Autologous Breast Reconstruction with Transverse Rectus Abdominis Musculocutaneous (TRAM) or Deep Inferior Epigastric Perforator (DIEP) Flaps: An Analysis of the 100 Most Cited Articles

Post-mastectomy autologous reconstruction with abdominal tissue has evolved over the past 4 decades and is a common reconstructive modality today. To gain more insight into this evolution, we performed an analysis of the 100 most commonly cited articles focusing on autologous breast reconstruction with transverse rectus abdominis musculocutaneous (TRAM) or deep inferior epigastric perforator (DIEP) flaps. A review of the ISI Web of Knowledge database was performed. Only peer-reviewed articles in English were included for analysis. Articles were ranked by their total citations as well as citation density (citations divided by years since publication). The 100 most cited articles were analyzed by their bibliographic parameters. The 100 most cited articles were published in 12 journals. The highest ranked plastic surgery journal published almost 2/3 of the articles. All articles were published within 23 years and marked the “rising age” of autologous breast reconstruction with TRAM and DIEP flaps. The focus of clinical research changed over this time period and ranged from innovations in surgical technique to analysis of clinical outcomes, comparative analyses with other reconstructive modalities, timing of reconstruction, and preoperative diagnostic workup, as well as cost-effectiveness analyses. This literature review illustrates the dramatic change that has occurred subsequent to introduction of abdominal flaps for breast reconstruction. While the use of abdominal flaps has become widely accepted for breast reconstruction, many questions remain unanswered, thus highlighting the need for ongoing clinical investigation.
Background

Breast cancer remains the leading cancer entity in women and is the second most common cancer worldwide [1–4]. The American Cancer Society estimates there were >260 000 new cases of invasive breast cancer in 2018 in the United States alone [5]. Despite significant therapeutic advances, mastectomy remains a cornerstone of breast cancer treatment [6]. Additionally, increased breast cancer awareness, as well as the use of genetic testing, has resulted in an increase in the number of women seeking prophylactic mastectomy [7,8]. The negative impact of mastectomy on physical and psychological well-being is beyond dispute, and numerous studies have demonstrated the benefit of post-mastectomy reconstruction [9–11]. In particular, the high long-term patient satisfaction associated with autologous reconstruction is noteworthy [10].

For decades, the pedicled latissimus dorsi flap described by Tansini (1906) and rediscovered by Olivari (1976) was a common approach for autologous breast reconstruction [12–14]. The abdomen as a tissue source was first described by Holmstroem, who reported his experience with the free transverse rectus abdominis musculocutaneous (TRAM) flap in 1979 [15]. Interestingly, it was not until Hartnampf et al. described the pedicled TRAM flap in 1982 that the abdomen became the preferred donor site for autologous breast reconstruction [16]. The ability to harvest the abdominal soft tissues in a muscle-preserving fashion, as initially reported by Koshima and Sueda, ushered in the era of perforator flap-based breast reconstruction that was championed and popularized by Allen et al. and Blondeel et al. [17–19]. Progressive experience with this reconstructive modality has resulted in the autologous breast reconstruction now widely performed, even in the elderly population, as well as extremes of body weight [20, 21].

In light of the prevalence of autologous breast reconstruction, we felt it prudent to reflect on the landmark articles that have shaped contemporary breast reconstruction.

Material and Methods

Assuming a correlation between the importance of an article and its number of citations, we sought to identify the 100 most cited peer-reviewed articles on autologous breast reconstruction with TRAM or DIEP flaps. We queried the ISI Web of Knowledge database (v5.21.1, Thomson Reuters, New York, USA) with the period of interest ranging from January 1979 to December 2015. The following keywords were utilized: “breast reconstruction TRAM flap” OR “breast reconstruction transverse rectus abdominis muscle flap” OR “breast reconstruction DIEP flap” OR “breast reconstruction deep inferior epigastric perforator flap”. The search was performed in July 2016 and was limited to articles in English. Following a preliminary review of titles and abstracts by 2 independent reviewers, articles meeting inclusion criteria underwent a full-text review. Discrepancies were resolved by consensus. Included articles were then ranked based on the number of citations.

A ranking of the 100 most cited articles was generated. If 2 articles had an identical citation count, the articles were ranked by their citation density (citations per year since publication). Additional parameters retrieved included the title, journal, publication year, number of authors and country of origin (of the first author), total number of citations as well as the citation density (citations per year since publication). Papers were additionally categorized according to the type of study (multi-center vs. single-center, prospective vs. retrospective, review, case report, experimental study) and clinical focus. Graphs were generated using Excel (Microsoft Corp., 2016).

Results

The initial search retrieved a total of 1984 articles, of which 1910 were in English. Table 1 demonstrates the 100 most cited articles on autologous breast reconstruction with TRAM and/or DIEP flaps. These were published in 12 different journals. However, substantial heterogeneity was noted, as 68 of the 100 articles were published in Plastic and Reconstructive Surgery, followed by 8 articles in Annals of Plastic Surgery. The remaining 24 articles were distributed across the 10 journals (Figure 1).

The most frequently cited (512 total citations) paper was published in 1994 by Allen and Treece, describing the surgical technique of DIEP flaps [17]. The oldest paper was published in 1989 with 200 total citations and compared conventional to free TRAM flap for immediate breast reconstruction [22]. The most recent paper in our ranking was published in 2012 with 56 citations and described lower abdominal flap breast reconstruction with simultaneous lymph node transfer for management of post-mastectomy lymphedema [23] (Figure 2). The largest number of articles (10 articles) in our ranking was published in the year 2000 [24–33] (Figure 2). Moreover, these articles were increasingly cited until cumulative citations reached a peak of 1107 citations per year by 2010 (99 out of 100 articles) (Figure 3).

To account for the fact that more recently published articles had less time to be cited, we calculated the citation density (citations divided by years since publication) in addition to the absolute number of citations (Table 1). Interestingly, the effect of the contribution by Allen and Treece is evidenced by the fact that their article remains at the top of the list, even after incorporation of the citation density data. Their article
Table 1. The 100 most cited articles regarding to autologous breast reconstruction with TRAM or DIEP flaps.

| RTC | RCD | Article                                                                 | Authors                   | Journal (IF)                  | PY  | TC  | CD  | Further article information                                                                                                                                                                                                 |
|-----|-----|------------------------------------------------------------------------|---------------------------|-------------------------------|-----|-----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | 1   | Deep inferior epigastric perforator flap for breast reconstruction    | Allen RJ et al.           | Ann Plas Surg (1.536)         | 1994| 512 | 24.38| 15 DIEP, diverse amount of perforators                                                                                                                                                                                      |
| 2   | 4   | A prospective study of microvascular free-flap surgery and outcome    | Khouri RK et al.          | Plast Reconstr Surg (3.621)   | 1998| 329 | 19.35| 493 free flaps including 118 TRAM (rest other free flaps), prospective, 23 centers during 6 month period, 60 variables recorded                                                                                                                                               |
| 3   | 7   | One hundred free DIEP flap breast reconstructions: A personal experience| Blondeel PN               | Brit J Plast Surg (1.95)      | 1999| 282 | 17.63| 100 DIEP in 87 patients, single center                                                                                                                                                                                        |
| 4   | 2   | A prospective study of microvascular free-flap surgery and outcome    | Gill PS et al.            | Plast Reconstr Surg (3.621)   | 2004| 245 | 22.27| 758 DIEP, retrospective 10 years                                                                                                                                                                                              |
| 5   | 6   | Breast reconstruction with the free TRAM or DIEP flap: Patient selection, choice of flap, and outcome | Nahabedian MY et al.     | Plast Reconstr Surg (3.621)   | 2002| 239 | 18.38| 143 free TRAM and 20 DIEP, retrospective, single surgeon                                                                                                                                                                      |
| 6   | 8   | Complications in postmastectomy breast reconstruction: Two-year results of the Michigan breast reconstruction outcome study | Alderman AK et al.       | Plast Reconstr Surg (3.621)   | 2002| 219 | 16.85| Expander/implant vs. pedicled TRAM vs. free TRAM in 326 patients, “Michigan Breast reconstruction outcome study”, prospective cohort, 12 centers/23 surgeons, evaluation 2 years after operation, multiple variables recorded, immediate vs. delayed breast reconstruction |
| 7   | 49  | Conventional TRAM flap versus free microsurgical TRAM flap for immediate breast reconstruction | Grotting JC et al.       | Plast Reconstr Surg (3.621)   | 1989| 200 | 7.69 | 135 breast reconstructions, 44 pedicled TRAM, 10 free TRAM, immediate vs. delayed reconstruction                                                                                                                                 |
| 8   | 31  | Choice of flap and incidence of free flap success                      | Kroll SS et al.          | Plast Reconstr Surg (3.621)   | 1996| 197 | 10.37| 854 free flaps including 315 free TRAM, single center                                                                                                                                                                      |
| 9   | 16  | Determinants of patient satisfaction in postmastectomy breast reconstruction | Alderman AK et al.      | Plast Reconstr Surg (3.621)   | 2000| 186 | 12.40| expander/implant vs. pedicled TRAM vs. free TRAM, 212 included patient questionnaires, “Michigan Breast reconstruction outcome study”, prospective cohort, 12 centers/23 surgeons, evaluation 1 years after operation, immediate vs. delayed breast reconstruction |
| 10  | 26  | Doppler flowmetry in the planning of perforator flaps                  | Blondeel PN et al.       | Brit J Plast Surg (1.95)      | 1998| 186 | 10.94| color Duplex scanning in SO DIEP flap patients, evaluated for sensitivity and positive predictive value, also 2 further flaps types                                                                                                                                 |
| 11  | 13  | Comparison of immediate and delayed free TRAM flap breast reconstruction in patients receiving postmastectomy radiation therapy | Tran NV et al.           | Plast Reconstr Surg (3.621)   | 2001| 184 | 13.14| 102 free TRAM, retrospective, single center, TRAM before radiation vs. radiation before TRAM                                                                                                                                 |

