

# ICG-ANGIOGRAPHY IN BREAST RECONSTRUCTIVE PROCEDURES DO WE HAVE EVIDENCE?

11<sup>th</sup> Aarhus Workshop in:  
**Breast Surgery**



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Department of Plastic Surgery and Burns Treatment  
Rigshospitalet, Copenhagen University Hospital



# ICG-JOURNEY

2011 IPRAS in Vancouver

2013 A. Salzberg, New York

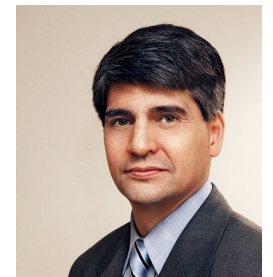
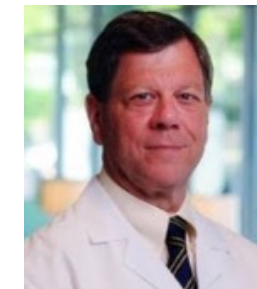
2014 Aarhus Breast Surgery Workshop -  
A. Ashikari, New York

2014-2019 AARHUS UNIVERSITY HOSPITAL

- Breast reconstruction
- Trauma – degloving injuries

2019 RIGSHOSPITALET

- Breast reconstruction
  - Localization of perforators
  - Angiosome and outline of flap
  - Mastectomy skin perfusion
- Lymphatic surgery
- Lymphatic flow to minimize postop complications
- Oncologic surgery



# THE OPTIMAL IMAGING TECHNIQUE

## Any imaging technique should aspire to

- ✓ have the lowest risk of harm to the patient ICG – safe and non-toxic
- ✓ acquire of the highest quality images Fluobeam/SPY-Elite/SpyPhi
- ✓ provide the greatest amount of information Real-time perfusion
- ✓ be performed with a short duration and minimal burden to the patient  
Half-life of 20 min – re-assessment - peroperatively

Mohan and Saint-Cyr. Gland Surg 2016; 5: 242



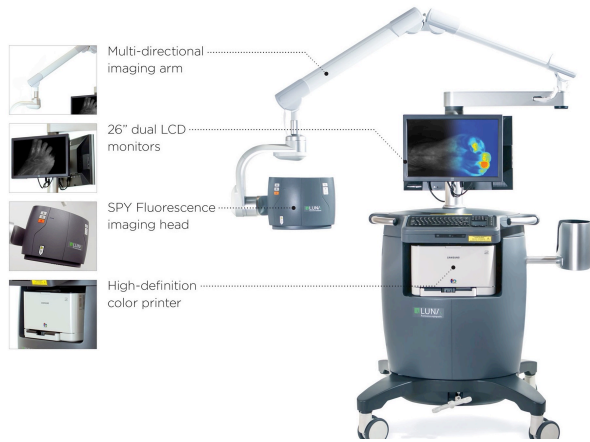
# ICG-IMAGING TOOLS



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# PERFUSION ASSESSMENT TOOLS



Spy-ELITE - Stryker

SPY-PHI  
Portable  
handheld  
imaging  
system



Spy-Phi - Stryker



Fluobeam - Fluoptics

# DO WE HAVE EVIDENCE?



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2020-2023

### A Systematic Review of the Utility of Indocyanine Angiography in Autologous Breast Reconstruction

Nisha Parmeshwar, MD,<sup>a</sup> Steven M. Sultan, MD,<sup>b</sup> Esther A. Kim, MD,<sup>a</sup> and Marisa L. Piper, MD<sup>a</sup>

**Background:** In the last decade, a number of studies have demonstrated the utility of indocyanine green (ICG) angiography in predicting mastectomy skin flap necrosis for immediate breast reconstruction. However, data are limited to investigate this technique for autologous breast reconstruction. Although it may have the potential to improve free flap outcomes, there has not been a large multicenter study to date that specifically addresses this application.

**Methods:** A thorough literature review based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines was conducted. All studies that examined the use of intraoperative ICG angiography or ICG to assess perfusion of abdominal-based free flaps for breast reconstruction from January 1, 2000, to January 1, 2020, were included. Free flap postoperative complications including total flap loss, partial flap loss, and fat necrosis were extracted from selected studies.

**Results:** Nine relevant articles were identified, which included 355 patients and 824 free flaps. A total of 472 free flaps underwent clinical assessment of perfusion intraoperatively, whereas 352 free flaps were assessed with ICG angiography. Follow-up was from 3 months to 1 year. The use of ICG angiography was associated with a statistically significant decrease in flap fat necrosis in the follow-up period (odds ratio = 0.31,  $P = 0.02$ ). There was no statistically significant difference for total or partial flap loss.

**Conclusions:** From this systematic review, it can be concluded that ICG angiography may be an effective and efficient way to reduce fat necrosis in free flap breast reconstruction and may be a more sensitive predictor of flap perfusion than clinical assessment alone. Future prospective studies are required to further determine whether ICG angiography may be superior to clinical assessment in predicting free flap outcomes.

**Key Words:** indocyanine green angiography, autologous breast reconstruction, mastectomy, free flap.

been shown that clinical assessment can miss up to 41% of cases of mastectomy skin flap ischemia.<sup>7</sup> It is clear based on this and other studies that there exists a need for more accurate, real-time assessments of tissue perfusion to help decrease ischemia-related complications in autologous free flap breast reconstruction.<sup>8-10</sup>

Indocyanine green (ICG) laser-assisted fluorescence angiography allows for such immediate assessment of tissue perfusion intraoperatively. Indocyanine green is a fluorescent agent that binds to plasma proteins and, when excited by 805-nm laser, emits fluorescence that is captured by a camera in the operating room. Previous studies have proven that this real-time visualization is helpful for preventing mastectomy skin flap necrosis with up to 90% sensitivity when compared with clinical assessment alone.<sup>11-13</sup> In addition, single-institution cohorts examining free flap outcomes have shown ICG to be useful in assessing perfusion zones to minimize flap failure and fat necrosis.<sup>14-16</sup> Although it may have the potential to improve free flap outcomes, there has not been a large multicenter study to date that specifically addresses this application and its ability to improve overall outcomes.

The purpose of this systematic review is to assess whether the use of intraoperative ICG angiography during free flap breast reconstruction effectively identifies areas of perfusion deficit, thereby allowing preemptive debridement and the prevention of future fat necrosis or flap loss. By pooling outcomes across studies, we hope to determine the relative utility of ICG angiography versus clinical judgment alone in optimizing autologous breast reconstruction in predicting free flap outcomes.



Review

### Use of Indocyanine Green Angiography decreases the risk of complications in autologous- and implant-based breast reconstruction: A systematic review and meta-analysis

Elisabeth Lauritzen\*, Tine Engberg Damsgaard

Department of Plastic Surgery and Burns Treatment, Copenhagen University Hospital, Denmark



Cochrane Library

Cochrane Database of Systematic Reviews

### Indocyanine green angiography for preventing postoperative mastectomy skin flap necrosis in immediate breast reconstruction (Review)

Pruimboom T, Schols RM, Van Kuijk SMJ, Van der Hulst RRRWJ, Qiu SS. Indocyanine green angiography for preventing postoperative mastectomy skin flap necrosis in immediate breast reconstruction. *Cochrane Database of Systematic Reviews* 2020, Issue 4. Art. No.: CD013280. DOI: 10.1002/14651858.CD013280.pub2.

### Outcomes of DIEP Flap and Fluorescent Angiography: A Randomized Controlled Clinical Trial

Ramon Varela, M.D., Cesar Casado-Sanchez, M.D., Ph.D., Shirin Zarbaksh, M.D., Jesus Diaz, M.D., Ph.D., Juan Hernandez-Godoy, M.D., Luis Landin, M.D., Ph.D. Madrid, Spain

**Background:** Breast reconstruction with the deep inferior epigastric perforator (DIEP) flap can be associated with complications such as fat necrosis. The authors' objective was to assess the safety and efficacy of fluorescent angiography with indocyanine green to reduce fat necrosis. **Methods:** The authors designed a parallel, randomized, controlled clinical trial for unilateral breast reconstruction. The poorly vascularized tissues of the DIEP flap were removed based on a clinical evaluation in group 1 and based on angiographic criteria in group 2. The authors recorded the flap dimensions, perfusion in terms of fluorescence intensity, complications, reoperations, and BREAST-Q questionnaire scores for both groups. **Results:** The study included a total of 51 patients. The flaps showed no size differences after the tissue was excised. The flaps of group 2 presented higher perfusion rates ( $p = 0.001$ ). The incidence of fat necrosis was 59.3 percent in group 1 and 8.3 percent in group 2 ( $p = 0.001$ ). Four cases of partial necrosis were recorded in group 1 (18.2 percent) compared with none in group 2 (0 percent) ( $p = 0.131$ ). Four patients underwent reoperation in group 1 (44.8 percent) compared with none in group 2 (0 percent) ( $p = 0.113$ ). The patients in group 2 reported higher scores in all domains of the BREAST-Q. **Conclusions:** Fluorescent angiography with indocyanine green significantly reduced the incidence of fat necrosis without diminishing the flaps' dimensions. The perfusion rates were significantly higher and the patients reported significantly greater satisfaction and quality of life. Fluorescent angiography with indocyanine green may be considered a safe and effective tool to enhance the outcomes of breast reconstruction with the DIEP flap. (*Plast Reconstr Surg* 145: 1, 2020.) **CLINICAL QUESTION/LEVEL OF EVIDENCE:** Therapeutic, I.



