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Breast Microsurgery in Plastic Surgery Literature: A 21-Year Analysis of Publication Trends

Lauren Tracy Daly, MD¹, Donald Mowlds, MD, MBA¹, Merrick A. Brodsky, BS¹, Michael Abrouk, BS¹, Jessica R. Gandy, ScB¹, and Garrett A. Wirth, MD, MS, FACS¹

¹Department of Plastic Surgery, University of California, Irvine, Orange, California

Abstract

Introduction—Microsurgical reconstruction of the breast represents an area of continual evolution, as new autologous flaps are introduced and principles are refined. This progression can be demonstrated by bibliometric analysis of the scientific literature.

Methods—The top 10 plastic surgery journals were determined by impact factor (IF). Each issue of every journal from 1993 to 2013 was accessed directly, and all articles discussing microsurgery on the female breast were classified by authors' geographic location, study design, and level of evidence (LOE, I–V). The productivity index and productivity share of each geographic region was calculated based on number of articles published and IF.

Results—A total of 706 breast microsurgery articles were analyzed. There was a significant increase in microsurgical breast research ($p < 0.01$), with an average 33.6 ± 31.1 articles per year and a mean increase of 4.4 articles per year. Most research was of lower LOE, with level I constituting 0.14% and level II constituting 5.21% of all articles. United States contributed the most research with 336.4 articles, followed by Western Europe with 242.2. However, Western Europe experienced the greatest increase in productivity share, with $+0.50 \pm 0.29$ growth, while United States demonstrated the greatest decrease in productivity share with -1.23 ± 0.31 growth. Among autologous flaps, transverse rectus abdominis muscle research had the greatest yearly publication volume until 2002, when overtaken by deep inferior epigastric perforator flap research.

Conclusion—Over the 21-year study period, the United States not only contributed the greatest volume of research on female breast microsurgery but also demonstrated the greatest decline in research productivity. Efforts should be made to increase the LOE in breast microsurgery research.

Keywords

bibliometry; microsurgery; breast microsurgery; plastic surgery literature; trends

Microsurgery of the breast represents an area of continual evolution, as new autologous flaps are introduced and microsurgical principles are refined. Trends in research on breast microsurgery can be assessed and quantified through bibliometric analyses of the plastic

Address for correspondence: Lauren Tracy Daly, MD, Department of Plastic Surgery, University of California, Irvine, 200 S. Manchester Ave #650, Orange, CA 92868 (ltracy@uci.edu).

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surgery literature. Bibliometry involves multiple methods of objectively analyzing academic literature to assess the output and impact of a specific scientific field, and has been used to analyze research trends in hand and wrist surgery, minimally invasive general surgery, and cleft lip and palate surgery.^{1–3} Bibliometrics are often used in the promotion of academic plastic surgeons to faculty positions, with productivity indices (such as h-index and g-index) being predictive of promotion.⁴ Routinely, bibliometric analysis involves assessment of impact factor (IF), which is defined as the number of citations a journal receives in the previous 2 years divided by the total number of articles published by the journal in those same years.⁵

Along with IF, level of evidence (LOE) is an important indicator of research quality. LOE defines the research methodology of an article on a scale of I to V; with level I evidence representing high-quality randomized controlled studies, and level V representing expert opinion or a case report. In accordance with the increased emphasis on evidence-based medicine in plastic surgery, the American Society of Plastic Surgeons has published official guidelines on LOE, and many plastic surgery journals have mandated that authors include a LOE for every published article.^{6–8}

Concurrent with the recent impetus for evidence-based plastic surgery research, over the last two decades, there have been many developments in microsurgery of the breast. New autologous flaps, including the deep inferior epigastric perforator (DIEP), superficial inferior epigastric artery (SIEA), and other perforator flaps have become popular choices for microsurgical breast reconstruction and technical innovations such as the venous coupler have stream-lined breast microsurgery operations.^{9,10} With these developments in mind, this study aims to evaluate literature trends in the worldwide literature on microsurgery of the female breast from 1993 to 2013.