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]
### Table 1 continued. The 100 most cited articles regarding to autologous breast reconstruction with TRAM or DIEP flaps.

| RTC | RCD | Article                                                                 | Authors              | Journal (IF)            | PY  | TC  | CD  | Further article information                                                                 |
|-----|-----|-------------------------------------------------------------------------|----------------------|-------------------------|-----|-----|-----|-------------------------------------------------------------------------------------------|
| 12  | 18  | Fat necrosis in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps | Kroll SS             | Plast Reconstr Surg (3.621) | 2000| 181 | 12.07| 310 free TRAM and DIEP, single surgeon                                                        |
| 13  | 3   | Multidetector-row computed tomography in the planning of abdominal perforator flaps | Masia J et al.      | J Plast Reconstr Aes (2.158) | 2006| 179 | 19.89| 56 expander/implant vs. 128 pedicled TRAM vs. 66 free TRAM, evaluation of CT angiography prior to operation, single center |
| 14  | 20  | Prospective analysis of psychosocial outcomes in breast reconstruction: One-year postoperative results from the Michigan Breast Reconstruction Outcome Study | Wilkins EG et al.   | Plast Reconstr Surg (3.621) | 2000| 174 | 11.60| 66 patients with DIEP, evaluation of CT angiography prior to operation, single center |
| 15  | 21  | Effect of smoking on complications in patients undergoing free TRAM flap breast reconstruction | Chang DW et al.     | Plast Reconstr Surg (3.621) | 2000| 174 | 11.60| 936 free TRAM in 718 patients, non-smoker vs. former smoker stopped at least 4 weeks before surgery vs. smoker, single center, retrospective |
| 16  | 24  | Venous congestion and blood flow in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps | Blondeel PN et al.  | Plast Reconstr Surg (3.621) | 2000| 167 | 11.13| 271 free TRAM and 240 DIEP, two centers, retrospective |
| 17  | 55  | A comparison of outcomes using three different methods of breast reconstruction | Kroll SS et al.     | Plast Reconstr Surg (3.621) | 1992| 166 | 7.22 | 161 free TRAM vs. 39 Latissimus dorsi flap vs. 87 expansion/implants, single surgeon, outcome: symmetry/shape/ptosis/scarring |
| 18  | 50  | Refinements in free flap breast reconstruction: the free bilateral deep inferior epigastric perforator flap anastomosed to the internal mammary artery | Blondeel PN et al.  | Brit J Plast Surg (1.95)  | 1994| 161 | 7.67 | 18 patients with unilateral DIEP vs. 20 free TRAM vs. 20 non-operated controls, abdominal wall stability, follow-up 1 year, single surgeon |
| 19  | 41  | The donor site morbidity of free DIEP flaps and free TRAM flaps for breast reconstruction. | Blondeel N et al.   | Brit J Plast Surg (1.95)  | 1997| 157 | 8.72 | 936 free TRAM in 718 patients, normal weight vs. overweight vs. obese, single center, retrospective |
| 20  | 33  | Effect of obesity on flap and donor-site complications in free transverse rectus abdominis myocutaneous flap breast reconstruction | Chang DW et al.     | Plast Reconstr Surg (3.621) | 2000| 154 | 10.27| 50 DIEP in 42 patients, immediate vs. delayed, abdominal wall stability follow-up of 20 patients, single center |
| 21  | 38  | Deep inferior epigastric perforator flap in breast reconstruction: Experience with the first 50 flaps | Hamdi M et al.      | Plast Reconstr Surg (3.621) | 1999| 146 | 9.13 | 168 free TRAM vs. 100 pedicled TRAM, single-pedicled vs. double-pedicled, mesh vs. no mesh, at least 6 months follow-up, single center |
| 22  | 53  | Abdominal wall strength, bulging, and hernia after TRAM flap breast reconstruction | Kroll SS et al.     | Plast Reconstr Surg (3.621) | 1995| 145 | 7.25 | 168 free TRAM vs. 100 pedicled TRAM, single-pedicled vs. double-pedicled, mesh vs. no mesh, at least 6 months follow-up, single center |
Table 1 continued. The 100 most cited articles regarding to autologous breast reconstruction with TRAM or DIEP flaps.