Systematic Review

Meta Analysis

Randomized Controlled Trial (RCT)

Cohort Study

Case Control Study

Case Report

Expert Opinion / Background Information



### COMPUTERIZED TOMOGRAPHY ANGIOGRAPHY AND INDOCYANINE-GREEN ANGIOGRAPHY IN PERFORATOR SELECTION IN AUTOLOGOUS BREAST RECONSTRUCTION WITH ABDOMINAL-BASED FREE FLAPS A PROSPECTIVE OBSERVATIONAL STUDY

Tine Engberg Damsgaard, Lisa Toft Jensen, Elisabeth Lauritzen

### Influence of vertical location and spacing of perforators on perfusion in deep inferior epigastric artery perforator flap breast reconstruction: quantitative analysis using indocyanine green angiography

Jin-Woo Park, Mi Kyung Lee, Kyong-Je Woo  
Department of Plastic and Reconstructive Surgery, Ewha Womans University Mokdong Hospital, College of Medicine, Ewha Womans University, Seoul, Republic of Korea  
**Contributions:** (I) Conception and design: JW Park, KJ Woo; (II) Administrative support: JW Park, MK Lee; (III) Provision of study materials or patients: JW Park, KJ Woo; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: JW Park, KJ Woo; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.  
**Correspondence:** to Kyong-Je Woo, MD, Ph.D., Associate Professor, Department of Plastic and Reconstructive Surgery, Ewha Womans University Mokdong Hospital, College of Medicine, Ewha Womans University, 1071, Anyangcheon-ro, Yangcheon-gu, Seoul 07985, Republic of Korea. Email: economywoo@gmail.com.



# BREAST RECONSTRUCTIVE PROCEDURES

ICG – safety and reliability



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# SYSTEMATIC REVIEW META-ANALYSIS

## METHODS

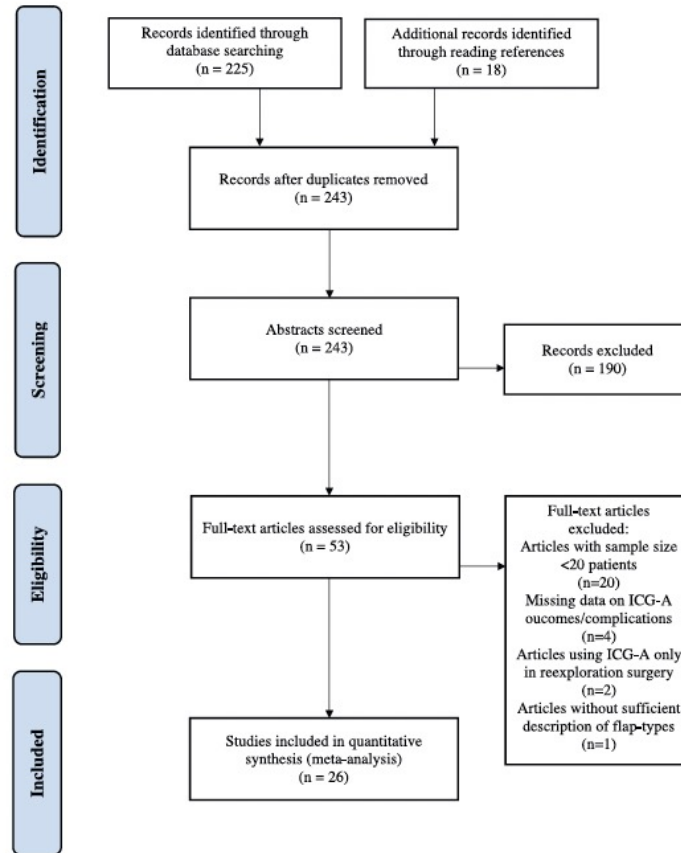
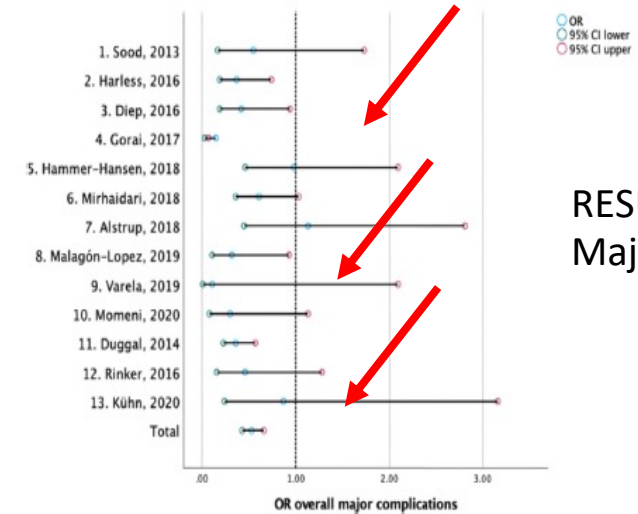


Fig. 1 PRISMA flowchart.



## RESULTS Major complications

Fig. 2 Forest plot: OR overall major complications.

OR = 0.53 95% CI (0.43, 0.66),  $p=0.00001$ , and DF: 1  $\text{Chi}^2$ : 33.66

Text: Forest plot showing the overall odds ratios [OR] for major complications. The data markers indicate the individual OR of each study. The vertical lines indicate the 95% confidence intervals.

Study 1-6 used ICG-A on mastectomy flaps.

Study 7-10 used ICG-A on autologous tissue.

Study 11-13 used ICG-A on both mastectomy flaps and autologous tissue.



# SYSTEMATIC REVIEW META-ANALYSES

Review

Use of Indocyanine Green Angiography decreases the risk of complications in autologous- and implant-based breast reconstruction: A systematic review and meta-analysis

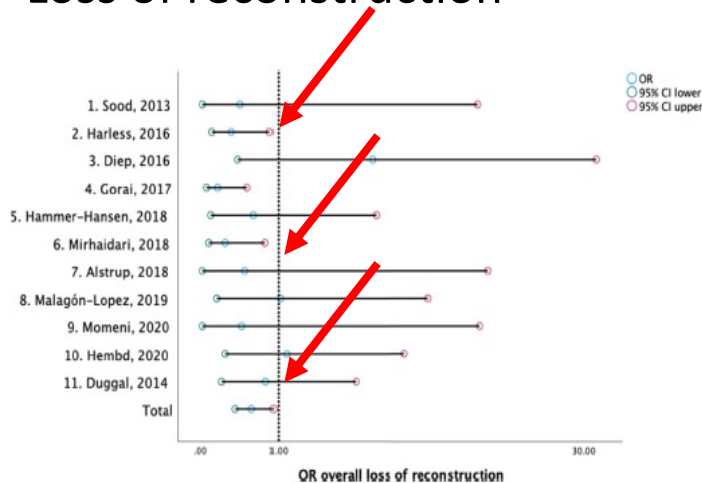
Elisabeth Lauritzen\*, Tine Engberg Damsgaard

Department of Plastic Surgery and Burns Treatment, Copenhagen University Hospital, Denmark

## CONCLUSION

## RESULTS

### Loss of reconstruction



**Fig. 3** Forest plot: OR overall loss of reconstruction.  
 $OR = 0.58$  95% CI (0.37, 0.92),  $p = 0.020$ , DF: 1, and  $Chi^2: 5.04$   
 Text: Forest plot showing the overall odds ratios [OR] for loss of reconstruction. The data markers indicate the individual OR of each study. The vertical lines indicate the 95% confidence intervals.  
 Study 1-6 used ICG-A on mastectomy flaps.  
 Study 7-10 used ICG-A on autologous tissue.  
 Study 11 used ICG-A on both mastectomy flaps and autologous tissue.

## APPLICATION OF INDOCYANINE GREEN ANGIOGRAPHY AUTOLOGOUS BREAST RECONSTRUCTION

- ✓ Reduces the risk of overall major complications
- ✓ Reduces the risk of loss of reconstruction

## IMPLANT-BASED BREAST RECONSTRUCTION

- ✓ Mastectomy skin flap
- ✓ Reduces the risk of major complications
- ✓ Reduces the risk of loss of reconstruction

# IMPLANT-BASED BREAST RECONSTRUCTION

# IMMEDIATE BREAST RECONSTRUCTION MASTECTOMY SKIN FLAP PERFUSION

## Predicting Mastectomy Skin Flap Necrosis with Indocyanine Green Angiography: The Gray Area Defined

Hunter R. Moyer, M.D.  
Albert Losken, M.D.  
Atlanta, Ga

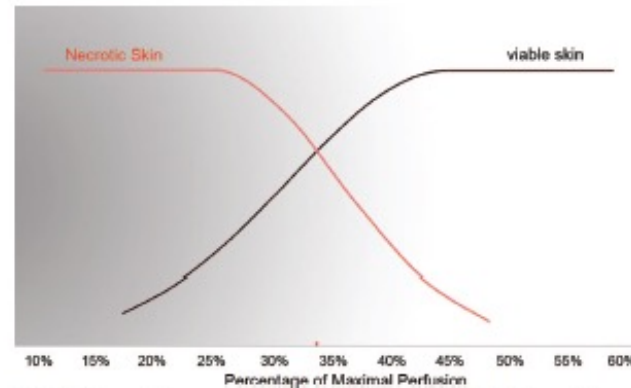
**Background:** Preservation of breast skin during mastectomy has improved the cosmetic results of breast reconstruction. Unfortunately, the incidence of mastectomy skin flap necrosis remains high using conventional evaluation methods; therefore, accurate prediction of flap viability is an important component of postmastectomy reconstruction.