Methods and Materials

Data Collection

The top 10 English language plastic surgery journals were determined by 2012 IF as cited in the Journal Citation Reports from the Institute for Scientific Information.¹¹ Each issue of every journal from 1993 to 2013 was accessed directly either digitally or in print, and all articles on microsurgery of female breast or nipple were compiled and classified by title, IF, authors' geographic location, study design, and LOE (I–V).

Journals and Articles

Articles were collected from *Aesthetic Surgery Journal*; *Aesthetic Plastic Surgery*; *Annals of Plastic Surgery*; *The Canadian Journal of Plastic Surgery*; *Clinics in Plastic Surgery*; *Journal of Plastic, Reconstructive and Aesthetic Surgery* (previously known as *British Journal of Plastic Surgery*); *Journal of Plastic Surgery and Hand Surgery* (previously known as *Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery*); *Journal of Reconstructive Microsurgery*; *Microsurgery*; and *Plastic and Reconstructive Surgery*. All peer-reviewed original articles were collected, including case reports, technical reports, and reviews, but excluding editorials, book reviews, and conference abstracts.

Impact Factor

Journal IF data for each study year 1993 to 2013 were determined by Journal Citation Reports from the Institute for Scientific Information.¹¹ IF data were not available before 2011 for *Aesthetic Surgery Journal*, or before 2009 for *Canadian Journal of Plastic Surgery*; therefore, articles published in these journals before these respective dates were not included in the study.

Authors' Geographic Location

The geographic location of authors was assigned to one of nine global regions: Africa, Asia (excluding Japan), Canada, Eastern Europe, Japan, Latin America, Oceania (which includes Australia, New Zealand, and New Guinea), the United States of America, and Western Europe. Eastern Europe was defined as all formerly communist or socialist economies of Europe, and comprises Belarus, Bulgaria, Czech Republic, Hungary, Moldova, Poland, Romania, Russia, Slovakia, and Ukraine. Israel, India, and all countries on the Arabian Peninsula were included as part of Asia. These geographic classifications have been established by other bibliometric analyses.^{1,12,13} When an article featured collaboration between authors in multiple regions, each geographic location was assigned a fraction based on total authorship in the article.

Study Design

All articles were defined as basic science or clinical research. Basic science research included animal, cadaveric, and histologic studies. Clinical research was further defined as diagnostic, prognostic, or therapeutic.

Level of Evidence

A LOE was assigned for every clinical research article. When available, the self-reported LOE of the article was used. When these data were not available, the authors of the current study read and assigned a LOE to each article based on the published American Society of Plastic Surgery guidelines.⁶ Multiple authors of the current study assigned LOE. To ensure comprehensive accuracy, the lead author independently reviewed each LOE and in cases of discrepancy, the lead author's assignment was used. Basic science research was not assigned a LOE.

Productivity Index

Productivity index was defined as the number of articles published by a region in a given year multiplied by the IF of each article's journal for that corresponding year.

Productivity Share

To define relative research contributions of different geographic regions over time, productivity share was defined as the productivity index contributed by a region over a 5-year period, divided by total world productivity index in that same period, measured over 17 consecutive overlapping 5-year periods (e.g., 1993–1997, 1994–1998).

Autologous Flaps

To compare temporal and publication trends between autologous flaps, articles discussing research on transverse rectus abdominis muscle (TRAM), DIEP, SIEA, superior gluteal artery perforator (SGAP), inferior gluteal artery perforator (IGAP), transverse upper gracilis (TUG), diagonal upper gracilis (DUG), and other gracilis flaps (not TUG or DUG) were queried from the dataset and analyzed.

Statistical Analysis

Statistical analyses were performed using GraphPad Prism 6.0 (GraphPad, La Jolla, CA). Data are presented as mean $\pm$ standard deviation. Statistical comparisons were analyzed using univariate linear regression, with time as the independent variable and number of articles, productivity index, or productivity share being the dependent variable. The p -values below 0.05 were considered statistically significant.

