Journal of Plastic, Reconstructive & Aesthetic Surgery (2015) 68, 792—799

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

"NACsomes": A new classification system of the blood supply to the nipple areola complex (NAC) based on diagnostic breast MRI exams☆

Iris A. Seitz [a,*], Alexander T. Nixon [b], Sarah M. Friedewald [c], Jonathan C. Rimler [d], Loren S. Schechter [a]

[a] *University Plastic Surgery, 9000 Waukegan Rd. Suite 210, Morton Grove, IL 60053, USA*
[b] *Penn State Milton S. Hershey Medical Center, 500 University Dr., Hershey, PA 17033, USA*
[c] *Department of Radiology, Advocate Lutheran General Hospital, 1775 Dempster St., Park Ridge, IL 60068, USA*
[d] *Aesthetic and Plastic Surgery Institute, University California Irvine, 200 South Manchester Ave. Suite 650, Orange, CA 92868, USA*

Received 12 August 2014; accepted 9 February 2015

KEYWORDS
Breast;
Magnetic resonance imaging;
Nipple-areola complex;
Oncoplastic

Summary *Background:* Breast MRIs have become increasingly common in breast cancer work-up. Previously obtained breast MRIs may facilitate oncoplastic surgery by delineating the blood supply to the nipple-areola complex (NAC). The aim of this study was to identify and classify the *in vivo* blood supply to the NAC using breast MRI exams.
Methods: Breast MRIs obtained over a one-year period were retrospectively reviewed. Patients with negative MRI findings (BI-RADS category 1) were included; patients with diagnoses of breast cancer or previous breast surgery were excluded. Twenty-six patients were evaluated. Dominant blood supply was determined by maximum filling at 70 s post-contrast. Blood supply to the NAC was classified into five anatomic zones: medial (type I), lateral (type II), central (type III), inferior (type IV) and superior (type V).

Abbreviations: BCT, breast conservation therapy; BI-RADS, breast imaging-reporting and data system; CTA, computed tomographic angiography; DIEP, deep inferior epigastric perforator; ICG, indocyanine green; MIP, maximum intensity projection; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; NAC, nipple-areola complex.

☆ Part of the work has been presented at Plastic Surgery 2010, 79th annual scientific meeting of the American Society of Plastic Surgeons (ASPS), Oct. 1—5, Toronto, Canada, at the 16th International Congress of the International Confederation for Plastic Reconstructive and Aesthetic Surgery (IPRAS), May 22—27, 2011, Vancouver, Canada, and the World Society of Reconstructive Microsurgery 6th Congress, June 29—July 2, 2011, Helsinki, Finland. The abstract of above listed presentations has been published in Plastic & Reconstructive Surgery. 126(suppl):27, October 2010 and in the Can J Plast Surg 2011, Vol 19 Suppl A Summer: 44—45.

* Corresponding author. University Plastic Surgery, 9000 Waukegan Rd., Suite 210, Morton Grove, IL 60053, USA. Tel.: +1 847 967 5122; fax: +1 847 967 5125.
E-mail address: iseitz@univplastics.com (I.A. Seitz).

http://dx.doi.org/10.1016/j.bjps.2015.02.027

Results: Patient age ranged from 33 to 70 years. Fifty-two breasts were evaluated and 80 source vessels were identified (37 right, 43 left). Twenty-eight breasts had type I only blood supply, 22 breasts had multi-zone blood supply (type I + II, n = 20; type I + III n = 2), one breast had type II only blood supply, and a single breast had type III only blood supply. Anatomic symmetry was observed in 96% of patients.
Conclusion: This study utilized MRI to evaluate *in vivo* vascular anatomy of the NAC, classify NAC perfusion ("NACsomes"), and assess vascular symmetry between breasts. Superomedial source vessels supplying the NAC were predominant. Preoperatively defining NAC blood supply may aid planning for oncoplastic procedures.