**Methods:** The authors studied a prospective cohort of women who underwent skin-sparing mastectomy and breast reconstruction over a 2-year period at Emory University. Mastectomy skin flap perfusion was measured intraoperatively using indocyanine green angiography. Once necrosis matured postoperatively, digital images were taken and superimposed over the intraoperative scan. Perfusion percentages were measured in healthy and nonviable skin.

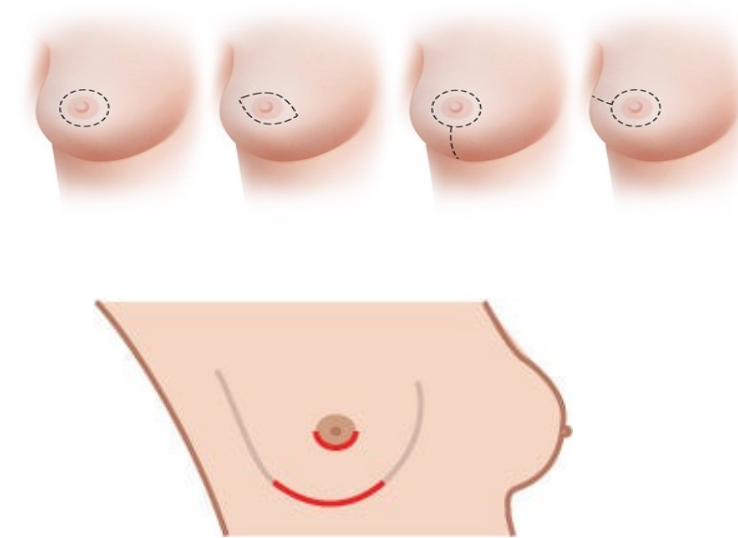
**Results:** One hundred eighteen patients were included, and 14 patients (15 breasts) with postoperative skin necrosis and sufficient image data were analyzed. The average woman's age was 49.7 years (range, 28 to 73 years) and the average body mass index was 27.7 (range, 21.2 to 42.2). Skin with 25 percent or less perfusion (perfusion score,  $\leq 25$ ) was not viable 90 percent of the time, and areas with greater than or equal to 45 percent perfusion survived 98 percent of the time. A 33 percent perfusion score had a positive predictive value of removing nonviable skin of 88 percent and a negative predictive value of removing healthy skin of 16 percent.

**Conclusions:** Indocyanine green angiography is a useful adjunct to assess mastectomy skin flap viability. A gray zone exists between 25 and 45 percent of maximal skin perfusion in which the ultimate viability remains in question. By designating the cutoff perfusion score of 33 percent, the surgeon can expect to more accurately remove nonviable skin. (*Plast. Reconstr. Surg.* 129: 1043, 2012.)

**CLINICAL QUESTION / LEVEL OF EVIDENCE:** Diagnostic, III.



**Fig. 2.** Intersecting graphs of viable and nonviable skin. Normal Gaussian distributions were created for necrotic and healthy skin. As shown, tissue with less than 25 percent of maximal perfusion was likely to necrose, and tissue with greater than 45 percent will survive. The intersecting point is 33 percent of maximal perfusion.



## Perfusion score

> 45 % - 98 % sensitivity for survival

< 25 % - 90% sensitivity for necrosis

IT IS ALL ABOUT BLOOD SUPPLY  
"The critical element for a successful outcome ... is actually the first part of the "reconstruction".  
A well-done nipple- or skin-sparing mastectomy"

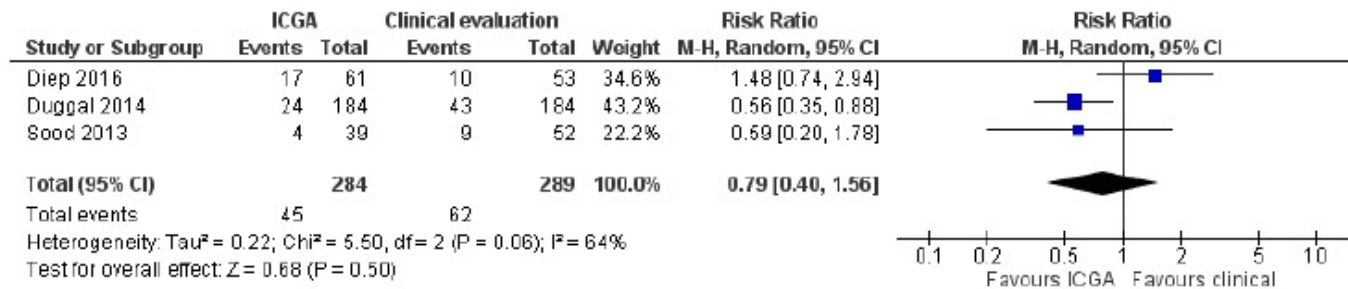
Direct-to-Implant Breast Reconstruction With Acellular Dermal Matrix. Salzberg AC, Koch RM.  
LWBK582-c34\_p412-419.qxd 8/27/10 9:14 AM Page 412 Aptara Inc



# IMMEDIATE BREAST RECONSTRUCTION MASTECTOMY SKIN FLAP

## RESULTS

**Figure 2. Forest plot of comparison: 1 Mastectomy skin flap necrosis, outcome: 1.1 Per patient.**



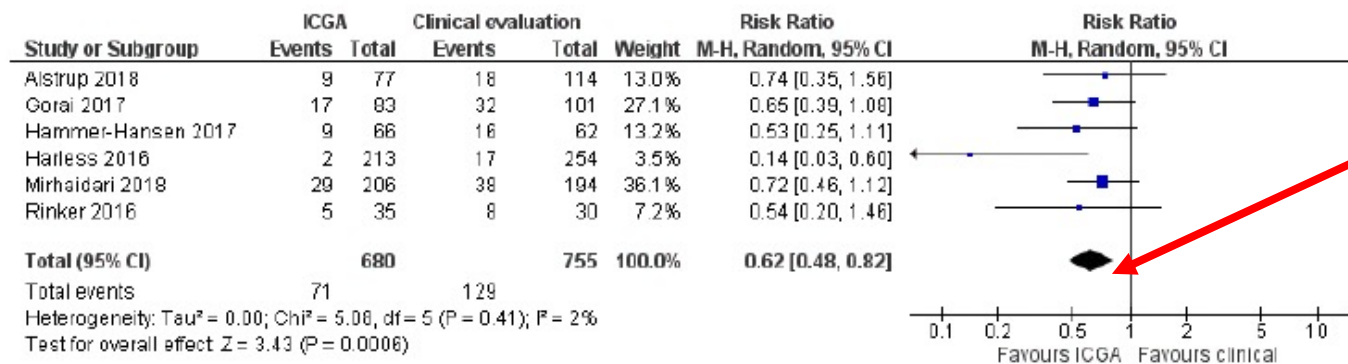
Indocyanine green angiography for preventing postoperative mastectomy skin flap necrosis in immediate breast reconstruction (Review)

Pruimboom T, Schols RM, Van Kuijk SMJ, Van der Hulst RRWJ, Qiu SS. Indocyanine green angiography for preventing postoperative mastectomy skin flap necrosis in immediate breast reconstruction. *Cochrane Database of Systematic Reviews* 2020, Issue 4. Art. No.: CD013280. DOI: 10.1002/14651858.CD013280.pub2.

Per breast basis: ICGA may reduce MSFN compared to clinical evaluation. Based on three studies, the pooled analysis showed RR 0.62 (95% CI 0.48 to 0.82; 1435 breasts, very low quality of evidence;

Figure 3; Analysis 1.2). The I<sup>2</sup> was 2%, representing heterogeneity that might not be important.

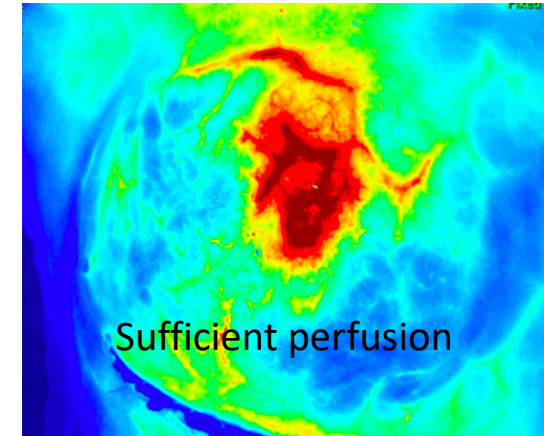
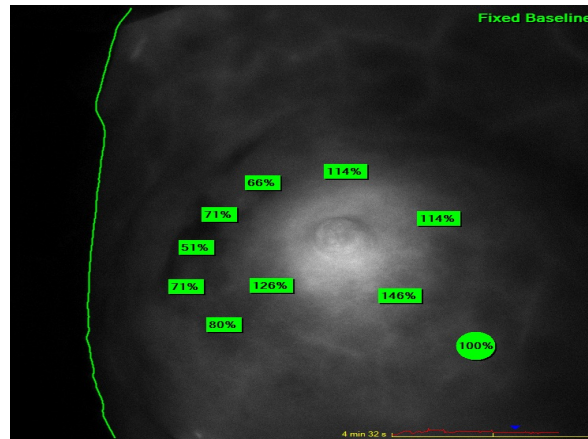
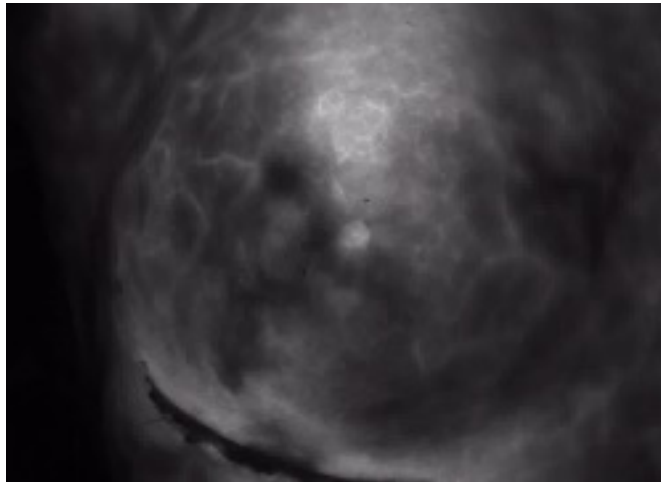
**Figure 3. Forest plot of comparison: 1 Mastectomy skin flap necrosis, outcome: 1.2 Per breast.**