Results

Journals and Articles

Over the 21-year study period, 706 articles on microsurgery of the female breast were published with a significant increase of 4.4 ± 0.53 articles per year ($p < 0.001$, $R^2 = 0.78$) (Fig. 1). Among journals, the *Plastic and Reconstructive Surgery* published the most with 354 articles (50.1%), followed by the *Journal of Plastic, Reconstructive and Aesthetic Surgery* with 101 articles (14.3%), and the *Annals of Plastic Surgery* with 95 articles (13.4%) (Fig. 2).

Impact Factor

Over 1993 to 2013, the mean IFs of the top 10 plastic surgery journals rose steadily and significantly ($p < 0.001$, $R^2 = 0.90$) with an increase of 0.05 ± 0.003 per year (Fig. 3). All individual journals experienced overall positive increase in IF, except for the *Aesthetic Surgery Journal* and *Canadian Journal of Plastic Surgery*, which had fewer years of IF data (3 and 5 years, respectively).

Authors' Geographic Location

The majority of breast microsurgery research from 1993 to 2013 came from the United States with 336.5 (47.7%), followed by Western Europe with 242.2 (34.4%), Oceania with 40.6 (5.8%), Asia with 36.4 (5.2%), Canada with 26.3 (3.7%), Japan with 10.0 (1.4%), Eastern Europe with 6.4 (0.90%), Latin America with 5.3 (0.75%), and Africa with 1.3 (0.18%) (Fig. 4).

Study Design

Most of the published studies were clinical research with 643 (91.1%), compared with 63 basic science articles (8.9%) (Fig. 5). The United States produced the highest proportion of basic science with 31.1 (44.4%) articles. Of clinical research articles, 534 of 643 (84.2%) discussed therapeutic interventions.

Level of Evidence

Over 21 years, there were 1 level I (0.14%), 33 level II (4.7%), 138 level III (19.5%), 254 level IV (40.0%), and 207 level V (29.3%) articles published (Fig. 6). The United States produced the highest proportion of levels III to V research with 59.6, 51.8, and 41.2% of all articles at each level, respectively. Western Europe produced the greatest proportion of level II research with 42.9% of all level II articles (Fig. 7). The only level I article came from Western Europe. The total number of levels II to V articles increased significantly over the study period ($p < 0.001$, $R^2 = 0.6, 0.8, 0.7, 0.5$, respectively). Interestingly, the number of levels II to IV articles decreased beginning in 2011 accompanied by an increase in level V articles in the same time frame.

Productivity Index

Worldwide productivity index rose steadily, with an increase of 10.7 ± 1.6 per year ($p < 0.001$, $R^2 = 0.70$), with the greatest gains seen between 2009 and 2013 (Fig. 1). The United States was the greatest producer of overall productivity index with a 51.6% contribution. Western Europe contributed 30.5%, Oceania 6.4%, Asia 5.3%, Canada 3.4%, Japan 1.4%, Latin America 0.7%, Eastern Europe 0.5%, and Africa 0.06% of global total (Fig. 8).

Productivity Share

The United States maintained the greatest productivity share over the 21-year period; however, it experienced the greatest overall decrease in productivity share with an overall -1.23 ± 0.31 drop in 5-year productivity over 1993 to 2013 ($p < 0.01$, $R^2 = 0.5$) (Fig. 9). Western Europe contributed the second greatest productivity share overall, and although not significant, it demonstrated the greatest increase in productivity with a 0.51 ± 0.29 growth in 5-year productivity over 21 years ($p = 0.09$, $R^2 = 0.17$). Other world regions with increasing productivity were Asia with 0.43 ± 0.07 ($p < 0.001$, $R^2 = 0.69$), Oceania with 0.34 ± 0.17 ($p = 0.06$, $R^2 = 0.21$), Canada with 0.21 ± 0.07 ($p < 0.001$, $R^2 = 0.38$), and Latin America with 0.08 ± 0.06 ($p = 0.22$, $R^2 = 0.09$) growths in 5-year productivity. World regions with decreasing productivity other than the United States were Japan with -0.23 ± 0.05 ($p < 0.001$, $R^2 = 0.61$), Eastern Europe with -0.28 ± 0.05 ($p < 0.001$, $R^2 = 0.70$), and Africa with -0.09 ± 0.02 ($p < 0.001$, $R^2 = 0.57$).

