



Safety and Outcomes of Oncoplastic Breast Surgery

Crystal Fancher¹ · Janie Grumley² · Alicia M. Terando¹

Accepted: 2 December 2020 / Published online: 5 January 2021

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC part of Springer Nature 2021

Abstract

Purpose of Review Traditional breast-conserving surgery combined with whole breast radiation results in equivalent overall survival as total mastectomy, with the benefit of being less invasive with fewer surgical complications and faster recovery. However, the surgical defect in the breast parenchyma, when combined with whole breast radiation, can result in cosmetic deformities that many patients find distressing. Partial mastectomy performed using plastic/reconstructive surgical techniques with the goal of optimizing both oncologic and esthetic outcomes is referred to as oncoplastic (breast) surgery. Herein, the surgical complications, oncologic, esthetic, and quality of life outcomes of oncoplastic surgery are reviewed.

Recent Findings Overall, the oncologic and surgical outcomes of oncoplastic surgery are similar to traditional partial mastectomy. The esthetic outcomes of oncoplastic surgery are, by design, objectively superior to that which can be achieved with standard partial mastectomy and translate into improved psychosocial quality of life for many women.

Summary Oncoplastic surgery provides patients with the benefit of improved cosmesis over traditional lumpectomy without compromising cancer treatment outcomes.

Keywords Breast cancer · Breast-conserving surgery · Oncoplastic surgery · Outcomes

Introduction

After breast-conserving surgery plus radiation therapy (breast-conserving therapy or BCT) was determined to be oncologically equivalent to mastectomy, its use became widespread due to its decreased morbidity and its clear benefit in avoiding the obvious cosmetic deformity associated with mastectomy. Initially, there was little consideration of the esthetic outcomes of BCT since the mere ability to preserve the breast was, at the time, a significant improvement over mastectomy. Over time however, it became apparent that the appearance of the breast is not entirely preserved following BCT. Early studies evaluating the esthetic outcomes after BCT showed high rates of “acceptable” cosmetic outcomes, but these studies were based on subjective scores that were highly variable

among reviewers [1–3]. As it became increasingly accepted that the esthetic outcome after BCT is important to women, factors associated with poor cosmesis were examined and methods to minimize deformities were developed.

Factors Affecting Breast Cosmesis After Breast-Conserving Therapy

Both patient factors and surgical technique are important determinants of breast cosmesis following BCT. While radiation therapy techniques also play a role in breast cosmesis, they will not be reviewed here. Incision placement at the areolar margin or inframammary fold avoids the creation of obvious scars on the breast. Preservation of the soft tissue under the skin with creation of thick flaps during dissection can aid in minimizing post-treatment contour deformities; however, results are inconsistent and may not be feasible in superficial tumors. The ratio of tumor size to breast size and the location of the disease in the breast are patient-specific factors that impact post-treatment cosmesis and are not entirely compensable by surgical technique in standard breast-conserving surgery/lumpectomy. In a study of 151 women who underwent standard breast-conserving surgery, Cochrane et al.

This article is part of the Topical Collection on *Local-Regional Evaluation and Therapy*

✉ Alicia M. Terando
Alicia.terando@med.usc.edu

¹ Keck School of Medicine, The University of Southern California, 1510 San Pablo Street, Suite 514, Los Angeles, CA 90033, USA

² John Wayne Cancer Institute, Santa Monica, CA, USA

demonstrated that excision of increasing percentages of breast tissue is associated with decreased cosmesis and patient satisfaction. Additionally, they showed that the cosmetic outcome following lumpectomy for cancers located in the lateral hemisphere of the breast is better than similar excision volumes in the medial hemisphere [4•].

Oncoplastic Surgery

The tissue defect that results from partial mastectomy is the primary cause of breast contour deformities following breast-conserving surgery. The term *oncoplastic surgery* refers to the use of various tissue rearrangement techniques in order to minimize or obliterate this tissue defect. In an effort to standardize terminology for ease of communication, in 2019, the American Society of Breast Surgeons performed a comprehensive search of the literature and, as a result, defined oncoplastic surgery as “Breast conservation surgery incorporating an oncologic partial mastectomy with ipsilateral defect repair using volume displacement or volume replacement techniques with contralateral symmetry surgery as appropriate” [5•]. Breast surgeons who are trained to perform oncoplastic techniques can perform both the partial mastectomy and the volume displacement or replacement. Alternatively, breast surgeons may partner with plastic surgeons, especially for cases requiring more complex tissue rearrangements or volume replacement.