ICG-A is superior to clinical evaluation



# IMMEDIATE BREAST RECONSTRUCTION -MASTECTOMY SKIN FLAPS IN SUBPECTORAL IMPLANT-BASED BREAST RECONSTRUCTION



Review Article

Page 1 of 12

## Indocyanine green angiography in breast reconstruction: a narrative review

Elisabeth Lauritzen, Rikke Bredgaard, Christian Bonde, Lisa Toft Jensen, Tine Engberg Damsgaard

Department of Plastic Surgery and Burns Treatment, University Hospital Copenhagen, Copenhagen, Denmark

Contributions: (I) Conception and design: E Lauritzen, TE Damsgaard; (II) Administrative support: E Lauritzen, TE Damsgaard; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: E Lauritzen, TE Damsgaard; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Dr. Elisabeth Lauritzen, MD, PhD-student, Department of Plastic Surgery and Burns Treatment, University Hospital Copenhagen, Blegdamsvej 9, DK-2100 Copenhagen, Denmark. Email: slau008@regionh.dk

**Abstract:** Sufficient tissue perfusion is important in achieving a successful breast reconstruction to provide the patient with an acceptable result in terms of shape, size, symmetry and possible sensation. Indocyanine green angiography (ICG-A) is a well-known imaging modality which can be applied to visualize the per-operative tissue perfusion assisting the surgeon in intraoperative decision making, flap design and trimming. The consequence of using per-operative ICG-A is reported to correlate with a decreased rate of complications and loss of reconstruction; thus, this technique may be a valuable intraoperative assessment tool for the breast reconstructive surgeon. This paper aims to provide a review of the recent knowledge on the use of ICG-A in breast reconstructive procedures. In addition, an evaluation of the favorable application in implant-based reconstruction, oncoplastic techniques and autologous breast reconstruction. The technique is presented with clinical examples illustrated by per-operative videos, photos and assessment of perfusion to provide the reader with a broader perspective on the application and use of ICG-A. There is a need for further standardization of the per-operative application and perfusion assessment using ICG-A in the field of breast reconstruction, also exploring the use of ICG-A in assessment of postoperative monitoring, microvascular anastomoses and venous insufficiency.

**Keywords:** Indocyanine green angiography (ICG-A); breast reconstruction; implant-based; autologous breast reconstruction; imaging technique

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PROFESSOR, CONSULTANT PLASTIC SURGEON



# AUTOLOGOUS BREAST RECONSTRUCTION



# EXPANDING OUR MINDSET

## AUTOLOGOUS BREAST RECONSTRUCTION

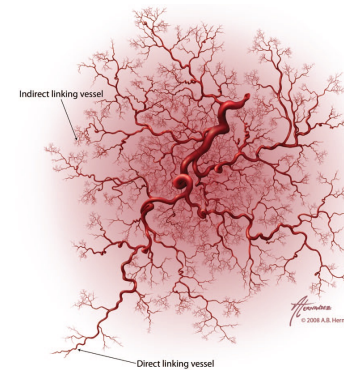
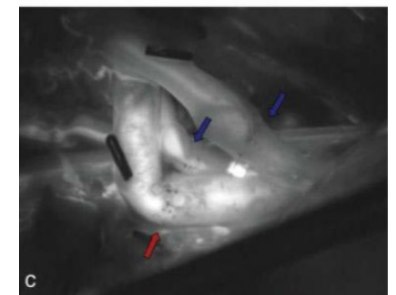
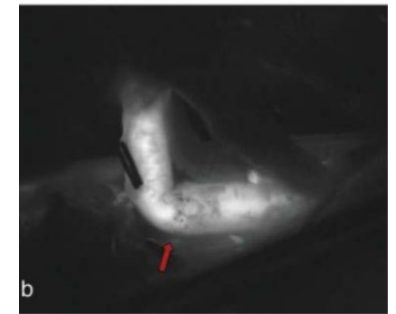
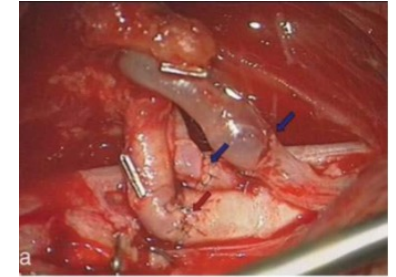
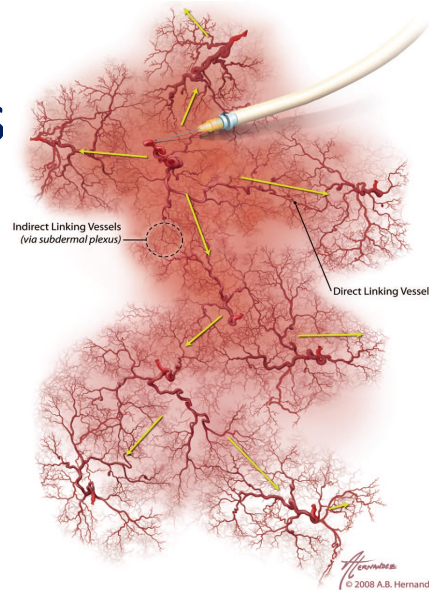
Optimal flap design

Perforator selection

Zones of perfusion

Evaluation of anastomoses

Venous outflow



Saint-Cyr M et al. The Perforasome Theory: Vascular Anatomy and Clinical Implications.  
PRS 124: 1529, 2009



# MICROVASCULAR ANASTOMOSES FLAP PERFUSION

Perfusion

Sensitivity 37,5 %

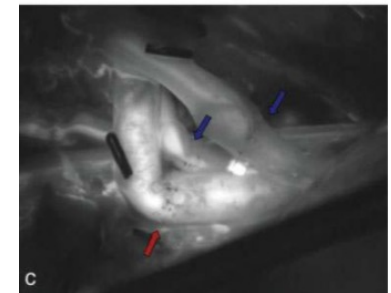
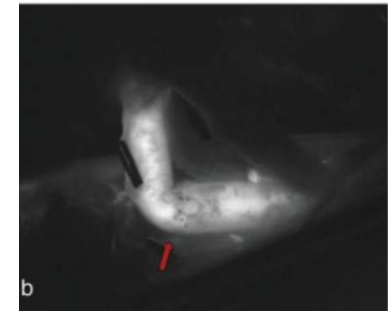
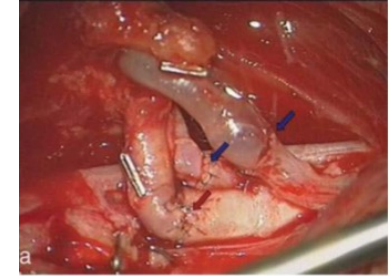
Specificity 100 %

Anastomoses

+ patent

22 % non-patent

Venous outflow



Sensitivity and specificity of ICG-angiography reexploration.

Holm C et al. J. Reconstr Microsurg 2010

Assessment of the patency of microvascular anastomoses

Holm C et al. Microsurgery 2009

**Background:** In the last decade, a number of studies have demonstrated the utility of indocyanine green (ICG) angiography in predicting autologous skin flap necrosis for immediate breast reconstruction. However, data are limited to investigate this technique for autologous breast reconstruction. Although it may have the potential to improve free flap outcomes, there has not been a large multicenter study to date that specifically addresses this application.

**Methods:** A thorough literature review based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines was conducted. All studies that examined the use of intraoperative ICG angiography or SPV to assess perfusion of abdominally based free flaps for breast reconstruction from January 1, 2000, to January 1, 2020, were included. Free flap postoperative complications including total flap loss, partial flap loss, and fat necrosis were extracted from selected studies.

**Results:** Nine relevant articles were identified, which included 135 patients and 824 free flaps. A total of 472 free flaps underwent clinical assessment of perfusion intraoperatively, whereas 352 free flaps were assessed with ICG angiography. Follow-up was from 1 month to 1 year. The use of ICG angiography was associated with a statistically significant decrease in flap fat necrosis in the follow-up period (odds ratio = 0.31,  $P = 0.02$ ). There was no statistically significant difference for total or partial flap loss.

