-sparing surgery. Recent evidence shows it may be beneficial in other types of plastic surgery as well, such as use of the anterolateral thigh flap in head and neck reconstruction. It requires communication between the surgeon and anesthesiologist during ICG dye injection and should not be used in patients allergic to iodine contrast. It is FDA approved for both microsurgical and reconstructive procedures.

REFERENCES