Under the overall umbrella heading of oncoplastic surgery, the techniques are subdivided relative to the volume of the defect they are best suited to correct. Level 1 oncoplastic procedures, intended for defects comprising less than 20% of the breast volume, include local tissue rearrangement and crescent and doughnut mastopexy. Level 2 oncoplastic procedures refer to circumvertical mastopexy and reduction mammoplasty procedures which are best applied to defects involving 20–50% of the volume of the breast. In cases in which more than 50% of the breast tissue is to be removed and the residual breast tissue is inadequate to result in an acceptable outcome, volume *replacement* techniques can be considered, such as implants and flaps [2]. This review will be limited to the safety and outcomes of volume displacement techniques.

Oncologic Outcomes of Oncoplastic Breast Surgery

As the volume of breast tissue excised during partial mastectomy increases, the rate of involved margins requiring re-excision or conversion to mastectomy decreases. However, increased breast resection volume comes at a cost of increased breast contour deformities. The use of oncoplastic volume displacement techniques allows for wider resection margins

while simultaneously preserving the contour of the breast. As a result, oncoplastic breast surgery is associated with lower rates of positive margins and a need for fewer re-excisions or conversions to mastectomy, while minimizing or eliminating breast contour deformities [6, 7]. In 2015, Crown et al. performed a single-institution retrospective analysis of their rates of conversion to mastectomy and re-excision lumpectomy both before and after adoption of oncoplastic breast surgery. They reported that the rate of conversion to mastectomy was significantly higher in the conventional breast-conserving surgery group (34%) compared to the oncoplastic surgery group (15%, $p < 0.001$). This higher conversion rate was found despite the fact that the average tumor size in the oncoplastic group was larger (15.4 mm for oncoplastic surgery vs 12.7 mm for standard surgery). Re-excision rates were also significantly lower after adoption of oncoplastic surgery (18% vs 32%, $p < 0.001$) [6]. In 2018, Crown et al. updated their re-excision data looking solely at oncoplastic surgery. They evaluated 71 patients treated with oncoplastic reduction mammoplasty and noted that in 95.8% of cases, there was no ink on tumor. The average disease span in this study was even larger than in their previous data set: 31.4 mm. Despite the larger extent of disease, re-excision rates remained low, with only 4 patients (5.6%) requiring re-excision, none of whom was found to have residual disease within the re-excision specimen. Two patients ultimately underwent mastectomy (2.8%), and both were found to have extensive residual disease on final pathology which indicates that breast conservation of any kind was likely not feasible. It should be noted that identification of margin(s) requiring re-excision following an oncoplastic reduction mammoplasty may not be straightforward. In this particular series, the breast surgical oncologist performed both the partial mastectomy and the oncoplastic reduction mammoplasty, instead of deferring the tissue rearrangement to a plastic surgeon. The authors assert that having the same surgeon perform both the resection and the reconstruction facilitates their ability to accurately identify involved margins requiring re-excision [7]. While it is not a requirement for the same surgeon to perform the resection and reconstructive portions of the procedure, it is important for surgeons performing oncoplastic surgery to consider how positive margins will be managed.

While these results appear promising, they stand in contrast to the re-excision and mastectomy rates reported in a 2019 meta-analysis of 11 studies including 3809 patients that reported no statistically significant difference in re-excision or mastectomy rates between conventional breast-conserving surgery and oncoplastic surgery [8]. The studies included in this meta-analysis represent procedures performed by surgeons with varying levels of training and experience. While it remains possible that the oncologic outcomes of oncoplastic surgery are superior than standard lumpectomy, at a minimum, it has been shown that oncoplastic surgery is at least

equivalent to standard lumpectomy in terms of oncologic safety, with the additional benefit of improved cosmetic results.