**Conclusions:** From this systematic review, it can be concluded that ICG angiography may be an effective and efficient way to reduce fat necrosis in free flap breast reconstruction and may be a more sensitive predictor of flap perfusion than clinical assessment alone. Future prospective studies are required to further determine whether ICG angiography may be superior to clinical assessment in predicting free flap outcomes.

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been shown that clinical assessment can miss up to 41% of cases of mastectomy skin flap necrosis.<sup>2</sup> It is clear based on this and other studies that there exists a need for more accurate, real-time assessments of tissue perfusion to help decrease ischemia-related complications in autologous free flap breast reconstruction.<sup>3-10</sup>

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# SYSTEMATIC REVIEW META-ANALYSIS

## RESULTS

## METHODS

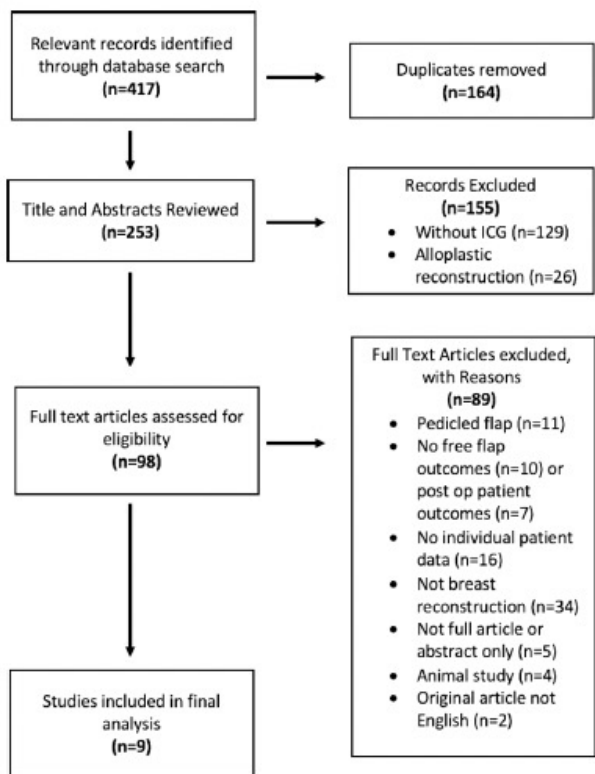
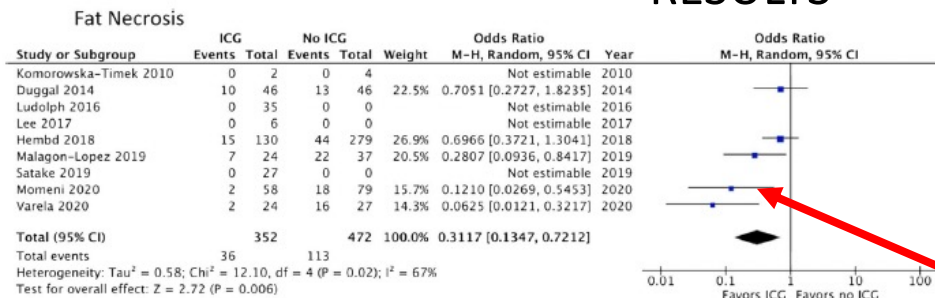
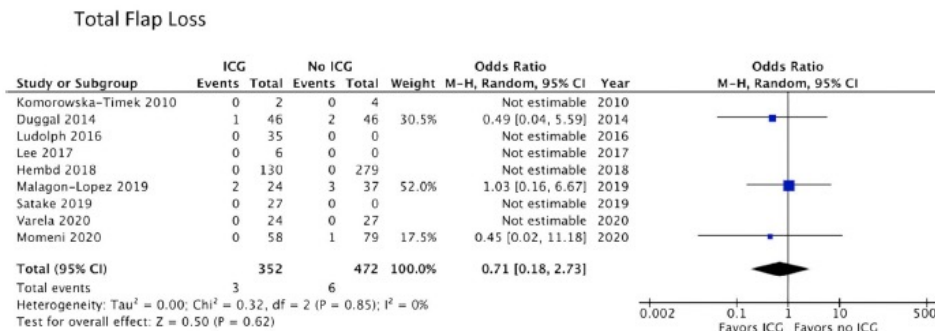


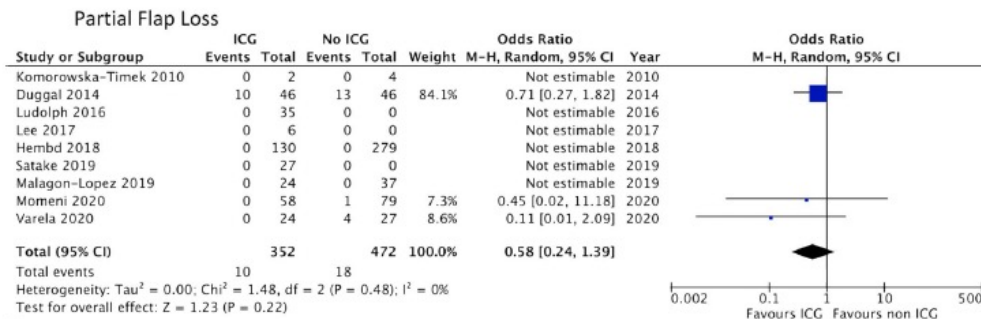
FIGURE 1. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram of study selection.



A



B



C

FIGURE 2. Odds ratio and forest plot meta-analysis of studies for fat necrosis (A), total flap loss (B), and partial flap loss (C).

full color online



Outcomes of DIEP Flap and Fluorescent Angiography: A Randomized Controlled Clinical Trial

Ramon Varela, M.D., Cesar Casado-Sanchez, M.D., Ph.D., Shirin Zarbaksh, M.D., Jesus Diaz, M.D., Ph.D., Juan Hernandez-Godoy, M.D., Luis Landin, M.D., Ph.D. Madrid, Spain

**Background:** Breast reconstruction with the deep inferior epigastric perforator (DIEP) flap can be associated with complications such as fat necrosis. The authors' objective was to assess the safety and efficacy of fluorescent angiography with indocyanine green to reduce fat necrosis.

**Methods:** The authors designed a parallel, randomized, controlled clinical trial for unilateral breast reconstruction. The poorly vascularized tissues of the DIEP flap were removed based on a clinical evaluation in group 1 and based on angiographic criteria in group 2. The authors recorded the flap dimensions, perfusion in terms of fluorescence intensity, complications, reoperations, and BREAST-Q questionnaire scores for both groups.

**Results:** The study included a total of 51 patients. The flaps showed no size differences after the tissue was excised. The flaps of group 2 presented higher perfusion rates ( $p = 0.001$ ). The incidence of fat necrosis was 59.3 percent in group 1 and 8.3 percent in group 2 ( $p = 0.001$ ). Four cases of partial necrosis were recorded in group 1 (18.2 percent) compared with none in group 2 (0 percent) ( $p = 0.131$ ). Four patients underwent reoperation in group 1 (14.8 percent) compared with none in group 2 (0 percent) ( $p = 0.113$ ). The patients in group 2 reported higher scores in all domains of the BREAST-Q.

**Conclusions:** Fluorescent angiography with indocyanine green significantly reduced the incidence of fat necrosis without diminishing the flaps' dimensions. The perfusion rates were significantly higher and the patients reported significantly greater satisfaction and quality of life. Fluorescent angiography with indocyanine green may be considered a safe and effective tool to enhance the outcomes of breast reconstruction with the DIEP flap. (*Plast. Reconstr. Surg.* 145: 1, 2020).

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, I.



# RANDOMIZED CLINICAL TRIAL

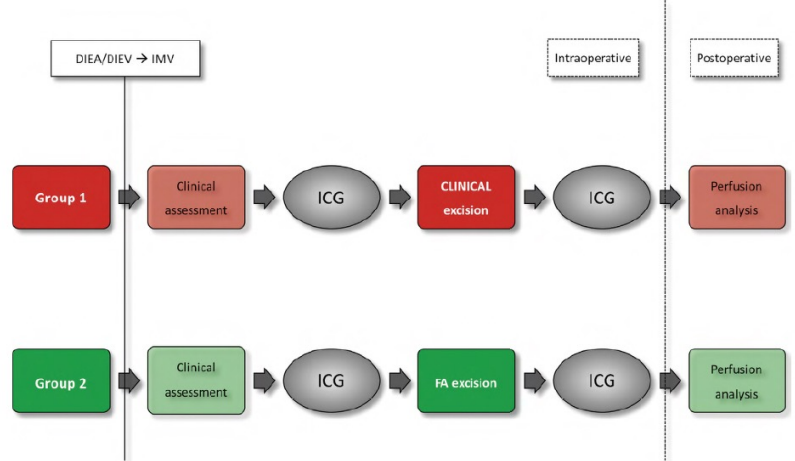


Fig. 1. Study protocol. In group 1, the flaps were also subject to fluorescent angiography with indocyanine green to analyze their fluorescence intensity postoperatively. DIEA, deep inferior epigastric artery; DIEV, deep inferior epigastric vein; IMV, internal mammary vessels; ICG, indocyanine green; FA, fluorescent angiography.