| RTC | RCD | Article                                                                 | Authors                  | Journal (IF)                  | PY | TC | CD  | Further article information                                                                 |
|-----|-----|-------------------------------------------------------------------------|--------------------------|-------------------------------|----|----|-----|---------------------------------------------------------------------------------------------|
| 23  | 36  | A retrospective comparison of abdominal muscle strength following breast reconstruction with a free TRAM or DIEP flap | Futter CM et al.         | Brit J Plast Surg (1.93)      | 2000 | 143 | 9.53 | 27 free TRAM vs. 23 DIEP vs. 32 non-operated controls, assessment of abdominal and back extensor muscle strength isokinetic dynamometer and questionnaires. |
| 24  | 56  | Reconstruction and the radiated breast: Is there a role for implants?  | Evans GRD et al.         | Plast Reconstr Surg (3.621)   | 1995 | 142 | 7.10 | inter alia 4 implants beneath TRAM vs. 16 TRAM vs. Latissimus dorsi flaps vs. prosthesis only, single center |
| 25  | 57  | TRAM flap anatomy correlated with a 10-year clinical experience with 556 patients | Watterson PA et al.      | Plast Reconstr Surg (3.621)   | 1995 | 140 | 7.00 | 556 TRAM, unipedicled vs. bipedicled, single center, risk factors and complications.         |
| 26  | 11  | Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: Is there a difference? | Nahabedian MY et al.     | Plast Reconstr Surg (3.621)   | 2005 | 137 | 13.70 | unilateral vs. bilateral, evaluation of risk factors and complications.                      |
| 27  | 58  | The free transverse rectus abdominis musculocutaneous flap for breast reconstruction: One center’s experience with 211 consecutive cases | Schusterman MA et al.    | Ann Plas Surg (1.536)         | 1994 | 137 | 6.52 | 211 free TRAM in 163 patients, complications.                                              |
| 28  | 72  | Complications of TRAM flap breast reconstruction in obese patients      | Kroll SS et al.          | Plast Reconstr Surg (3.621)   | 1989 | 134 | 5.15 | 82 unilateral TRAM, patients grouped by BMI, evaluation of aesthetic outcome and complication rate, single center. |
| 29  | 29  | Perforator flaps: Evolution, classification, and applications           | Geddes CR et al.         | Ann Plas Surg (1.536)         | 2003 | 126 | 10.50 | review of perforator flaps including TRAM and DIEP.                                         |
| 30  | 70  | Immediate TRAM flap breast reconstruction: 128 consecutive cases        | Elliott LF et al.        | Plast Reconstr Surg (3.621)   | 1993 | 123 | 5.59 | 89 free TRAM and 88 DIEP, 128 TRAM (86 pedicled, 40 free, 2 “supercharged” TRAM), immediate reconstruction, bilateral and unilateral. |
| 31  | 73  | Abdominal wall function after rectus abdominis transfer                | Lejour M et al.          | Plast Reconstr Surg (3.621)   | 1991 | 123 | 5.13 | 57 TRAM, delayed, up to 2 years follow-up, evaluation by clinical examination, questionnaire, physiotherapist, computer tomography. |
| 32  | 27  | Delayed-immediate breast reconstruction                                 | Kronowitz SJ et al.      | Plast Reconstr Surg (3.621)   | 2004 | 119 | 10.82 | 16 patients, 6 free TRAM vs. other techniques, single center.                              |
| 33  | 14  | Preoperative planning of deep inferior epigastric artery perforator flap reconstruction with multislice-CT angiography: Imaging findings and initial experience | Alonso-Burgos A et al.  | J Plast Reconstr Aes (2.158) | 2006 | 117 | 13.00 | 6 DIEP, evaluation of pre-operative computer tomography angiography, single center.         |
| 34  | 74  | Comparison of strategies for preventing abdominal wall weakness after TRAM flap breast reconstruction | Kroll SS et al.          | Plast Reconstr Surg (3.621)   | 1992 | 117 | 5.09 | 130 pedicled TRAM, single center, mean follow-up 18 months.                                |
| 35  | 51  | Postoperative adjuvant irradiation: Effects on transverse rectus abdominis muscle flap breast reconstruction | Tran NV et al.           | Plast Reconstr Surg (3.621)   | 2000 | 115 | 7.67 | 32 free TRAM vs. 9 pedicled TRAM, average of 50.99 Gy within 6 months after breast reconstruction. |
| RTC | RCD | Article | Authors | Journal (IF) | PY | TC | CD | Further article information |
|-----|-----|---------|---------|-------------|----|----|----|----------------------------|
| 36  | 77  | Immediate breast reconstruction: why the free TRAM over the conventional TRAM flap? | Schusterman MA et al. | Plast Reconstr Surg (3.621) | 1992 | 114 | 4.96 | 20 free TRAM vs. 48 pedicled TRAM, single center |
| 37  | 43  | Radiation effects on breast reconstruction with the deep inferior epigastric perforator flap | Rogers NE et al. | Plast Reconstr Surg (3.621) | 2002 | 112 | 8.62 | 30 DIEP with radiation after surgery vs. 30 non-radiated DIEP, single center, analysis of structural and aesthetic outcome |
| 38  | 44  | Contour abnormalities of the abdomen after breast reconstruction with abdominal flaps: The role of muscle preservation | Nahabedian MY et al. | Plast Reconstr Surg (3.621) | 2002 | 112 | 8.62 | 108 free TRAM vs. 37 pedicled TRAM vs. 10 DIEP, single center |
| 39  | 17  | DIEP and pedicled TRAM flaps: A comparison of outcomes | Garvey PB et al. | Plast Reconstr Surg (3.621) | 2006 | 111 | 12.33 | 94 pedicled TRAM vs. 96 DIEP, single center, comparison of multiple parameters |
| 40  | 19  | Perfusion zones of the DIEP flap revisited: A clinical study | Holm C et al. | Plast Reconstr Surg (3.621) | 2006 | 108 | 12.00 | 15 DIEP, single center, laser-induced fluorescence of indocyanine green |
| 41  | 67  | The effects of radiation treatment after TRAM flap breast reconstruction | Williams JK et al. | Plast Reconstr Surg (3.621) | 1997 | 103 | 5.72 | 608 pedicled TRAM (19 radiation after reconstruction vs. 108 prior radiation vs. 572 non-radiated), single center, retrospective |
| 42  | 10  | Breast reconstruction after surgery for breast cancer | Cordeiro PG | New Engl J Med (79.258) | 2008 | 102 | 14.57 | Review of breast reconstruction techniques |
| 43  | 79  | Breast reconstruction with myocutaneous flaps in previously irradiated patients | Kroll SS et al. | Plast Reconstr Surg (3.621) | 1994 | 100 | 4.76 | 66 TRAM (after radiation) vs. 16 Latissimus dorsi (after radiation) vs. 158 TRAM (non-radiated) vs. 44 Latissimus dorsi (non-radiated), single center |
| 44  | 84  | Experience with 50 free TRAM flap breast reconstructions | Amez ZM et al. | Plast Reconstr Surg (3.621) | 1991 | 100 | 4.17 | 50 free TRAM, patient’s data analyzed, risk factors and complications |
| 45  | 65  | Fat necrosis in free and pedicled TRAM flaps | Kroll SS et al. | Plast Reconstr Surg (3.621) | 1998 | 99 | 5.82 | 49 free TRAM vs. 67 pedicled TRAM, single center, examination clinically and mammographically |
| 46  | 80  | Assessment of the abdominal wall after pedicled TRAM flap surgery: 5- to 7-year follow-up of 150 consecutive patients | Mizgala CL et al. | Plast Reconstr Surg (3.621) | 1994 | 99 | 4.71 | 135 patients (98.5%) returned questionnaire 5–7.5 years postoperatively, 132 patients with clinical examination (68 single pedicled, 63 double rectus harvest, 4 single pedicled with contralateral microvascular augmentation) |
| 47  | 68  | A comparison of resource costs of immediate and delayed breast reconstruction | Khoo A et al. | Plast Reconstr Surg (3.621) | 1998 | 97 | 5.71 | 194 TRAM vs. 82 implant reconstructions, immediate vs. delayed, single center |
| 48  | 12  | Preoperative imaging for DIEA perforator flaps: A comparative study of computed tomographic angiography and Doppler ultrasound | Rozen WM et al. | Plast Reconstr Surg (3.621) | 2008 | 94 | 13.43 | 8 DIEP patients, preoperative computer tomography angiography and Doppler ultrasound, single center |