Margin positivity, re-excision rates, and need for conversion to mastectomy are measures of the immediate oncologic results of breast-conserving surgery. The more clinically relevant question is whether oncoplastic surgery impacts cancer recurrence rates. In a 2019 report that compared 677 women who underwent conventional breast-conserving surgery with 288 who had oncoplastic procedures, no significant differences were identified as far as local control, progression-free survival, or overall survival. At 5 years, local control rate was 96.8% for the oncoplastic group and 95.3% for the standard breast conservation group [9]. A grouped meta-analysis of 13 studies including 15,883 patients also found no difference in recurrence rates for oncoplastic versus traditional breast conservation techniques [8].

Overall, the available literature shows that resection margins achieved with oncoplastic breast surgery are at least equivalent, if not at times better, than with traditional breast-conserving surgery, as evidenced by similar rates of re-excision and conversion to mastectomy. Most importantly, recurrence rates for patients undergoing oncoplastic procedures are not different from those undergoing traditional breast-conserving operations. With at least no difference in oncologic outcome, and the benefit of improved cosmesis, oncoplastic techniques are likely to supplant traditional breast-conserving surgery in the future.

Complications of Oncoplastic Surgery

The benefits of oncoplastic breast-conserving surgery including reduced re-excision rates and improved cosmetic outcomes have been well-reported in the literature. The low risk of perioperative complications associated with traditional breast-conserving surgery has also been well-documented. With the added complexity inherent in oncoplastic techniques and contralateral procedures performed for symmetry, increased rates of complications would be expected. However, when compared to traditional breast-conserving surgery, the literature has shown that oncoplastic surgical approaches have similar if not lower rates of complications as conventional breast-conserving surgery. Crown et al. reported in their series of 561 patients undergoing breast-conserving surgery a lower perioperative complication rate in those undergoing oncoplastic breast conservation surgery compared to traditional breast-conserving surgery (8% vs. 18%, $p < 0.001$). The most common complications noted in both groups were wound infection, wound dehiscence, and seroma formation. However, the risks of wound infection and seroma formation were lower in patients who underwent oncoplastic procedures: 3.3% (vs. 8.4%, $p = 0.01$) for wound infection and 1.8%

(vs. 4.4%, $p = 0.04$) for seroma formation [10]. When examining more complex oncoplastic techniques, the same group reported a series of 71 patient undergoing oncoplastic reduction mammoplasty. The most common reported complication in this series was superficial ulceration of the vertical and inframammary junction (13%). Low rates of wound infection (1.4%) and seroma formation (0.7%) were again reported [7].

Oncoplastic breast-conserving surgery often involves a breast lift which results in asymmetry of the treated versus native breast in many patients. Thus, immediate contralateral symmetry procedures are commonly offered. Despite the additional surgery involved in contralateral symmetry procedures, the literature has not shown an increased risk of complications. Deigni et al. examined the complication rates of simultaneous symmetry procedures compared to delayed symmetry procedures in patients undergoing oncoplastic breast-conserving surgery. In their series of 429 patients, the overall complication rate was 25.9%. There was no difference in the complication rate between immediate or delayed symmetry procedures (25.4% vs 26.9% respectively $p = 0.82$). Complication rates for the index breast (with cancer) were noted to be higher at 22% compared to a much lower 9% for the contralateral breast. The overall risk of perioperative complications which led to delays to adjuvant treatment was low at 4.2% [11].

Neoadjuvant chemotherapy is an added consideration when discussing options for surgical treatment of breast cancer patients. Adamson et al. compared the complication rates in patients undergoing oncoplastic breast-conserving surgery with and without neoadjuvant chemotherapy. In their retrospective review of 429 patients, it was noted that the overall complication rate was not statistically different between those who were treated with neoadjuvant chemotherapy and those who were not (23% vs 27% respectively, $p = 0.4$) [12]. Treatment with neoadjuvant chemotherapy did not alter rates of wound infection, seroma formation, wound healing issues/dehiscence, or fat necrosis.

On multivariate analysis, both Adamson et al. and Deigni et al. reported higher BMI and diabetes mellitus to be risk factors for complications in patients undergoing oncoplastic breast-conserving surgery [11, 12]. While the report by Crown et al. did not show these same risk factors, BMI was reported as a categorical value in their analysis rather than as a continuous variable as was done in the series by Adamson and Deigni [10–12].