DESIGN Randomized controlled trial  
 MATERIALS AND METHODS  
 51 patients  
 Delayed breast reconstruction with DIEP flap  
 Group 1 - clinical evaluation 27 patients  
 Group 2 – ICG 24 patients  
 Outcomes

**RESULTS**  
**Fat necrosis** – significant  
 Group 1 59.3 %  
 Group 2 8.3 %  
**Breast-Q**  
 Group 2 > group 1  
 in all domains

flap dimensions  
 fluorescence intensity/perfusion  
 complications  
 reoperations  
 Breast-Q

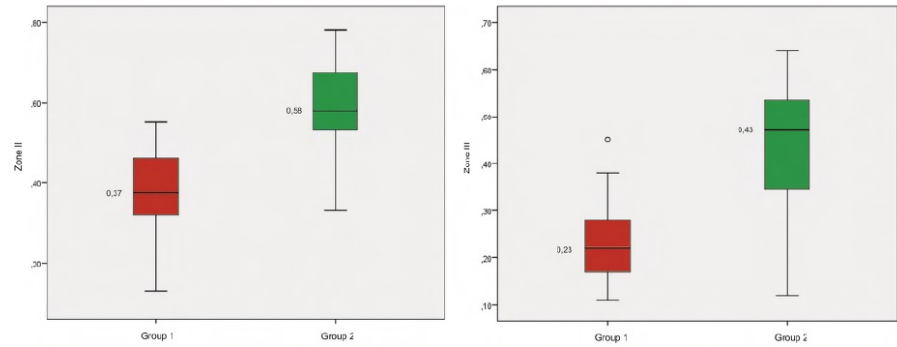


Fig. 4. Perfusion rates in Holm zone II and zone III in both groups. The box plots show significantly higher perfusion rates in the flaps tailored using fluorescent angiography with indocyanine green.

Table 4. Complications\*

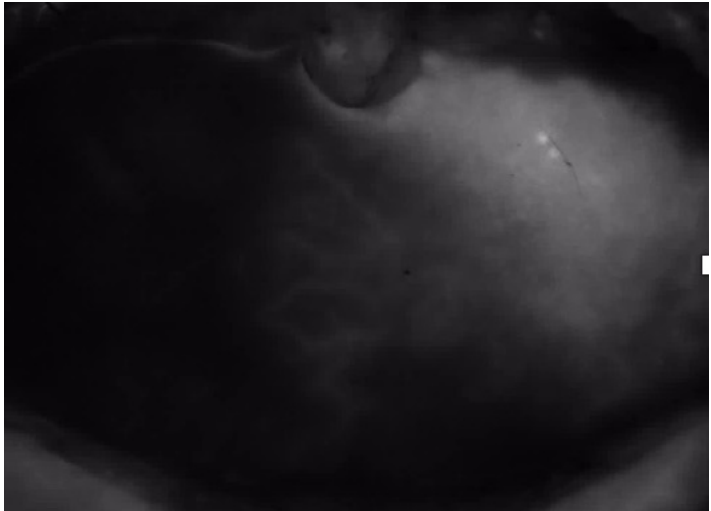
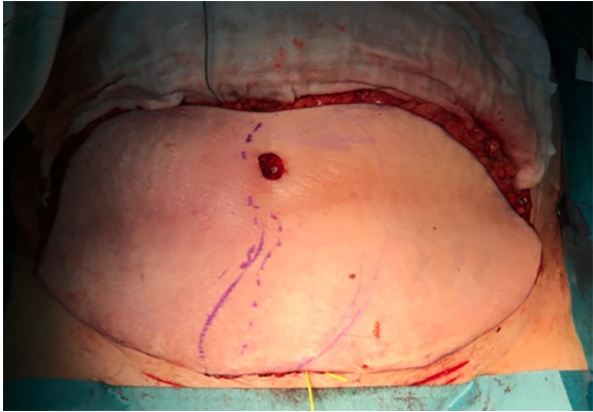
	Fat Necrosis	Partial Necrosis	Reoperation	Total Necrosis
Total	35.3 (18/51)	10.8 (4/37)	7.8 (4/51)	0 (0/51)
Group 1	59.3 (16/27)	18.2 (4/22)	14.8 (4/27)	0 (0/27)
Group 2	8.3 (2/24)	0 (0/15)	0 (0/24)	0 (0/24)
<i>p</i>	0.000	0.131	0.113	—

\*Values are presented as percentages (no. of patients).

**CONCLUSION**  
 ICG-A is a safe and efficient tool to enhance the outcomes of DIEP-flap breast reconstruction

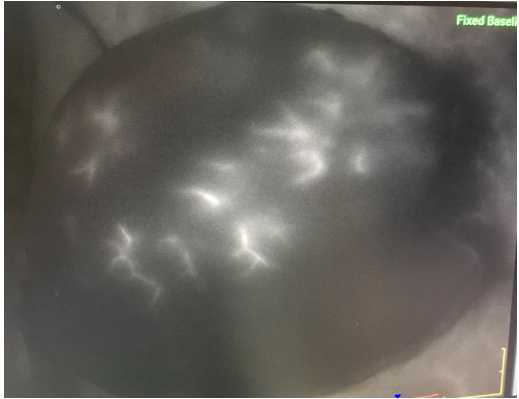
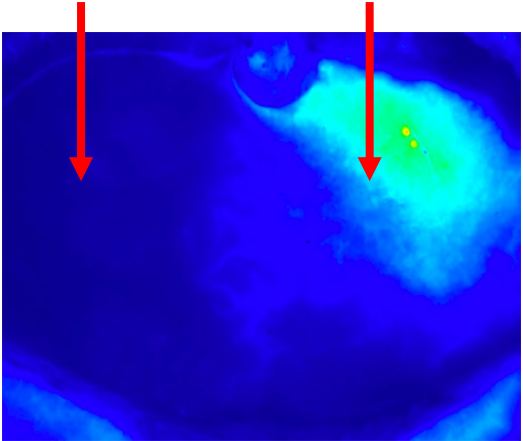


# IMMEDIATE BREAST RECONSTRUCTION DIEAP FLAP



DIEAP- flap

Insufficient perfusion    Sufficient perfusion



TINE ENGBERG DAMSGAARD, MD, PHD, MRBS  
PROFESSOR, CONSULTANT PLASTIC SURGEON



# NEW STUDIES PERFORATOR SELECTION



Tine Engberg Damsgaard MD, PhD, MRBS  
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Rigshospitalet, Copenhagen University Hospital





# COHORT STUDY

## Influence of vertical location and spacing of perforators on perfusion in deep inferior epigastric artery perforator flap breast reconstruction: quantitative analysis using indocyanine green angiography

Jin-Woo Park, Mi Kyung Lee, Kyong-Je Woo

Department of Plastic and Reconstructive Surgery, Ewha Womans University Mokdong Hospital, College of Medicine, Ewha Womans University, Seoul, Republic of Korea

Contributors: (I) Conception and design: JW Park, KJ Woo; (II) Administrative support: JW Park, MK Lee; (III) Provision of study materials or patients: JW Park, KJ Woo; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: JW Park, KJ Woo; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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## MATERIALS AND METHODS

67 patients

Delayed breast reconstruction with DIEP flap

Classification of perforators

- Vertical zone 1
- Vertical zone 2

ICG-A

- one dominant perforator
  - additional perforator
- Vertical spacing - + perforator from an additional zone

Outcomes

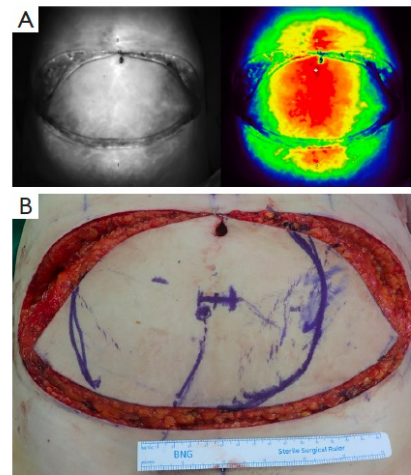
- flap dimensions
- fluorescence intensity/perfusion
- complications

**Table 4** Perfusion outcomes in DIEP flaps with an additional perforator: comparison between vertical-spacing and no-vertical-spacing groups

Variable	Vertical-spacing* group	No-vertical-spacing† group	P
Perfused area, cm <sup>2</sup>			
Dominant perforator	140.6±42.9	154.7±27.5	
All perforators	184.0±48.4	184.1±28.9	
Increment of dimension	43.4±13.8	29.4±15.2	0.009
Perfused proportion			
Dominant perforator	0.56±0.09	0.63±0.10	
All perforators	0.73±0.09	0.75±0.08	
Increment of proportion	0.17±0.05	0.12±0.05	0.004

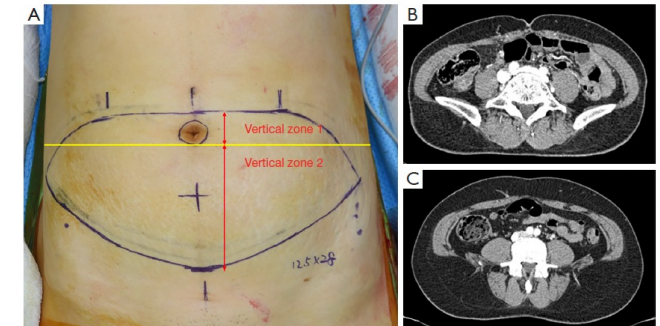
Adding an additional perforator increased the angiosome/size and the perfusion of the flap

## RESULTS



**Figure 1** Example of intraoperative deep inferior epigastric artery perforator flap perfusion evaluation using indocyanine green angiography. (A) Perfusion assessment was performed in 30 to 40 s after fluorescence was started to visualize the abdominal flap; (B) tissue with less than 40% of relative value units were marked on the skin surface of the flap and primarily discarded.