Autologous Flaps

The TRAM flap was the most researched flap until 2002, when overtaken by DIEP research in every subsequent year except 2005 (Fig. 10). The SIEA was the next most researched flap with 39 articles overall, followed by SGAP (20), TUG (14), IGAP (7), and gracilis not otherwise specified (6). Between regions, the United States published the most TRAM research with 29.6 articles, while Western Europe predominated in DIEP research with 45.3 articles (Fig. 11).

Discussion

Globally, breast microsurgery is a growing and evolving field. In 2013, more than 12,000 free flap breast reconstructions were performed in the United States, and more than 5,000 performed in 2008 in the United Kingdom.^{14,15} As the number of procedures continues to

grow, so too does amount of the research on breast microsurgery. Trends in the developing research on breast microsurgery can be quantified using bibliometry. This study is a bibliometric analysis of all articles on breast microsurgery published in the top 10 plastic surgery journals between the years of 1992 and 2013.

Over our 21-year study period, the volume of publications on microsurgery of the breast more than quadrupled, from single digit yearly publication rates in the early 1990s to almost 90 publications a year on average in the current decade. Along with increased breast microsurgery publication volumes, all but 2 of the top 10 plastic surgery journals experienced significant rises in IF. As a group, the top 10 plastic surgery journals had a 1993 average IF of 0.433, which rose to a 2013 average IF of 1.506. As both publication volume and IF continued to grow, increasing total global research productivity on breast microsurgery was observed, with the biggest rise seen after 2009.

The United States is historically recognized as one of the world leaders in both microsurgery and general plastic surgery research, having produced a majority of the 50 most-cited articles in microsurgery, as well as 57 of the 100 most-cited articles in all of plastic surgery.^{16,17} In our study, the United States was the greatest contributor to breast microsurgery research, both in terms of publication volume and productivity. However, the United States demonstrated significant overall decline in breast microsurgery research production over 21 years ($p < 0.01$) as other world regions, notably Western Europe demonstrated increased productivity ($p = 0.09$). Other world regions, especially Asia and Oceania, also demonstrated increases in breast microsurgery productivity, especially over the last decade ($p < 0.001$, $p = 0.06$). Asia as defined in this study includes Mainland China, Taiwan, and India, which have demonstrated increases in plastic surgery publication volume and research quality.^{18,19} As noted by Zhang et al, the Chang Gung Memorial Hospital has been a leader in plastic surgery research, producing 56% of Taiwan's total contribution in the years studied.

The average LOE for all breast microsurgery articles in our 21-year study is 3.6, which denotes slightly lower research quality than the average LOE of 3.2 noted by Sinno et al in a 1-year study of all articles published, the top six plastic surgery journals.²⁰ The same study also found that 2.2% of all plastic surgery articles were level I, while in the current study, we found that only 0.16% of breast microsurgery articles were level I. The United States led the world in production of levels III to V clinical research, as well as basic science, having produced almost half of all breast microsurgery basic science worldwide. However, the quality of breast microsurgery research from the United States, as determined by LOE, lagged slightly behind Western Europe, which produced the greatest proportion of level II research (as well as the only level I article) in this study.

Following the multispecialty Colorado Springs Evidence-Based Medicine Summit, in 2011, many plastic surgery journals implemented policies that encouraged specialty-wide incorporation of evidence-based medicine and required authors to self-assign a LOE to all articles.^{7,8} This policy implementation coincided with several changes in observed LOE in breast microsurgery research (Fig. 12). After 2011, the number of levels II to IV breast microsurgery articles initially decreased, while the number of level V articles initially increased. This was immediately followed by a dramatic decrease in level V articles, and a

moderate increase in levels II to IV articles in 2013. This observation could be due to researchers' increasing awareness of LOE definitions and attempts to improve research quality, or it could be due to journals shifting away from publication of level V breast microsurgery research with an increased emphasis on more evidence-based plastic surgery research.