Table 1 continued. The 100 most cited articles regarding to autologous breast reconstruction with TRAM or DIEP flaps.
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| RTC | RCD | Article                                                                 | Authors              | Journal (IF)          | PY  | TC | CD | Further article information                                                                 |
|-----|-----|-------------------------------------------------------------------------|----------------------|-----------------------|-----|----|----|---------------------------------------------------------------------------------------------|
| 49  | 30  | Complications after microvascular breast reconstruction: Experience with 1195 flaps | Mehrara BJ et al.    | Plast Reconstr Surg (3.621) | 2006 | 94 | 10.44 | 1195 breast reconstructions in 952 patients (978 TRAM and 217 other flaps), single center (11-year period), retrospective, risk factors and complications |
| 50  | 37  | The effect of radiation on pedicled TRAM flap breast reconstruction: Outcomes and implications | Spear SL et al.      | Plast Reconstr Surg (3.621) | 2005 | 93 | 9.30  | 171 pedicled TRAM in 150 patients (91 TRAM only, 42 radiation pre-TRAM, 38 radiation post-TRAM), risk factors and complications, single center |
| 51  | 34  | Comparison of donor-site complications and functional outcomes in free muscle-sparing TRAM flap and free DIEP flap breast reconstruction | Bajaj AK et al.      | Plast Reconstr Surg (3.621) | 2006 | 91 | 10.11 | 124 free TRAM vs. 35 DIEP, unilateral vs. bilateral, single center, 99 patients with questionnaire |
| 52  | 48  | Breast reconstruction with superficial inferior epigastric artery flaps: A prospective comparison with TRAM and DIEP flaps | Chevray PM           | Plast Reconstr Surg (3.621) | 2004 | 89 | 8.09  | 12 SIEA (superficial inferior epigastric artery flap) vs. 21 TRAM vs. 7 DIEP, single center, prospective |
| 53  | 63  | A prospective and randomized study, SVEA, comparing effects of three methods for delayed breast reconstruction on quality of life, patient-defined problem areas of life, and cosmetic result | Brandberg Y et al.   | Plast Reconstr Surg (3.621) | 2000 | 88 | 5.87  | 29 pedicled TRAM vs. 30 Latissimus dorsi vs. 16 lateral thoracodorsal flap, randomized, “SVEA” study |
| 54  | 76  | A comparison of morbidity from bilateral, unipedicled and unilateral, unipedicled TRAM flap breast reconstructions | Paige KT et al.      | Plast Reconstr Surg (3.621) | 1998 | 86 | 5.06  | 257 pedicled TRAM (only unipedicled), single center, retrospective |
| 55  | 87  | Prospective evaluation of immediate reconstruction after mastectomy | Eberlein TJ et al.   | Ann Surg (9.203)          | 1993 | 86 | 3.91  | 101 TRAM vs. 71 implants vs. 23 tissue expander vs. 21 Latissimus dorsi, only immediate reconstruction, single center |
| 56  | 60  | Postoperative morphine requirements of free TRAM and DIEP flaps | Kroll SS et al.      | Plast Reconstr Surg (3.621) | 2001 | 84 | 6.00  | 132 free TRAM vs. 26 DIEP, single center, retrospective |
| 57  | 85  | A comparison of factors affecting aesthetic outcomes of TRAM flap breast reconstructions | Kroll SS et al.      | Plast Reconstr Surg (3.621) | 1995 | 83 | 4.15  | 68 free TRAM vs. 169 pedicled TRAM, single center, unilateral vs. bilateral, immediate vs. delayed |
| 58  | 64  | Complications of postmastectomy breast reconstructions in smokers, ex-smokers, and non-smokers | Padubidri AN et al.  | Plast Reconstr Surg (3.621) | 2001 | 82 | 5.86  | 263 TRAM vs. 4 Latissimus dorsi vs. 11 implants vs. 466 tissue expanders, 155 smokers vs. 76 ex-smokers vs. 517 non-smokers, single center, retrospective |
| 59  | 40  | Breast reconstruction with the deep inferior epigastric perforator flap: History and an update on current technique | Granzow JW et al.    | J Plast Reconstr Aes (2.158) | 2006 | 80 | 8.89  | Review of abdominal wall anatomy and DIEP technique |
### Table 1 continued. The 100 most cited articles regarding autologous breast reconstruction with TRAM or DIEP flaps.

| RTC | RCD | Article | Authors | Journal (IF) | PY | TC | CD | Further article information |
|-----|-----|---------|---------|--------------|----|----|----|--------------------------------|
| 60  | 9   | Patient Satisfaction in postmastectomy breast reconstruction: A comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques | Yueh JH et al. | Plast Reconstr Surg (3.621) | 2010 | 79 | 15.80 | 439 patients completed questionnaire, 117 DIEP vs. 119 pedicled TRAM vs. 87 tissue expander vs. 116 Latissimus dorsi (+/- implants), single center |
| 61  | 23  | Prospective analysis of long-term psychosocial outcomes in breast reconstruction: Two year postoperative results from the Michigan Breast Reconstruction Outcomes Study | Atisha D et al. | Ann Surg (9.203) | 2008 | 79 | 11.29 | 40 free TRAM vs. 91 pedicled TRAM vs. 42 expander/implant, immediate vs. delayed, “Michigan Breast Reconstruction Outcome Study”, multi-center, prospective |
| 62  | 86  | Comparison of resource costs between implant- based and TRAM flap breast reconstruction | Kroll SS et al. | Plast Reconstr Surg (3.621) | 1996 | 78 | 4.11 | 154 TRAM vs. 86 implants, only full reconstruction (including nipple), single center, retrospective |
| 63  | 25  | Does the preoperative imaging of perforators with CT angiography improve operative outcomes in breast reconstruction? | Rozen WM et al. | Microsurg (2.071) | 2008 | 77 | 11.00 | 88 patients with abdominal free flaps, 40 preoperative CTA vs. 48 without, comparing operation data, complications and surgeons stress levels during operation, single center |
| 64  | 15  | Patient-Reported aesthetic satisfaction with breast reconstruction during the long-term survivorship period | Hu ES et al. | Plast Reconstr Surg (3.621) | 2009 | 75 | 12.50 | 109 TRAM vs. 110 expander/implants, follow-up to >8 years post-reconstruction, single center, questionnaire |
| 65  | 66  | Radiotherapy and breast reconstruction: Complications and cosmesis with tram versus tissue expander/implant | Chawla AK et al. | Int J Radiat Oncol Biol Phys (4.967) | 2002 | 75 | 5.77 | 30 TRAM vs. 18 expander/implant, radiation prior or following reconstruction, single center, evaluation of complications and cosmetic outcome |
| 66  | 89  | Late results of breast reconstruction with free TRAM flaps: A prospective multicentric study | Banic A et al. | Plast Reconstr Surg (3.621) | 1995 | 75 | 3.75 | 123 free TRAM, unilateral vs. bilateral, evaluation of risk factors and complications, multi-center, prospective |
| 67  | 99  | Double-pedicled TRAM flap for unilateral breast reconstruction | Wagner DS et al. | Plast Reconstr Surg (3.621) | 1991 | 74 | 3.08 | 500 pedicled TRAM, only unilateral, unipedicled vs. bipedicled, single center |
| 68  | 59  | An outcome analysis comparing the thoracodorsal and internal mammary vessels as recipient sites for microvascular breast reconstruction: A prospective study of 100 patients | Moran SL et al. | Plast Reconstr Surg (3.621) | 2003 | 73 | 6.08 | 60 free TRAM, randomized recipient vessel, prospective, evaluation of risk factors and aesthetic outcome |
| 69  | 32  | Arterial and venous anatomies of the deep inferior epigastric perforator and superficial inferior epigastric artery flaps | Schaverien M et al. | Plast Reconstr Surg (3.621) | 2008 | 72 | 10.29 | 20 cadavers and 2 abdominoplastic specimens, experimental setting, computer tomography studies |
| 70  | 91  | TRAM flap vascular delay for high-risk breast reconstruction | Codner MA et al. | Plast Reconstr Surg (3.621) | 1995 | 72 | 3.60 | 30 bi-pedical TRAM in 23 high-risk patients, vascular delay by ligation 2 weeks prior to flap elevation |
Table 1 continued. The 100 most cited articles regarding to autologous breast reconstruction with TRAM or DIEP flaps.