ICG-A



**Figure 2** The definition of vertical zones of perforators. (A) The lower margin of the umbilical stalk was defined as the border between the vertical zone 1 and 2; (B) perforators were classified as being situated in zone 1 when the perforator penetrated the anterior rectus sheath at or above the lower margin of the umbilical stalk on preoperative computed tomographic angiography; (C) perforators located below the lower margin of the umbilical stalk were classified as situated in zone 2.

## CONCLUSION

DIEP flap perfusion can be affected by the vertical location of perforators, and flap perfusion can be augmented effectively by vertical spacing of perforators. Perfusion-related complications and donor site morbidity could be balanced by using the suggested protocol for perforator selection and flap design.

GAARD, MD, PHD, MRBS  
TANT PLASTIC SURGEON



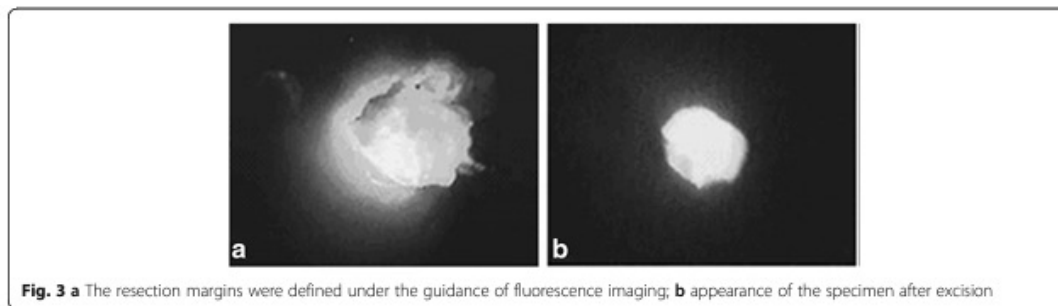
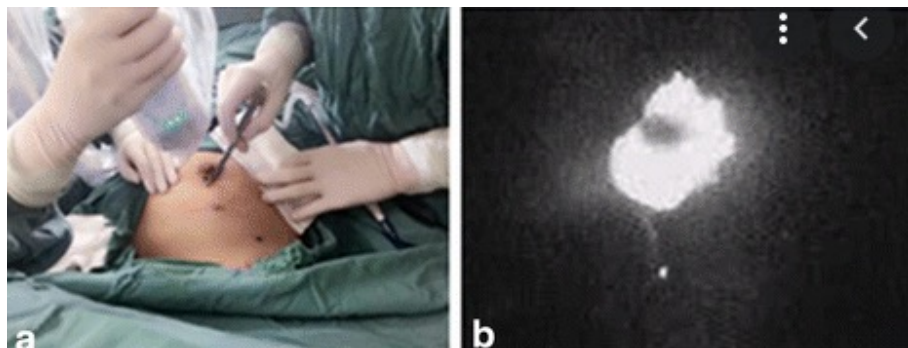
# AND INNOVATION CONTINUES



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# BREAST CANCER – ONCOLOGIC SURGERY



**Fig. 3** a The resection margins were defined under the guidance of fluorescence imaging; b appearance of the specimen after excision

Liu et al. *World Journal of Surgical Oncology* (2016) 14:266  
DOI 10.1186/s12957-016-1014-2

World Journal of  
Surgical Oncology

## RESEARCH

## Open Access



### Intraoperative indocyanine green fluorescence guidance for excision of nonpalpable breast cancer

Jintao Liu, Wenbin Guo\* and Meng Tong

## Intra-lesional injection+wire

**Table 2** Marginal status of excision and volumes of the specimens in the patients

Characteristic	Histological diagnosis in re-excision specimen	n (%)	Mean volume ± SD (cm <sup>3</sup> )
No re-excision (including one focal positive case)		53 (94.6 %)	
Re-excision		3 (5.4 %)	
	DICS	2 (3.6 %)	
	Multifocal invasive cancer (mastectomy)	1 (1.8 %)	
Excision specimens			38.2 ± 16.5

DICS ductal carcinoma in situ

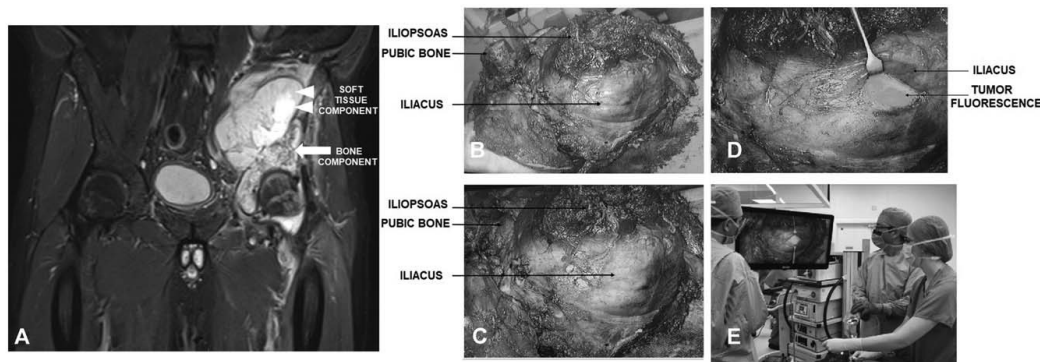
## CONCLUSION

Although further studies assessing the feasibility and validation of this technique are required, intraoperative ICG guidance should be considered whenever a breast cancer need image-guided excision.





# ICG-IMAGING SURGICAL MARGINS IN SARCOMA SURGERY



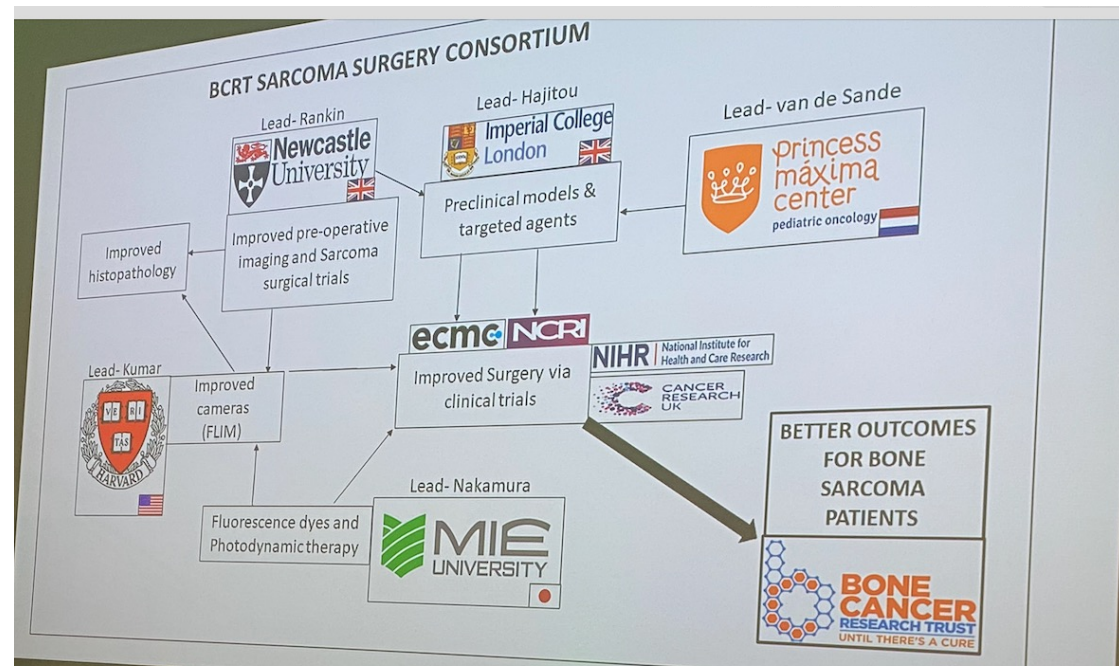
## Sarcoma

### BRIEF CLINICAL REPORT

Intraoperative Near-infrared Fluorescence (NIR) Imaging With Indocyanine Green (ICG) Can Identify Bone and Soft Tissue Sarcomas Which May Provide Guidance for Oncological Resection

Fabio Nicoli, MD, PhD,\*†† Daniel B. Saleh, FRCS,\* Bence Baljer, MBBS,\*† Corey D. Chan, MBBS,† Tom Beckingsale, FRCS,§ Kanishka M. Ghosh, FRCS,§ Maniram Ragbir, FRCS,\* and Kenneth S. Rankin, FRCS†§✉

## INTERNATIONAL STUDY



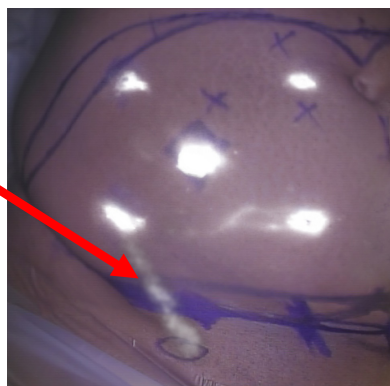
Annals of Surgery • Volume 273, Number 2, February 2021



# ALIGNMENT OF LYMPHATIC FLOW

Possible reduction of local complication rates

Lymphatics draining to the right inguinal region



ABDOMINAL DONOR-SITE

*Overlay of intraoperative indocyanine green fluorescence lymphangiography images and white light images of a right abdominal flap before incision*

Lymphatics draining superomedially after alignment of donor and recipient lymphatic channels



*Overlay of postoperative indocyanine green fluorescence lymphangiography images and white light images of the right abdominal DIEP flap after transfer to the left chest, at 3-week follow-up*

VIEWPOINT

## Lymphatic Drainage Reconstitution in DIEP Flap Procedures

Christensen, Joani M. M.D.; Johnson, Anna Rose M.D.; Fleishman, Aaron M.P.H.; Cauley, Ryan M.D.; Pardo, Jaime M.D.; Lee, Bernard T. M.D., M.P.H.; Singhal, Dhruv M.D.