The need for improvement in research quality (and thus LOE) in plastic surgery has been noted by many authors. Out of 7,121 plastic surgery articles analyzed between 1990 and 2010, Becker et al found only 159 (2.23%) randomized controlled trials (RCTs), which represent level I evidence.²¹ Similarly, low percentages of level I studies in plastic surgery literature were described by McCarthy et al and Agha et al, who also noted systemic problems with RCTs including ineffective randomization and blinding.^{22,23} A dearth of level I evidence is not a problem unique to breast microsurgery and general plastic surgery; however, as little level I has been published in other fields, including facial plastic surgery.²⁴

As total publication of breast microsurgery increased from 1993 to 2013, so did research published on specific flaps. The TRAM flap was the most researched autologous flap until 2002, when overtaken by DIEP flap research (Fig. 10). Although first described in 1991, the first report of DIEP flaps being used for breast reconstruction was by Allen and Treece in 1994.²⁵ Between its literary debut in 1991 and 2001, the number of articles on DIEP flap research published per year remained in the single digits, after which DIEP research increased markedly. The approximately 10-year gap between the first description of the DIEP flap and its dramatic rise in publication popularity highlights the relatively rapid diffusion and adoption of new innovations in the field of plastic surgery.²⁶ Another observation of our study was the difference in regional production of autologous free flap research. Between regions, the United States published the most TRAM research with 29.6 articles, while Western Europe predominated in DIEP research with 45.3 articles. This regional difference in production of research on autologous tissue breast microsurgery has not been noted previously. This difference in research production may not be indicative of actual surgical practice in the United States or Western Europe. Despite producing less overall DIEP research, a recent survey of the United States Nationwide Inpatient Sample revealed that the number of DIEP procedures being performed in the United States increased significantly, outnumbering the quantity of free TRAM flaps, which decreased from 2009 to 2011.²⁷ Although no national or regional data have been published from Western Europe, several case series indicate the growing surgeon preference for DIEP flaps in this area as well.^{28–31}

There are several limitations to our study. First, we limited our study to English language journals that had IF data in the year 2012, although we recognize the importance of breast microsurgery research contributions from non-English speaking researchers (i.e., Brazil, China, and Japan). In addition, the *Aesthetic Surgery Journal* and *Canadian Journal of Plastic Surgery* are variably under-represented in this study as they lacked IF data for all study years, and data were excluded from each study year for which the journal lacked a reported IF. Likewise, IF is an imperfect method of measuring the scientific significance of published research, as it is susceptible to manipulation via self-citation and variable article obtainability.³² However, IF is an established and widespread metric and is commonly used

in bibliometric studies. Another potential source of bias is the inclusion of LOE as self-reported by each study author, when allowed by journal guidelines. Although guides for LOE assignment exist, this is a new classification for many authors and is susceptible to author manipulation. Finally, the use of overlapping 5-year intervals to calculate productivity share, while useful in demonstrating temporal trends, can overestimate standard errors and thus artificially lower *p*-values. Thus, *p*-values used for describing productivity share should be interpreted with caution.

Conclusion

Between 1993 and 2013, there has been significant growth in the volume and impact of breast microsurgery research published in the top 10 plastic surgery journals. Over this 21-year study period, the United States was the greatest contributor to breast microsurgery research, both in terms of publication volume and productivity. However, the United States also demonstrated a decline in research productivity over time, and lagged behind Western Europe in the production of evidence levels I and II research. There was a relative increase in research productivity from Asia, Oceania, Canada, Western Europe, and Latin America.