Overall, oncoplastic breast-conserving surgery has been shown to be associated with a low risk of perioperative complications. Most reported complications are minor wound complications, with wound infection and seroma formation being the most common. Comorbid conditions such as diabetes mellitus and higher BMI may increase a patient's risk for complications, and patients should be counseled accordingly.

Impact of Oncoplastic Surgery on Breast Cancer Surveillance

The complex rearrangement of breast tissue that is a part of oncoplastic breast-conserving surgery has raised concerns regarding post-operative cancer surveillance and the ability to interpret follow-up breast imaging. The ability to detect subtle mammographic changes is critical in the detection of early disease; however, these same subtle changes may also be associated with benign post-surgical changes which can complicate mammographic interpretation. An early report of patients undergoing oncoplastic breast-conserving surgery showed longer time to mammographic stabilization, with a higher rate of tissue sampling in the follow-up period [13]. These results should be interpreted with caution, however, as this study was a small, single-radiologist series comparing 17 patients who underwent oncoplastic breast-conserving surgery to 17 patients who underwent traditional breast-conserving surgery.

In order to determine the effect of reduction mammoplasty, performed for non-cancerous reasons, on subsequent mammographic findings, Roberts et al. examined the mammographic findings and need for biopsy in patients who underwent therapeutic reduction mammoplasty for macromastia compared to those who did not undergo surgery. They reported no differences in suspicious mammographic findings or biopsy rates after therapeutic reduction mammoplasty compared to women who did not undergo breast surgery [14]. Based on these results, it follows that oncoplastic reduction mammoplasty, performed for cancer, should not result in increased suspicious mammographic findings or biopsy rates. To address this question directly, Piper et al. reported their series of 49 patients who underwent oncoplastic reduction mammoplasty and compared the post-operative imaging findings to age-matched patients who underwent standard lumpectomy. This series also reported no significant difference in the overall rate of abnormal mammographic findings at 6 months, 2 years, and 5 years post-operatively. At the 1-year post-operative time point however, the oncoplastic surgery patients were found to have a significantly higher rate of abnormal mammographic findings and recommendations for biopsy. Of the 12 patients who were recommended to have biopsies in the oncoplastic surgery group, 10 patients opted for observation and ultimately did not develop recurrent cancer, which implies that the excess abnormal imaging findings in this group were benign. When compared to standard lumpectomy, patients in this study undergoing oncoplastic reduction had more benign calcifications and fat necrosis, while the patients who had standard lumpectomies were more likely to have “benign post-surgical” changes. The local recurrence rate in this series was slightly higher for the oncoplastic surgery patients at 12%, compared to 8% in the standard surgery group [15]. Although this difference was not statistically significant, it was noted that patients in the

oncoplastic group had a higher stage of disease on presentation which may account for this difference. Overall, the incidence of abnormal mammographic findings in this cohort was low with no difference between patients having oncoplastic surgery versus standard lumpectomy.

The sensitivity and specificity of mammography are greatly affected by technology. The ability to discern between abnormal mammographic findings and normal anatomy has improved with the introduction of tomosynthesis. In a more recent series, Crown et al. examined 422 patients who underwent either oncoplastic surgery or standard lumpectomy. They found that the rate of additional imaging with diagnostic views, ultrasound, and/or MRI was not different between the two groups. It was however noted that for patients who underwent standard lumpectomy, when additional imaging was recommended, there was a significantly higher rate of biopsy (18.9%) compared to those who underwent oncoplastic surgery (18.9% for standard lumpectomy vs. 9.3% for oncoplastic surgery, $p < 0.01$). This higher biopsy rate was not different within the first 3 years of follow-up but diverged at year 4 with a significant increase in patients who underwent standard lumpectomy. Overall, there was a higher reported rate of recurrence in patients who underwent standard lumpectomy compared to oncoplastic surgery (11.5% vs. 4.9% respectively, $p = 0.014$). However, this difference may be explained by the longer follow-up in patients who underwent standard lumpectomy (10 vs. 5 years). Interestingly, when malignancy was detected on biopsy, patients who had oncoplastic surgery were more likely to have in situ disease compared to those who underwent standard lumpectomy (70% vs 24% respectively, $p = 0.02$) [16]. Taken together, these results suggest that oncoplastic surgery did not increase the need for additional imaging and biopsy, and oncoplastic tissue rearrangement did not impair the ability to detect early recurrence.