| RTC | RCD | Article                                                                 | Authors                  | Journal (IF)              | PY  | TC  | CD  | Further article information                                                                 |
|-----|-----|-------------------------------------------------------------------------|--------------------------|---------------------------|-----|-----|-----|-------------------------------------------------------------------------------------------|
| 71  | 97  | Breast reconstruction in women treated with radiation therapy for breast cancer: cosmesis, complications, and tumor control | Schuster RH et al.       | Plast Reconstr Surg (3.621) | 1992 | 72  | 3.13 | 8 TRAM vs. 11 Latissimus dorsi plus implants vs. 1 gluteal artery flap vs. 39 expander/implant, every patient with mastectomy and radiation, single center |
| 72  | 75  | Clinical determinants of patient satisfaction with breast reconstruction | Andrade WN et al.       | Plast Reconstr Surg (3.621) | 2001 | 71  | 5.07 | 185 TRAM vs. 26 implant, groups: satisfied vs. unsatisfied, questionnaire and retrospective chart review, single center |
| 73  | 90  | Skin-sparing mastectomy with immediate breast reconstruction: The M D Anderson Cancer Center experience | Singletary SE            | Ann Surg Oncol (3.857)    | 1996 | 70  | 3.68 | single center review                                                                        |
| 74  | 94  | Color-flow duplex scanning in the preoperative assessment of TRAM flap perforators: a report of 32 consecutive patients | Rand RP et al.          | Plast Reconstr Surg (3.621) | 1994 | 70  | 3.33 | 32 free TRAM patients, preoperative color-flow duplex scanning, single center |
| 75  | 96  | The deep inferior epigastric artery free skin flap: Anatomic study and clinical application | Itoh Y et al.           | Plast Reconstr Surg (3.621) | 1993 | 70  | 3.18 | 17 cadavers, DIEP anatomic study and clinical applications                                 |
| 76  | 82  | Cost-based comparison between perforator flaps and TRAM flaps for breast reconstruction | Kaplan JL et al.       | Plast Reconstr Surg (3.621) | 2000 | 69  | 4.60 | 59 DIEP vs. 5 gluteal artery flaps vs. 154 TRAM, comparison of costs, single center, retrospective |
| 77  | 52  | Risk factors and complications in free TRAM flap breast reconstruction | Selber JC et al.        | Ann Plas Surg (1.536)     | 2006 | 68  | 7.56 | 500 free TRAM, risk factors and complications, single center, retrospective                |
| 78  | 69  | Recurrence following treatment of ductal carcinoma in situ with skin-sparing mastectomy and immediate breast reconstruction | Spiegel AJ et al.     | Plast Reconstr Surg (3.621) | 2003 | 68  | 5.67 | 138 TRAM vs. 75 implant, 8 Latissimus dorsi (with or without implant), retrospective, single center |
| 79  | 78  | Prospective evaluation of late cosmetic results following breast reconstruction: II. TRAM flap reconstruction | Clough KB et al.       | Plast Reconstr Surg (3.621) | 2001 | 68  | 4.86 | 171 TRAM, follow-up 8 years, complications and cosmetic outcome, prospective, single center |
| 80  | 92  | TRAM flap breast reconstruction after radiation treatment                 | Williams JK et al.     | Ann Surg (9.203)          | 1995 | 68  | 3.40 | 108 pedicled TRAM with radiation prior vs. 572 non-radiated patients with TRAM, unilateral vs. bilateral, unipedicled vs. bipedicled, single center, retrospective |
| 81  | 71  | Skin-sparing mastectomy with conservation of the nipple-areola complex and autologous reconstruction is an oncologically safe procedure | Gerber B et al.        | Ann Surg (9.203)          | 2003 | 67  | 5.58 | 55 TRAM in total and 67 Latissimus dorsi vs. 32 implants, local recurrence rates, single center, retrospective |
| 82  | 83  | Rational selection of flaps from the abdomen in breast reconstruction to reduce donor site morbidity | Amez ZM et al.         | Brit J Plast Surg (1.95)   | 1999 | 67  | 4.19 | 5 SIEA vs. 13 DIEP vs. 2 TRAM, complications, single center |

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]
Table 1 continued. The 100 most cited articles regarding autologous breast reconstruction with TRAM or DIEP flaps.

| RTC | RCD | Article                                                                 | Authors            | Journal (IF)          | PY | TC | CD | Further article information                                                                 |
|-----|-----|--------------------------------------------------------------------------|--------------------|-----------------------|----|----|----|---------------------------------------------------------------------------------------------|
| 83  | 93  | Postmastectomy reconstruction: comparative analysis of the psychosocial, functional, and cosmetic effects of transverse rectus abdominis musculocutaneous flap versus breast implant reconstruction | Cederna PS et al. | Ann Plas Surg (1.536) | 1995 | 67 | 3.35 | 8 TRAM patients vs. 14 implant patients, mastectomy and immediate or delayed reconstruction, questionnaire, single center |
| 84  | 47  | Microvascular complications of DIEP flaps                               | Tran NV et al.     | Plast Reconstr Surg (3.621) | 2007 | 65 | 8.13 | 100 DIEP in 74 patients, evaluation of microvascular complications, prospective, single center |
| 85  | 61  | Factors associated with anastomotic failure after microvascular reconstruction of the breast | Nahabedian MY et al. | Plast Reconstr Surg (3.621) | 2004 | 65 | 5.91 | 176 free TRAM vs. 58 DIEP vs. 6 SGAP, analysis of complications, single center                |
| 86  | 81  | An outcome study of breast reconstruction: Presurgical identification of risk factors for complications | Lin KY et al.      | Ann Surg Oncol (3.857) | 2001 | 65 | 4.64 | 14 free TRAM vs. 70 pedicled TRAM vs. 39 expander/implants, analysis of complications and risk factors, single center, retrospective |
| 87  | 88  | Donor-site morbidity after pedicled or free TRAM flap surgery: A prospective and objective study | Edsander-Nord A et al. | Plast Reconstr Surg (3.621) | 1998 | 65 | 3.82 | 19 free TRAM vs. 23 pedicled TRAM, questionnaire and evaluation of abdominal wall strength, prospective, single center |
| 88  | 98  | Free TRAM. Results and abdominal wall function                           | Feller AM          | Clin Plast Surg (1.68) | 1994 | 65 | 3.10 | 151 free TRAM                                                                                |
| 89  | 100 | The sensational transverse rectus abdominis musculocutaneous (TRAM) flap: Return of sensibility after TRAM breast reconstruction | Slezak S et al.   | Ann Plas Surg (1.536) | 1992 | 65 | 2.83 | 10 pedicled TRAM vs. 10 healthy volunteers, evaluation of sensibility, single center          |
| 90  | 28  | Abdominal wall following free TRAM or DIEP flap reconstruction: a meta-analysis and critical review | Man LX et al.      | Plast Reconstr Surg (3.621) | 2009 | 64 | 10.67 | Review of six studies (DIEP vs. free TRAM), outcome analysis                                 |
| 91  | 95  | Internal mammary vessels: Anatomical and clinical considerations         | Hefel L et al.     | Brit J Plast Surg (1.95) | 1995 | 64 | 3.20 | Investigating the anatomy of the internal mammary (thoracic) artery (IMA) and comitant vein(s) (IMV) relevant to their use in microsurgery, 86 cadavers dissected and Doppler ultrasound of 34 healthy female volunteers, single center |
| 92  | 39  | True incidence of all complications following immediate and delayed breast reconstruction | Sullivan SR et al. | Plast Reconstr Surg (3.621) | 2008 | 63 | 9.00 | 124 DIEP vs. 33 free TRAM vs. 22 pedicled Latiissimus dorsi vs. 142 expander/implant, immediate vs. delayed, single center, retrospective |
| 93  | 42  | The value of the multidetector row computed tomography for the preoperative planning of deep inferior epigastric artery perforator flap: Our experience in 162 cases | Masia J et al.   | Ann Plas Surg (1.536) | 2008 | 61 | 8.71 | 162 DIEP patients, preoperative computer tomography, single center, prospective               |
Abdominal wall CT angiography: A detailed account of a newly established preoperative imaging technique

Preoperative CT angiography reduces surgery time in perforator flap reconstruction

Risk factors for abdominal donor-site morbidity in free flap breast reconstruction

Skin-sparing mastectomy and immediate reconstruction is an acceptable treatment option for patients with high-risk breast carcinoma

Intraoperative perfusion mapping with laser-assisted indocyanine green imaging can predict and prevent complications in immediate breast reconstruction

A detailed account of a newly established preoperative imaging technique for planning free TRAM/DIEP

Preoperative computer tomography angiography vs. Doppler ultrasound, single center, retrospective

Analysis of abdominal donor-site morbidity, single center

38 TRAM vs. 3 Latissimus dorsi vs. 4 expander/implants, skin-sparing mastectomy and immediate reconstruction, single center, retrospective

6 DIEP/SIEA vs. 2 Latissimus dorsi vs. 16 expander/implants, immediate reconstruction after mastectomy, single center

319 free TRAM vs. 128 DIEP, analysis of abdominal donor-site morbidity, single center

A critical review of perioperative complications in 175 free deep inferior epigastric perforator flap breast reconstructions

9 modified lower abdominal reconstruction flap containing lymph nodes and lymphatic vessels surrounding the superficial circumflex vessel pedicle, single center

In the ISI Web of Knowledge data base the 100 most cited articles for autologous breast reconstruction with TRAM or DIEP flaps were searched. By analyzing the abstracts inclusion and exclusion was made. All articles are in English language and published in a peer-reviewed journal. Articles were ranked based on the total citations (RTC) and the citation density (citations per year since publication; RCD). RTC – rank total citations; RCD – rank citation density; PY – publication tear; TC – total citations; CD – citation density; IF – impact factor (most recent IF are listed for each journal). Ann Surg – Annals of Surgery; Ann Plas Surg – Annals of Plastic Surgery; Ann Surg Oncol – Annals of Surgical Oncology; Brit J Plast Surg – British Journal of Plastic Surgery; Clin Plast Surg – Clinics in Plastic Surgery; Int J Radiat Oncol – International Journal of Radiation Oncology Biology Physics; J Plast Reconstr Aes – Journal of Plastic Reconstrucive and Aesthetic Surgery; Microsurg – Microsurgery; New Engl J Med – New England Journal of Medicine; Plast Reconstr Surg – Plastic And Reconstructive Surgery.