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References

1. Ahn CS, Li RJ, Ahn BS, Kuo P, Bryant J, Day CS. Hand and wrist research productivity in journals with high impact factors: a 20 year analysis. *J Hand Surg Eur Vol.* 2012; 37(3):275–283. [PubMed: 21987270]
2. Antoniou SA, Lasithiotakis K, Koch OO, Antoniou GA, Pointner R, Granderath FA. Bibliometric analysis of scientific contributions in minimally invasive general surgery. *Surg Laparosc Endosc Percutan Tech.* 2014; 24(1):26–30. [PubMed: 24487154]
3. Mahon NA, Joyce CW. A bibliometric analysis of the 50 most cited papers in cleft lip and palate. *J Plast Surg Hand Surg.* 2015; 49(1):52–58. [PubMed: 25196126]
4. Gast KM, Kuzon WM Jr, Waljee JF. Bibliometric indices and academic promotion within plastic surgery. *Plast Reconstr Surg.* 2014; 134(5):838e–844e.
5. Labanaris AP, Vassiliadu AP, Polykandriotis E, Tjiawi J, Arkudas A, Horch RE. Impact factors and publication times for plastic surgery journals. *Plast Reconstr Surg.* 2007; 120(7):2076–2081. [PubMed: 18090778]
6. Sullivan D, Chung KC, Eaves FF III, Rohrich RJ. The level of evidence pyramid: indicating levels of evidence in Plastic and Reconstructive Surgery articles. *Plast Reconstr Surg.* 2011; 128(1):311–314. [PubMed: 21701349]
7. Rohrich RJ, Eaves FF III. So you want to be an evidence-based plastic surgeon? A lifelong journey. *Plast Reconstr Surg.* 2011; 127(1):467–472. [PubMed: 21200243]
8. Eaves FF III, Rohrich RJ. So you want to be an evidence-based plastic surgeon? A lifelong journey. *Aesthet Surg J.* 2011; 31(1):137–142. [PubMed: 21239681]
9. Granzow JW, Levine JL, Chiu ES, Allen RJ. Breast reconstruction with the deep inferior epigastric perforator flap: history and an update on current technique. *J Plast Reconstr Aesthet Surg.* 2006; 59(6):571–579. [PubMed: 16716950]
10. Sullivan SK, Dellacroce F, Allen R. Management of significant venous discrepancy with microvascular venous coupler. *J Reconstr Microsurg.* 2003; 19(6):377–380. [PubMed: 14515228]