[Author Information](#)

Plastic and Reconstructive Surgery: October 05, 2021 - Volume - Issue -  
10.1097/PRS.00000000000008471  
doi: 10.1097/PRS.00000000000008471

Beth Israel Deaconess Medical Center, Boston

[https://journals.lww.com/plasreconsurg/Fulltext/9900/Lymphatic\\_Drainage\\_Reconstitution\\_in\\_DIEP\\_Flap.443.aspx](https://journals.lww.com/plasreconsurg/Fulltext/9900/Lymphatic_Drainage_Reconstitution_in_DIEP_Flap.443.aspx)



CERTIFIES THAT

Tine Engberg Damsgaard

Has successfully developed the

BCN Lymphedema Research and Clinical Fellowship  
Barcelona Lymphedema Research Group

From 29th September to 15th December, 2021.

At the request of the interested party, and in order to be submitted to the authorities that shall demand it, we issue the current certificate, in the city of Barcelona, Spain, on December 14th, 2021.

Jaume Masia Ayala

Chief of the Department of Plastic Reconstructive Surgery at Sant Pau University Hospital



Review Article

Page 1 of 8

### Immediate lymphatic reconstruction for breast cancer

Akhil K. Seth<sup>1</sup>, Dhruv Singhal<sup>2</sup>

<sup>1</sup>Division of Plastic and Reconstructive Surgery, NorthShore University HealthSystem, Evanston, IL, USA; <sup>2</sup>Division of Plastic and Reconstructive Surgery, Beth Israel Deaconess Medical Center, Boston, MA, USA

**Contributions:** (I) Conception and design: Both authors; (II) Administrative support: D Singhal; (III) Provision of study material or patients: D Singhal; (IV) Collection and assembly of data: None; (V) Data analysis and interpretation: None; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

**Correspondence to:** Dhruv Singhal, MD, Division of Plastic and Reconstructive Surgery, Beth Israel Deaconess Medical Center/Harvard Medical School, 110 Francis St, Suite 5A, Boston, MA 02215, USA. Email: dsinghal@bidmc.harvard.edu

Annals of Breast Surgery, 2021

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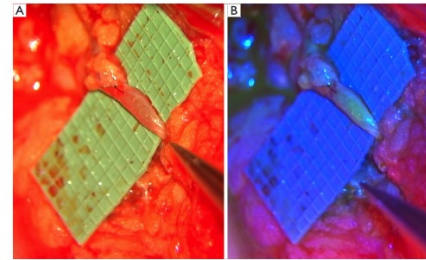


Figure 4 Completed lympho-venous anastomosis as part of immediate lymphatic reconstruction. Anastomosis is visualized both without (A) and with (B) the fluorescein isothiocyanate (FTTC) filter on the microscope. Note the appearance of FTTC within the vein lumen following completion of the anastomosis.

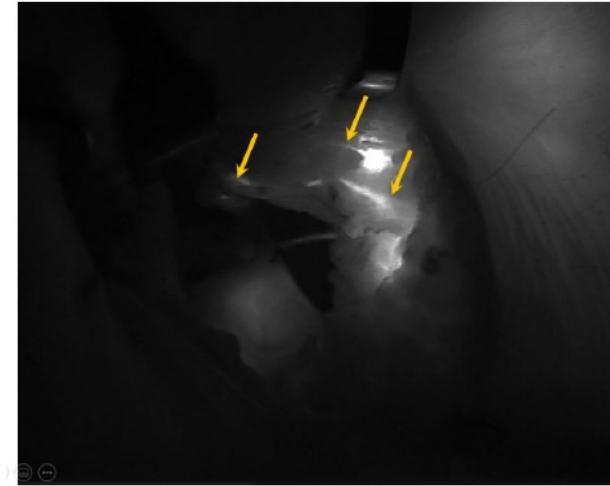


Figure 3: Intraoperative arm ICG lymphography following axillary clearance showing adequate collateral arm lymphatic drainage, in such case, no need for immediate lymphatic reconstruction. ICG: indocyanine green.

Boccardo et al 2014  
4-year follow-up  
4% experienced lymphedema after ALND and RT (30 %)

Johnson et al 2019  
Without immediate lymphatic reconstruction  
ALND - RT 15,6%  
ALND + RT 26,5%

With immediate lymphatic reconstruction  
ALND-RT 4,6%  
ALND+RT 10,6%

How to cite this article: Abdelfattah U, Pons G, Masia J. Prophylactic lymphatic surgery: the T-LAR approach. *Plast Aesthet Res* 2021;8:[Accept]. <http://dx.doi.org/10.20517/2347-9264.2021.30>

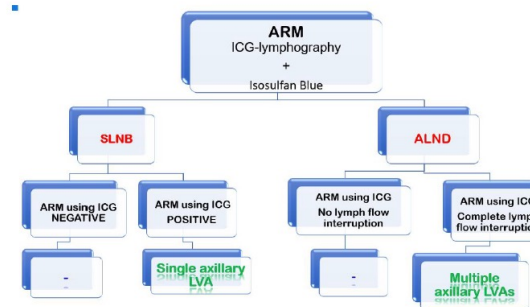


Figure 4: Diagram demonstrating the algorithmic T-LAR approach. ARM: axillary reverse mapping; ICG: indocyanine green; SLNB: sentinel lymph node biops; ALND: axillary lymph node dissection; T-LAR: Targeted-lymphatic axillary repair.



# LEVEL OF EVIDENCE

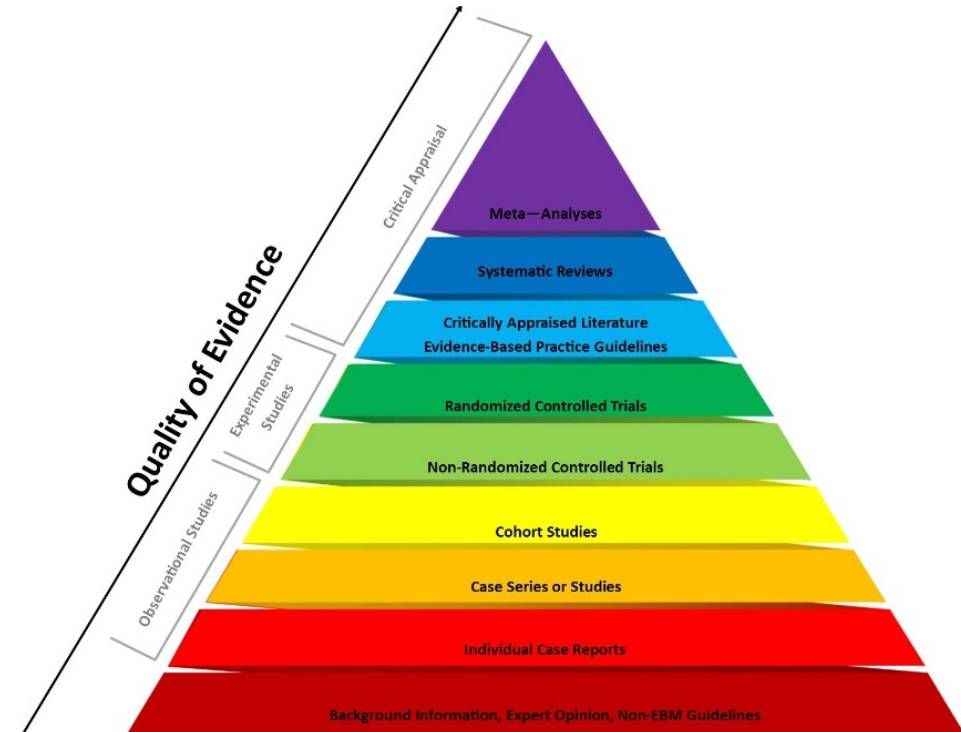
## APPLICATION OF INDOCYANINE GREEN ANGIOGRAPHY

### AUTOLOGOUS BREAST RECONSTRUCTION

- ✓ Reduces the risk of overall major complications
- ✓ Reduces the risk of loss of reconstruction
- ✓ Localization of perforators
- ✓ Reduce fat necrosis

### IMPLANT-BASED BREAST RECONSTRUCTION

- ✓ Mastectomy skin flap
  - ✓ Reduces the risk of major complications
  - ✓ Reduces the risk of loss of reconstruction





# THANK YOU

***NOTHING IS REALLY IMPOSSIBLE IF YOU SET YOUR MIND TO IT***



Tine Engberg Damsgaard MD, PhD, MRBS  
Professor, Consultant Plastic Surgeon  
Department of Plastic Surgery and Burns Treatment  
Rigshospitalet, Copenhagen University Hospital