Most articles were published by more than 2 authors, with the largest number of authors being 11 in an article published in 1994 [35]. Only 6 articles were published by a single author and 11 articles by 2 authors (Figure 5). A slight increase in the number of authors was noted as demonstrated by the mean number of authors being 4.81 from 1989 to 2000 versus 4.98 from 2001 to 2012.

Stephen S. Kroll was the first author of 11 articles in our ranking (Table 1). Furthermore, 36 articles were published by the
same leading author 2 or more times. The majority of studies were retrospective (71 articles). The remaining studies included 20 prospective studies, 1 case report, 3 experimental studies, and 5 reviews. The articles could be furthermore divided into 89 single-center and 7 multicenter studies.

Studies most commonly focused on indications for TRAM/DIEP flaps, postoperative complications, preoperative diagnostics, and perioperative risk factors. Sixty-two articles reported on peri-/postoperative complications and associated risk factors. Twenty-six articles particularly investigated the issue of donor site morbidity. While earlier studies evaluated advantages of DIEP flaps compared to free TRAM flaps [36] or free TRAM flaps compared to conventional TRAM flaps [37,38] with respect to effect on abdominal wall function, more recent studies focused on muscle-sparing TRAM and DIEP flaps [39,40]. These results suggest that contrary to free and conventional TRAM flaps, which lead to a higher rate of abdominal bulging or hernia, muscle-sparing...
Table 2. The 25 most cited articles regarding autologous breast reconstruction with TRAM or DIEP flaps ranked by citation density.

| RTC | RCD | Article | Authors | Journal (IF) | PY | TC | CD |
|-----|-----|---------|---------|-------------|----|----|----|
| 1   | 1   | Deep inferior epigastric perforator flap for breast reconstruction | Allen RJ et al. | Ann Plas Surg (1.536) | 1994 | 512 | 24.38 |
| 4   | 2   | A 10-year retrospective review of 758 DIEP flaps for breast reconstruction | Gill PS et al. | Plast Reconstr Surg (3.621) | 2004 | 245 | 22.77 |
| 13  | 3   | Multidetector-row computed tomography in the planning of abdominal perforator flaps | Masia J et al. | J Plast Reconstr Aes (2.158) | 2006 | 179 | 19.89 |
| 2   | 4   | A prospective study of microvascular free-flap surgery and outcome | Khouri RK et al. | Plast Reconstr Surg (3.621) | 1998 | 329 | 19.35 |
| 100 | 5   | Microvascular breast reconstruction and lymph node transfer for postmastectomy lymphedema patients | Saaristo AM et al. | Ann Surg (9.203) | 2012 | 56 | 18.67 |
| 5   | 6   | Breast reconstruction with the free TRAM or DIEP flap: Patient selection, choice of flap, and outcome | Nahabedian MY et al. | Plast Reconstr Surg (3.621) | 2002 | 239 | 18.38 |
| 3   | 7   | One hundred free DIEP flap breast reconstructions: A personal experience | Blondeel PN | Brit J Plast Surg (1.95) | 1999 | 282 | 17.63 |
| 6   | 8   | Complications in postmastectomy breast reconstruction: Two-year results of the Michigan breast reconstruction outcome study | Alderman AK et al. | Plast Reconstr Surg (3.621) | 2002 | 219 | 16.85 |
| 60  | 9   | Patient satisfaction in postmastectomy breast reconstruction: A comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques | Yueh JH et al. | Plast Reconstr Surg (3.621) | 2010 | 79 | 15.80 |
| 42  | 10  | Breast reconstruction after surgery for breast cancer | Cordeiro PG | New Engl J Med (79.258) | 2008 | 102 | 14.57 |
| 26  | 11  | Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: Is there a difference? | Nahabedian MY et al. | Plast Reconstr Surg (3.621) | 2005 | 137 | 13.70 |
| 48  | 12  | Preoperative imaging for DIEA perforator flaps: A comparative study of computed tomographic angiography and Doppler ultrasound | Rozen WM et al. | Plast Reconstr Surg (3.621) | 2008 | 94 | 13.43 |
| 11  | 13  | Comparison of immediate and delayed free TRAM flap breast reconstruction in patients receiving postmastectomy radiation therapy | Tran NV et al. | Plast Reconstr Surg (3.621) | 2001 | 184 | 13.14 |
| 33  | 14  | Preoperative planning of deep inferior epigastric artery perforator flap reconstruction with multislice-CT angiography: Imaging findings and initial experience | Alonso-Burgos A et al. | J Plast Reconstr Aes (2.158) | 2006 | 117 | 13.00 |
| 64  | 15  | Patient-reported aesthetic satisfaction with breast reconstruction during the long-term survivorship period | Hu ES et al. | Plast Reconstr Surg (3.621) | 2009 | 75 | 12.50 |
| 9   | 16  | Determinants of patient satisfaction in postmastectomy breast reconstruction | Alderman AK et al. | Plast Reconstr Surg (3.621) | 2000 | 186 | 12.40 |
| 39  | 17  | DIEP and pedicled TRAM flaps: A comparison of outcomes | Garvey PB et al. | Plast Reconstr Surg (3.621) | 2006 | 111 | 12.33 |
| 12  | 18  | Fat necrosis in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps | Kroll SS | Plast Reconstr Surg (3.621) | 2000 | 181 | 12.07 |
| 40  | 19  | Perfusion zones of the DIEP flap revisited: A clinical study | Holm C et al. | Plast Reconstr Surg (3.621) | 2006 | 108 | 12.00 |
| 14  | 20  | Prospective analysis of psychosocial outcomes in breast reconstruction: One-year postoperative results from the Michigan Breast Reconstruction Outcome Study | Wilkins EG et al. | Plast Reconstr Surg (3.621) | 2000 | 174 | 11.60 |
| 15  | 21  | Effect of smoking on complications in patients undergoing free TRAM flap breast reconstruction | Chang DW et al. | Plast Reconstr Surg (3.621) | 2000 | 174 | 11.60 |
| 98  | 22  | Intraoperative perfusion mapping with laser-assisted indocyanine green imaging can predict and prevent complications in immediate breast reconstruction | Komorowska-Tinek E et al. | Plast Reconstr Surg (3.621) | 2010 | 58 | 11.60 |
TRAM, and DIEP flaps are equivalent in terms of abdominal wall morbidity.