11. Information of S. Journal Citation Reports®. Thomson Reuters; Available at: <http://thomsonreuters.com/journal-citation-reports/> [Accessed 2014]
12. Rosmarakis ES, Vergidis PI, Soteriades ES, Paraschakis K, Papastamataki PA, Falagas ME. Estimates of global production in cardiovascular diseases research. *Int J Cardiol.* 2005; 100(3): 443–449. [PubMed: 15837089]
13. Falagas ME, Papastamataki PA, Bliziotis IA. A bibliometric analysis of research productivity in Parasitology by different world regions during a 9-year period (1995–2003). *BMC Infect Dis.* 2006; 6:56. [PubMed: 16545114]
14. American Society of Plastic Surgeons. [Accessed October 2013] Plastic Surgery Statistics Report. Available at: <http://www.plasticsurgery.org/Documents/news-resources/statistics/2013-statistics/plastic-surgery-statistics-full-report-2013.pdf>
15. The NHS Information Centre for Health and Social Care. [Accessed 2011] National Mastectomy and Breast Reconstruction Audit. Available at <http://www.hscic.gov.uk/catalogue/PUB02731/clin-audi-supp-prog-mast-brea-reco-2011-rep1.pdf>
16. Joyce CW, Carroll SM. Microsurgery: the top 50 classic papers in plastic surgery: a citation analysis. *Arch Plast Surg.* 2014; 41(2):153–157. [PubMed: 24665424]
17. Zhang W-J, Ding W, Jiang H, Zhang Y-F, Zhang J-L. National representation in the plastic and reconstructive surgery literature: a bibliometric analysis of highly cited journals. *Ann Plast Surg.* 2013; 70(2):231–234. [PubMed: 22156891]
18. Zhang W-J, Zhang J-L, Jiang H. Growing trend of China's contribution to the field of plastic and reconstructive surgery: a 10-year study of the literature. *Ann Plast Surg.* 2012; 68(3):328–331. [PubMed: 21629091]
19. Sreekar H, Dawre S, Lamba S, Gupta AK. Trend of India's Contribution to the Field of Plastic and Reconstructive Surgery. *Ann Plast Surg.* 2012; 69(2):223. [PubMed: 22772069]
20. Sinno H, Neel OF, Lutfy J, Bartlett G, Gilardino M. Level of evidence in plastic surgery research. *Plast Reconstr Surg.* 2011; 127(2):974–980. [PubMed: 21285804]
21. Becker A, Blümle A, Momeni A. Evidence-based Plastic and Reconstructive Surgery: developments over two decades. *Plast Reconstr Surg.* 2013; 132(4):657e–663e.
22. McCarthy JE, Chatterjee A, McKelvey TG, Jantzen EMG, Kerrigan CL. A detailed analysis of level I evidence (randomized controlled trials and meta-analyses) in five plastic surgery journals to date: 1978 to 2009. *Plast Reconstr Surg.* 2010; 126(5):1774–1778. [PubMed: 21042137]
23. Agha RA, Camm CF, Doganay E, Edison E, Siddiqui MR, Orgill DP. Randomised controlled trials in plastic surgery: a systematic review of reporting quality. *Eur J Plast Surg.* 2014; 37:55–62. [PubMed: 24707112]
24. Xu CC, Côté DWJ, Chowdhury RH, Morrissey AT, Ansari K. Trends in level of evidence in facial plastic surgery research. *Plast Reconstr Surg.* 2011; 127(4):1499–1504. [PubMed: 21187806]
25. Allen RJ, Treece P. Deep inferior epigastric perforator flap for breast reconstruction. *Ann Plast Surg.* 1994; 32(1):32–38. [PubMed: 8141534]
26. Wang Y, Kotsis SV, Chung KC. Applying the concepts of innovation strategies to plastic surgery. *Plast Reconstr Surg.* 2013; 132(2):483–490. [PubMed: 23897344]
27. Pien I, Caccavale S, Cheung MC, et al. Evolving Trends in Autologous Breast Reconstruction: Is the Deep Inferior Epigastric Artery Perforator Flap Taking Over? *Ann Plast Surg.* 2014; doi: 10.1097/SAP.0000000000000339
28. Bonde CT, Christensen DE, Elberg JJ. Ten years' experience of free flaps for breast reconstruction in a Danish microsurgical centre: an audit. *Scand J Plast Reconstr Surg Hand Surg.* 2006; 40(1):8–12. [PubMed: 16428207]
29. Atherton DD, Hills AJ, Moradi P, Muirhead N, Wood SH. The economic viability of breast reconstruction in the UK: comparison of a single surgeon's experience of implant; LD; TRAM and DIEP based reconstructions in 274 patients. *J Plast Reconstr Aesthet Surg.* 2011; 64(6):710–715. [PubMed: 21112263]
30. Acosta R, Smit JM, Audolfsson T, et al. A clinical review of 9 years of free perforator flap breast reconstructions: an analysis of 675 flaps and the influence of new techniques on clinical practice. *J Reconstr Microsurg.* 2011; 27(2):91–98. [PubMed: 21046538]

31. Mohan AT, Al-Ajam Y, Mosahebi A. Trends in tertiary breast reconstruction: literature review and single centre experience. *Breast*. 2013; 22(2):173–178. [PubMed: 22795362]
32. Seglen PO. Why the impact factor of journals should not be used for evaluating research. *BMJ*. 1997; 314(7079):498–502. [PubMed: 9056804]

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Fig. 1.

The blue line marked with squares denotes the volume of research published. A total of 706 articles on microsurgery of the female breast were published by the top 10 plastic surgery journals over 1993 to 2013, with a significant increase over time of 4.4 ± 0.53 articles per year ($p < 0.001$, $R^2 = 0.78$). The red line marked with circles depicts productivity index over time, which was defined as the number of articles published in a given year multiplied by the each impact factor of each article's publishing journal. Productivity index also demonstrated a significant increase of 10.7 ± 1.6 per year ($p < 0.001$, $R^2 = 0.70$). Dotted lines represent respective best-fit linear regression slopes.