Expanding Indications—“Extreme Oncoplasty”

NSABP B06 established lumpectomy with radiation therapy as an acceptable treatment option for women with breast cancer in the 1980s. This option was largely limited to women with unifocal breast cancer measuring 4 cm or smaller. The findings of NSABP B06 were then later adapted to women with T1 and T2 lesions, expanding the upper end of tumor size to 5 cm. In their 20-year follow-up report, Fisher et al. concluded that lumpectomy with radiation therapy is still an appropriate therapy provided that clear margins and acceptable cosmetic results can be obtained [17••]. The ability to obtain clear margins with acceptable cosmetic outcome has limited the use of BCT in women with larger and/or multifocal disease. Oncoplastic surgery allows for wide local excision

without compromise to the cosmetic appearance of the breast, and it has been largely accepted as an option for patients meeting traditional criteria for breast conservation: unifocal lesions less than 5 cm. The term “extreme oncoplasty” was first coined by Melvin J. Silverstein as a “breast conserving operation, using oncoplastic techniques, in a patient who in most physician’s opinions, require a mastectomy.” Silverstein et al. reported their initial experience with 66 patients who underwent extreme oncoplastic breast-conserving surgery after being advised to have mastectomies by another surgeon. All patients in this series had a clinical span of disease measuring 5 cm or greater, with a median tumor size of 6.2 cm. The negative margin rate, defined as no tumor on ink, was high at 83.3%. The rate of positive margins requiring re-excision was low at 9.1%, and the ultimate mastectomy rate was 6.1%. In this series, 93.9% (62 patients) who were previously advised to have mastectomies were able to avoid mastectomy by utilizing extreme oncoplastic breast-conserving techniques. At 24 months of follow-up, the local recurrence rate in this cohort was low at 1.5% [18]. While longer follow-up is warranted to fully assess the efficacy of this approach, this series was the first to demonstrate feasibility of the oncoplastic approach for patients with large cancers.

Crown et al. later reported their experience with extreme oncoplastic breast-conserving surgery in 111 patients with multicentric or multifocal disease, and/or a disease span exceeding 5 cm. In this series, the same surgeon performing the oncologic portion of the operation also performed the tissue rearrangement, which the authors assert facilitated identification of any positive margins requiring re-excision. Seventy-four percent of these patients had multiple lesions, with an average number of lesions of 3.2 and an average disease span of 57.1 ± 23.6 mm. The remaining patients had unifocal disease with an average disease span of 67.6 mm. In this series, no-tumor-on-ink was achieved in 78.3% of patients, although 51.4% of patients were advised to have additional surgery for close or positive margins. Of the 42 patients who elected for re-excision, the majority (78%) achieved adequate margins with a single re-excision. Overall, 88.4% of patients avoided mastectomy. Ninety-three percent of patients had a good-to-excellent cosmetic outcome as reported by surgeons using the Harvard Breast Cosmesis Scale, though the cosmesis score was not recorded for 24 patients in this series. The overall recurrence rate in this cohort of patients was 2.7% with an average follow-up time of 36 months [19].

The use of oncoplastic surgery beyond the traditional parameters for breast-conserving surgery has not been widely employed. However, the current literature would suggest that oncoplastic surgery may be a reasonable alternative for women with more extensive disease who are motivated to preserve their breast. In patients with more advanced disease, post-mastectomy radiation therapy is recommended for local disease control, which limits options for reconstruction and

ultimate cosmetic outcome. Extreme oncoplastic surgery may offer those patients a way to preserve their breast tissue, achieve a more acceptable cosmetic outcome, and avoid the need for post-mastectomy reconstruction in the setting of radiation therapy and its associated complications. While longer follow-up is needed to assess the efficacy of this approach, the reported short-term outcomes suggest a low rate of local recurrence when used in conjunction with optimal systemic therapy and adjuvant radiation therapy.