Introduction

Approximately one of every eight women in the United States will develop breast cancer during her life.[1] With early detection, improved adjuvant therapy, and better understanding of tumor biology, more women are opting for breast conserving therapy (BCT). Long-term follow-up studies have demonstrated no significant difference in disease-free survival, relapse-free survival, or overall survival comparing total mastectomy and BCT.[2,3] As such, the field of oncoplastic surgery, combining the tenets of oncologic surgery and reconstructive plastic surgery, has become increasingly popular. Ideally, oncoplastic surgery provides aesthetically pleasing results, while achieving appropriate oncologic margins.[4–6] However, one potential pitfall of the oncoplastic approach is the uncertainty of the blood supply to the nipple-areola complex (NAC). When utilizing an oncoplastic approach, it is important to consider perfusion to the NAC prior to choosing the vascular pedicle upon which to relocate the NAC. Pre-operative imaging may be helpful in this planning process.

The blood supply to the NAC has been defined in various cadaver studies[7–9] and seems to originate from several sources, including the internal thoracic artery (internal mammary artery), lateral thoracic artery (external mammary artery), thoracoacromial artery, superior thoracic artery (highest thoracic artery), or anterior/posterior branches of the intercostal arteries. Dominant blood supply to the NAC appears to be attributable to the internal thoracic artery and/or the lateral thoracic artery in the vast majority of these studies.[7–9] However, there is a paucity of data correlating these anatomic findings with *in vivo* perfusion studies of the NAC.

The role of *in vivo* imaging techniques evaluating tissue perfusion patterns and perforator anatomy (angiosomes) preoperatively has increased in microsurgical breast reconstruction over the past several years. Computed tomographic angiography (CTA) represents the gold standard in preoperative vascular perforator imaging, and preoperative CTA for deep inferior epigastric perforator (DIEP) evaluation has become common practice in many institutions.[10–12] Dependent on the specific anatomic location, disease and tissues to evaluate, magnetic resonance angiography (MRA) maintains or enhances the imaging quality without ionizing radiation.[13,14] This advantage combined with a very high sensitivity has led to increased use of MRI based imaging in the workup of many diseases.

MRI for breast cancer diagnosis and workup was initially used as a second line modality in selected clinical scenarios such as equivocal mammographic and/or ultrasound findings. Currently, MRI is used not only as an adjunct, but also as a first line modality for screening in selected subsets of women with an increased lifetime risk for breast cancer.[15,16] Although the sensitivity for breast MRI is quite high, its lack of specificity has limited its use as a general screening method for the detection of breast cancer.[17] Regardless of the ongoing debate concerning breast MRI indications, the use of breast MRI has increased 20- fold since 2000.[18] The increased use of MRI for both screening and pre-operative tumor evaluation could offer a potential benefit in delineating the *in vivo* blood supply to the NAC, and this information could be used for pre-operative surgical planning in oncoplastic and reconstructive procedures. Previously obtained diagnostic imaging may negate the need for additional angiographic studies.[19]

The aim of this study is to identify and classify the blood supply to the NAC ("NACsomes") using early phase MRI images from patients undergoing MRI for clinical evaluation. An attempt is made to compare *in vivo* NAC perfusion via MRI with cadaver NAC perfusion studies. To the authors' knowledge, this is the first study evaluating specific *in vivo* arterial perfusion to the NAC, and the largest study specifically addressing NAC perfusion.

Patients and methods

Following IRB approval, bilateral breast MRIs of 26 female patients, obtained over a one-year period, were retrospectively reviewed by the breast MR radiologist (SF). Inclusion criteria were breast MRIs with a Breast Imaging-Reporting and Data System (BI-RADS) category 1 assessment (negative examination). Patients with a known diagnosis of breast cancer or previous breast surgery were excluded, while those with prior core biopsies were eligible. The reviewed indications for breast MRI included at least one of the following: breast nodule or cyst (n = 12), abnormal mammogram and/or ultrasound (n = 7), screening due to a strong family history of breast cancer (n = 6), dense or painful breasts (n = 5), or history of ovarian cancer (n = 1) (Table 1).