Fig. 2.

Total number of articles on microsurgery of the breast published in the top 10 plastic surgery journals between 1993 and 2013, for years when impact factor data for individual journals was available.

Fig. 3.

The average impact factor for the top 10 plastic surgery journals rose significantly ($p < 0.001$, $R^2 = 0.90$) over the 21-year study period, with an increase of 0.05 ± 0.003 per year. Dotted line represents best-fit linear regression slope.

Breast Microsurgery Publications per Geographic Region

Fig. 4.

Global distribution of research on breast microsurgery from 1993 to 2013. The United States produced the most articles with 336.5 (47.7%), followed by Western Europe with 242.2 (34.4%), Oceania with 40.6 (5.8%), Asia with 36.4 (5.2%), Canada with 26.3 (3.7%), Japan with 10.0 (1.4%), Eastern Europe with 6.4 (0.90%), Latin America with 5.3 (0.75%), and Africa with 1.3 (0.18%).

Study Design of Breast Microsurgery Publications

Fig. 5. Study design of research published between 1993 and 2013 on microsurgery of the female breast. A total of 63 (8.9%) basic science articles and 643 (91.1%) clinical research articles were published in this time frame.

Level of Evidence in Breast Microsurgery Publications

Fig. 6.

Level of evidence in breast microsurgery published in the top 10 plastic surgery journals between 1993 and 2013. Over this 21-year period, there were 1 level I (0.14%), 33 level II (4.7%), 138 level III (19.5%), 254 level IV (40.0%), and 207 level V (29.3%) articles published.

Fig. 7.

Level of evidence in published breast microsurgery research by geographic region. The United States produced the highest proportion of levels III to V research with 59.6, 51.8, and 41.2% of all articles at each level, respectively. Western Europe produced the greatest proportion of level II research with 42.9% of all level II articles.

Productivity Index in Breast Microsurgery by Geographic Region

Fig. 8.

Changes in breast microsurgery research productivity between geographic regions over 1993 to 2013. Productivity share was defined as the productivity index of a region over a 5-year period, divided by total world productivity index in that same period. This was measured over 17 consecutive overlapping 5-year periods to provide data on temporal trends. The United States maintained the greatest productivity share over the 21-year period; however, it experienced the greatest decrease in productivity share with an overall -1.23 ± 0.31 drop in 5-year productivity over 1993 to 2013 ($p < 0.01$, $R^2 = 0.5$). Western Europe contributed demonstrated the greatest increase in productivity with a 0.51 ± 0.29 growth in 5-year productivity over 21 years ($p = 0.09$, $R^2 = 0.17$).

Fig. 9.

The breast microsurgery database was queried for all common autologous flaps. The TRAM flap was the most researched flap until 2002, when overtaken by DIEP research in every subsequent year except 2005. “Gracilis NOS” represents gracilis flaps not otherwise specified (excluding TUG and DUG flaps). DIEP, deep inferior epigastric perforator; DUG, diagonal upper gracilis; TRAM, transverse rectus abdominis muscle; TUG, transverse upper gracilis.

Fig. 10.

Between regions, the United States published the most TRAM research with 29.6 articles (65.3% of TRAM research), while Western Europe predominated in DIEP research with 45.3 articles (59.6% of DIEP research). DIEP, deep inferior epigastric perforator; TRAM, transverse rectus abdominis muscle

Fig. 11.

Level of evidence in breast microsurgery research between 1993 and 2013. The total number of levels II to V articles increased significantly over the study period ($p < 0.001$, $R^2 = 0.6$, 0.8, 0.7, and 0.5, respectively). Interestingly, the number of levels II to IV articles decreased beginning in 2011 accompanied by an increase in level V articles. Many journals instituted policies requiring authors to self-assign LOEs in 2011. Basic science research is not represented in this graph, as LOE classification does not currently apply to basic science research. LOE, level of evidence.

Fig. 12.

Contributions to overall breast microsurgery productivity index by each geographic region from 1993 to 2013. Productivity index was defined as total number of articles published per region multiplied by the impact factor of that article's journal.