Esthetic and Quality of Life Outcomes

Although the definition of a good esthetic outcome and the importance placed on breast cosmesis vary greatly from woman to woman, the genesis of oncoplastic surgery was the idea that breast cosmesis is an important outcome for many women with breast cancer. Aside from being a reasonable assumption, the relationship between breast cosmesis and psychosocial quality of life in patients with breast cancer has been studied. For instance, Waljee et al. examined the impact of breast cosmesis on psychosocial quality of life using a survey of 714 women who underwent breast-conserving therapy for breast cancer. They found that women who self-reported “pronounced” breast asymmetry were more likely to report a feeling of stigmatization stemming from their breast cancer treatment, although this finding was more striking for women 40 years old and younger as compared with older women [20].

Because oncoplastic surgical techniques were developed specifically to optimize breast cosmesis, it can be inferred that oncoplastic surgery would be associated with improved psychosocial quality of life indicators as compared with conventional breast-conserving surgery, but there have been few direct comparisons of the two approaches with respect to these parameters. In one large single-institution study out of Budapest, Hungary, Kelemen et al. specifically examined the impact of oncoplastic surgery on the esthetic and quality of life outcomes of a total of 700 women who underwent breast-conserving surgery, half of whom had oncoplastic procedures. The esthetic outcome for each of these patients was assessed at the 1-year post-operative time point by a committee of 3 surgeons using a 5-point Likert scale. Patients who underwent oncoplastic surgery were found to have significantly better esthetic results than those who underwent conventional breast-conserving surgery (4.4 vs 3.2 out of 5, $p = 0.001$). The European Organization for Research and Treatment of Cancer – Quality of Life Questionnaire (EORTC-QLQ) was used to assess the quality of life of these patients, using the scales for social functioning, emotional functioning, and body image. For each of these domains, the scores were significantly higher for patients who underwent oncoplastic surgery as opposed to conventional breast-

conserving surgery [21]. In a smaller study of 122 women, 57 (46.7%) of whom underwent one of a variety of oncoplastic breast-conserving procedures, Santos et al. found that the patients undergoing oncoplastic procedures had significantly superior cosmetic outcomes as determined through the use of a software program designed for this purpose (BCCT.core) and numerical scores assigned by breast and plastic surgeons. Furthermore, patients' satisfaction with their cosmetic outcome was better for those undergoing oncoplastic procedures versus those having standard lumpectomies [22, 23]. Despite the paucity of studies on this subject, these studies support the assumption that oncoplastic surgery provides both esthetic and quality of life benefits for women with breast cancer.