The most prevalent risk factors leading to complications such as flap necrosis, reoperation, or abdominal issues were radiation (16 articles), obesity (10 articles), and smoking (7 articles). DIEP and TRAM flaps were directly compared to each other in 10 articles, while they were compared to other autologous or alloplastic breast reconstruction techniques in 25 articles. Twenty articles included description of surgical technique, anatomical or experimental studies, or reported on flap success. Another important topic was immediate breast reconstruction (16 articles), which was associated with higher complications rates [41,42], lower resource costs [43], and superior aesthetic and psychosocial outcome compared to delayed procedures [37,44]. More recent studies emphasize the effect of breast reconstruction on

Table 2 continued. The 25 most cited articles regarding autologous breast reconstruction with TRAM or DIEP flaps ranked by citation density.

| RTC | RCD | Article | Authors | Journal (IF) | PY  | TC  | CD  |
|-----|-----|---------|---------|--------------|-----|-----|-----|
| 61  | 23  | Prospective analysis of long-term psychosocial outcomes in breast reconstruction: Two-year postoperative results from the Michigan Breast Reconstruction Outcomes Study | Atisha D et al. | Ann Surg (9.203) | 2008 | 79  | 11.29 |
| 16  | 24  | Venous congestion and blood flow in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps | Blondeel PN et al. | Plast Reconstr Surg (3.621) | 2000 | 167 | 11.13 |
| 63  | 25  | Does the preoperative imaging of perforators with CT angiography improve operative outcomes in breast reconstruction? | Rozen WM et al. | Microsurg (2.071) | 2008 | 77  | 11.00 |

RCD – rank citation density (citations per year since publication); RTC – rank total citations; PY – publication year; TC – total citations; CD – citation density; IF – impact factor (most recent IF are listed for each journal).

Figure 4. All ranked articles were analyzed for authors and official institutions they were published by as labeled in the ISI Web of Knowledge. All 100 articles in our ranking are shown. USA – United States of America; UK – United Kingdom.

Figure 5. We recorded all authors from the ISI Web of Knowledge database for every article in our ranking of the most cited articles for autologous breast reconstruction. Six articles were published by 1 author. In contrast, 1 article had a maximum of 11 authors.
quality of life and patient satisfaction (9 articles), imaging tools (10 articles), cosmetic outcome (2 articles), resource costs (3 articles), and recipient vessels (2 articles). Current imaging tools include preoperative CT angiography for identification of perforators (7 articles) and laser-assisted indocyanine green imaging for intraoperative perfusion mapping (1 article) (Table 1).

Discussion

Breast cancer is the leading cancer entity in female patients and has been the second most common cancer for decades [45,46]. The high incidence and prevalence of this disease entity is paralleled by an increasing awareness of reconstructive options after mastectomy. The increasing demand is further reflected by an increasing number of breast reconstructions being performed annually [47].

Although tremendous advances have also been made in the field of implant-based breast reconstruction, the focus of our analysis was on autologous breast reconstruction with abdominal tissue, specifically TRAM and DIEP flaps. Among the most commonly cited articles, study objectives included clinical outcomes data (specifically postoperative complication rates) [28–30,36,39,42], comparative analyses with other reconstructive techniques [10, 24, 42, 44, 48], and description of surgical techniques, including experimental and anatomical studies [17,18,23,29,35,49] (Table 1).

Due to recent microsurgical advances, breast reconstruction techniques have developed from a flap safety-based approach using pedicled or free TRAM flaps to more perforator-based flaps and super-microsurgery due to co-factors like donor-site morbidity [50] and lymphedema [23]. Furthermore, novel imaging technologies such as intraoperative perfusion mapping have increased the safety profile of the procedure and have allowed for more predictable results to be achieved [51]. While experimental (e.g., tissue-engineered) options for breast reconstruction have been theorized, they are not yet available for clinical application [52].

In the early period of autologous breast reconstruction with abdominal tissue, authors from the United States, Belgium, Sweden, and Japan were at the forefront of developing these surgical techniques [15,17,18,53]. While the pedicled TRAM flap as described by Hartrampf 1982 has been frequently cited and described as the origin of modern autologous breast reconstruction, it is important to acknowledge that the free TRAM flap was described earlier by Holmstrom, in 1979 [15,16].

It is interesting that the first articles in our ranking were published in 1989, 10 years after the initial TRAM techniques were described. This may be because scientific progress cannot always be described in terms of breakthroughs or landmark publications alone, since a finding may at times not immediately be recognized as a breakthrough until decades later. Regardless, the description of a perforator-based abdominal flap harvest in 1989 certainly was a “starting-signal” for the propagation of the abdominal donor site as a reliable source for autologous breast reconstruction. Since then, surgeons from the United States have dominated the literature on autologous breast reconstruction with TRAM and DIEP flaps, as evidenced by the fact that 2/3 of the most cited articles have been published by authors/institutions from the United States (Figures 4, 5).

During our analysis of the literature, the impressive evolution of progressively less morbid techniques of abdominal flap harvest became evident. The transition from pedicled TRAM flap harvest to muscle-sparing techniques and finally perforator-based approaches has not only resulted in a progressive decrease in abdominal wall morbidity, but also highlights the innovative nature of our specialty.

All articles in our ranking were published within the 23-year period from 1989 to 2012, with a peak of total citations being noted in 2010 (Figures 2, 3). Our results show that a substantial lag period can exist between publication of a novel technique and widespread clinical adoption. Naturally, when it comes to reporting long-term data on pedicled TRAM flaps outcomes, a number of articles appeared decades after free flaps have been published and after free flaps have become a prevalent technique in the interim. Because of the latency of long-term reports, our review included all 3 prevailing techniques in our ranking. Hence, long-term analyses of pedicled and free TRAM flaps coincide with the period of comparative analyses of free TRAM vs. DIEP flaps.

Limitations of our study are related to the design, which includes a single electronic database. However, we believe that the database chosen is comprehensive and, hence, do not believe that highly cited articles eluded us. Of course, the quality of the included studies determines the quality of any literature review. However, since we did not perform a quantitative analysis, but rather provide a descriptive report of highly cited studies, this concern is not particularly relevant.

We believe that this study provides a general overview of the most cited articles on autologous breast reconstruction with TRAM and DIEP flaps and highlights the various areas of study.

Conclusions

This literature review illustrates not only the dramatic change that has occurred subsequent to introduction of abdominal flaps for breast reconstruction, but also the lag period from publication to widespread clinical adoption of a particular
References:

1. Curado MP: Breast cancer in the world: Incidence and mortality. Salud Publica Mex, 2011; 53: 372–84

2. Ghoncheh M, Mirzaei M, Salehiniya H: Incidence and mortality of breast cancer and their relationship with the Human Development Index (HDI) in the world in 2012. Asian Pac J Cancer Prev, 2015; 16: 8439–43

3. Ghoncheh M, Pourmandar Z, Salehiniya H: Incidence and mortality and epidemiology of breast cancer in the world. Asian Pac J Cancer Prev, 2016; 17: 43–46

4. Tao Z, Shi A, Lu C et al: Breast cancer: Epidemiology and etiology. Cell Biochem Biophys, 2015; 72: 333–38

5. American Cancer Society: Breast Cancer Facts & Figures 2017–2018. Atlanta: American Cancer Society, 2017

6. Wolters R, Regliener AC, Schwentner L et al: A comparison of international breast cancer guidelines – do the national guidelines differ in treatment recommendations? Eur J Cancer, 2012; 48: 1–11

7. Lostumbo L, Carbine NE, Wallace J: Propylphatic mastectomy for the prevention of breast cancer. Cochrane Database Systematic Review, 2010; 10: CD007248

8. Pinell-White XA, Kolegraff K, Carlson GW: Predictors of contralateral prophylactic mastectomy and the impact on breast reconstruction. Ann Plast Surg, 2014; 72: 153–57

9. Cederna PS, Yates WR, Chang P et al: Postmastectomy reconstruction: Comparative analysis of the psychosocial, functional, and cosmetic effects of transverse rectus abdominis musculocutaneous flap versus breast implant reconstruction. Ann Plast Surg, 1995; 35: 458–68

10. Hu ES, Pusic AL, Waljee JF: Patient-reported satisfaction with breast reconstruction during the long-term survivorship period. Plast Reconstr Surg, 2009; 124: 1–8

11. Ng SK, Hare RM, Kuang RJ et al: Breast reconstruction post mastectomy: Patient satisfaction and decision making. Ann Plast Surg, 2016; 76: 640–44

12. Olivari N: The latissimus flap. Br J Plast Surg, 1976; 29: 126–2.

13. [New procedure for breast cancer amputation]. Reforma Med, 1896; 12 [in Italian]

14. [Presentation of my new breast amputation procedure]. Riforma Medica, 1906; 12 [in Italian]

15. Holmstrom H: The free abdominoplasty flap and its use in breast reconstruction. An experimental study and clinical case report. Scand J Plast Reconstr Surg, 1979; 13: 423–27

16. Hartrampf CR, Scheffran M, Black PW: Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg, 1982; 69: 216–25

17. Allen RJ, Treece P: Deep inferior epigastric perforator flap for breast reconstruction. Plast Reconstr Surg, 1994; 92: 32–38

18. Blondeel PN: One hundred free DIEP flap breast reconstructions: A personal experience. Br J Plast Surg, 1999; 52: 104–11

19. Koshima I, Soeda S: Inferior epigastric artery skin flaps without rectus abdominis muscle. Br J Plast Surg, 1989; 42: 645–48

20. Ludolph I, Horch RE, Harlander M: Is there a rationale for autologous breast reconstruction in older patients? A retrospective single center analysis of quality of life, complications and comorbidities after DIEP or MS-TRAM flap using the BREAST-Q. Breast J, 2015; 21: 588–95

21. Momeni A, Ahdoot MA, Kim RY et al: Should we continue to consider obesity a relative contraindication for autologous microsurgical breast reconstruction? Plast Reconstr Aesthet Surg, 2012; 65: 420–25

22. Grotting JC, Urist MM, Maddox WA, Vasconez LO: Conventional TRAM flap versus free microsurgical TRAM flap for immediate breast reconstruction. Plast Reconstr Surg, 1989; 83: 828–41; discussion 842–44

23. Saaristo AM, Niemi TS, Villanen TP et al: Microvascular breast reconstruction and lymph node transfer for postmastectomy lymphedema patients. Ann Surg, 2012; 255: 468–73

24. Alderman AK, Wilkins EG, Lowery JC et al: Determinants of patient satisfaction in postmastectomy breast reconstruction. Plast Reconstr Surg, 2000; 106: 769–76

25. Kaplan JL, Allen RI: Cost-based comparison between perforator flaps and TRAM flaps for breast reconstruction. Plast Reconstr Surg, 2000; 105: 943–48

26. Kroll SS: Fat necrosis in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps. Plast Reconstr Surg, 2000; 106: 576–83

27. Wilkins EG, Cederna PS, Lowery JC et al: Prospective analysis of psychosocial outcomes in breast reconstruction: One-year postoperative results from the Michigan Breast Reconstruction Outcome Study. Plast Reconstr Surg, 2000; 106: 1014–25; discussion 1026–27

28. Chang DW, Reece GP, Wang B et al: Effect of smoking on complications in patients undergoing free TRAM flap breast reconstruction. Plast Reconstr Surg, 2000; 105: 1640–48

29. Blondeel PN, Arinstein M, Verstraete K et al: Venous congestion and blood flow in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps. Plast Reconstr Surg, 2000; 106: 1295–99

30. Chang DW, Wang B, Robb GL et al: Effect of obesity on flap and donor-site complications in free transverse rectus abdominis myocutaneous flap breast reconstruction. Plast Reconstr Surg, 2000; 105: 1640–48

31. Futter CM, Webster MH, Hagen S, Mitchell SL: A retrospective comparison of abdominal muscle strength following breast reconstruction with a free TRAM or DIEP flap. Br J Plast Surg, 2000; 53: 578–83

32. Tran NV, Evans GR, Kroll SS et al: Postoperative adjuvant irradiation: Effects on transverse rectus abdominis muscle flap breast reconstruction. Plast Reconstr Surg, 2000; 106: 313–17; discussion 318–20

33. Brandberg Y, Malm M, Blomqvist L: A prospective and randomized study, “SVEA,” comparing effects of three methods for delayed breast reconstruction on quality of life, patient-defined problem areas of life, and cosmetic result. Plast Reconstr Surg, 2000; 105: 66–74; discussion 75–76

34. Sleazak S, McGibbon B, Dellen AL: The sensational transverse rectus abdominis musculocutaneous (TRAM) flap: Return of sensibility after TRAM breast reconstruction. Ann Plast Surg, 1992; 28: 210–17

35. Schusterman MA, Kroll SS, Miller MJ et al: The free transverse rectus abdominis musculocutaneous flap for breast reconstruction: One center’s experience with 211 consecutive cases. Ann Plast Surg, 1994; 32: 234–41; discussion 41–12

36. Blondeel N, Vanderstraeten GG, Monstrey SJ et al: The donor site morbidity of free DIEP flaps and free TRAM flaps for breast reconstruction. Br J Plast Surg, 1997; 50: 322–30

37. Kroll SS, Schusterman MA, Reece GP et al: Abdominal wall strength, bulging, and hernia after TRAM flap breast reconstruction. Plast Reconstr Surg, 1995; 96: 616–19

38. Edsander-Nord A, Jurell G, Wickman M: Donor-site morbidity after pedicled TRAM or DIEP flap. Br J Plast Surg, 1998; 102: 1508–16

39. Bajaj AK, Chevry PM, Chang DW: Comparison of donor-site complications and functional outcomes in free muscle-sparing TRAM flap and free DIEP flap breast reconstruction. Plast Reconstr Surg, 2006; 117: 717–36; discussion 747–50

40. Nahabedian MY, Tsangaris T, Momen B: Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: Is there a difference? Plast Reconstr Surg, 2000; 105: 436–44; discussion 445–46

41. Tran NV, Chang DW, Gupta A et al: Comparison of immediate and delayed free TRAM flap breast reconstruction in patients receiving postmastectomy radiation therapy. Plast Reconstr Surg, 2001; 108: 78–82

42. Alderman AK, Wilkins EG, Kim HM, Lowrey JC: Complications in postmastectomy breast reconstruction: Two-year results of the Michigan Breast Reconstruction Outcome Study. Plast Reconstr Surg, 2002; 109: 2265–74

43. Khoo A, Kroll SS, Reece GP et al: A comparison of resource costs of immediate and delayed breast reconstruction. Plast Reconstr Surg, 1998; 101: 964–68; discussion 969–70
44. Atisha D, Alderman AK, Lowery JC et al: Prospective analysis of long-term psychosocial outcomes in breast reconstruction: Two-year postoperative results from the Michigan Breast Reconstruction Outcomes Study. Ann Surg, 2008; 247: 1019–28
45. Ferlay J, Shin HR, Bray F et al: Estimates of worldwide burden of cancer in 2008. GLOBOCAN 2008. Int J Cancer, 2010; 127: 2893–917
46. Ferlay J, Soerjomataram I, Dikshit R et al: Cancer incidence and mortality worldwide: Sources, methods and major patterns in GLOBOCAN 2012. Int J Cancer, 2015; 136: E359–86
47. Surgeons ASoP. 2016 Plastic Surgery Statistic Report, 2016
48. Yueh JH, Slavin SA, Adesiyun T et al: Patient satisfaction in postmastectomy breast reconstruction: A comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques. Plast Reconstr Surg, 2010; 125: 1585–95
49. Schaverien M, Saint-Cyr M, Arbique G, Brown SA: Arterial and venous anat-omies of the deep inferior epigastric perforator and superficial inferior epi-gastric artery flaps. Plast Reconstr Surg, 2008; 121: 1909–19
50. Leyngold MM: Is unipedicled transverse rectus abdominis myocutane-ous flap obsolete owing to superiority of DIEP flap? Ann Plast Surg, 2018; 80(Suppl. 6): S418–20
51. Komorowska-Timek E, Gurtner GC: Intraoperative perfusion mapping with laser-assisted indocyanine green imaging can predict and prevent compli-cations in immediate breast reconstruction. Plast Reconstr Surg, 2010; 125: 1065–73
52. Horch RE, Beier JP, Kneser U, Arkudas A: Successful human long-term appli-cation of in situ bone tissue engineering. J Cell Mol Med, 2014; 18: 1478–85
53. Itoh Y, Arai K: The deep inferior epigastric artery free skin flap: Anatomic study and clinical application. Plast Reconstr Surg, 1993; 91: 853–63; discussion 864