Conclusions

A growing appreciation for the importance of breast cosmesis in women undergoing breast-conserving surgery for cancer has led to the development of a variety of techniques that are referred to as oncoplastic surgery. Once considered controversial, oncoplastic surgery is gaining wide acceptance within the field of breast surgical oncology as research has demonstrated it to be oncologically safe without an increase in complications or a deleterious impact on cancer surveillance. The benefits of oncoplastic surgery also extend to the ability to offer breast conservation to women with large and/or multifocal cancers that would not otherwise be amenable to traditional breast-conserving surgery. The ability to offer oncoplastic surgery to patients with breast cancer, either oneself or by partnering with a plastic surgeon, is rapidly becoming an essential part of breast surgical oncology practice. Oncoplastic surgical techniques should be considered one of the standard surgical treatment options for women with breast cancer.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Dewar JA, Benhamou S, Benhamou E, Arriagada R, Petit JY, Fontaine F, et al. Cosmetic results following lumpectomy, axillary dissection and radiotherapy for small breast cancers. *Radiother Oncol.* 1988;12(4):273–80. [https://doi.org/10.1016/0167-8140\(88\)90016-3](https://doi.org/10.1016/0167-8140(88)90016-3).
2. Olivotto IA, Weir LM, Kim-Sing C, Bajdik CD, Trevisan CH, Doll CM, et al. Late cosmetic results of short fractionation for breast conservation. *Radiother Oncol.* 1996;41(1):7–13. [https://doi.org/10.1016/s0167-8140\(96\)91824-1](https://doi.org/10.1016/s0167-8140(96)91824-1).
3. Matory WE Jr, Wertheimer M, Fitzgerald TJ, Walton RL, Love S, Matory WE. Aesthetic results following partial mastectomy and radiation therapy. *Plast Reconstr Surg.* 1990;85(5):739–46. <https://doi.org/10.1097/00006534-199005000-00014>.
4. Cochrane RA, Valasiadou P, Wilson AR, Al-Ghazal SK, Macmillan RD. Cosmesis and satisfaction after breast-conserving surgery correlates with the percentage of breast volume excised. *Br J Surg.* 2003;90(12):1505–9. <https://doi.org/10.1002/bjs.4344> **Shows correlation of estimated percent volume of breast tissue excised and tumor location with cosmetic results and patient satisfaction.**
5. Chatterjee A, Gass J, Patel K, Holmes D, Kopkash K, Peiris L, et al. A consensus definition and classification system of oncoplastic surgery developed by the American Society of Breast Surgeons. *Ann Surg Oncol.* 2019;26(11):3436–44. <https://doi.org/10.1245/s10434-019-07345-4> **Definition of oncoplastic surgery.**
6. Crown A, Wechter DG, Grumley JW. Oncoplastic breast-conserving surgery reduces mastectomy and postoperative re-excision rates. *Ann Surg Oncol.* 2015;22(10):3363–8. <https://doi.org/10.1245/s10434-015-4738-2>.
7. Crown A, Handy N, Rocha FG, Grumley JW. Oncoplastic reduction mammoplasty, an effective and safe method of breast conservation. *Am J Surg.* 2018;215(5):910–5. <https://doi.org/10.1016/j.amjsurg.2018.02.024>.
8. Kosasih S, Tayeh S, Mokbel K, Kasem A. Is oncoplastic breast conserving surgery oncologically safe? A meta-analysis of 18,103 patients. *Am J Surg.* 2020;220(2):385–92. <https://doi.org/10.1016/j.amjsurg.2019.12.019>.
9. Borm KJ, Schonknecht C, Nestler A, Oechsner M, Waschulzik B, Combs SE, et al. Outcomes of immediate oncoplastic surgery and adjuvant radiotherapy in breast cancer patients. *BMC Cancer.* 2019;19(1):907. <https://doi.org/10.1186/s12885-019-6104-4>.
10. Crown A, Scovel LG, Rocha FG, Scott EJ, Wechter DG, Grumley JW. Oncoplastic breast conserving surgery is associated with a lower rate of surgical site complications compared to standard breast conserving surgery. *Am J Surg.* 2019;217(1):138–41. <https://doi.org/10.1016/j.amjsurg.2018.06.014>.
11. Deigni OA, Baumann DP, Adamson KA, Garvey PB, Selber JC, Caudle AS, et al. Immediate contralateral mastopexy/breast reduction for symmetry can be performed safely in oncoplastic breast-conserving surgery. *Plast Reconstr Surg.* 2020;145(5):1134–42. <https://doi.org/10.1097/PRS.00000000000006722>.
12. Adamson K, Chavez-MacGregor M, Caudle A, Smith B, Baumann D, Liu J, et al. Neoadjuvant chemotherapy does not increase complications in oncoplastic breast-conserving surgery. *Ann Surg Oncol.* 2019;26(9):2730–7. <https://doi.org/10.1245/s10434-019-07408-6>.
13. Losken A, Schaefer TG, Newell M, Styblo TM. The impact of partial breast reconstruction using reduction techniques on postoperative cancer surveillance. *Plast Reconstr Surg.* 2009;124(1):9–17. <https://doi.org/10.1097/PRS.0b013e3181ab10e5>.
14. Roberts JM, Clark CJ, Campbell MJ, Paige KT. Incidence of abnormal mammograms after reduction mammoplasty: implications for oncoplastic closure. *Am J Surg.* 2011;201(5):611–4. <https://doi.org/10.1016/j.amjsurg.2011.01.019>.
15. Piper M, Peled AW, Sbitany H, Foster RD, Esserman LJ, Price ER. Comparison of mammographic findings following oncoplastic mammoplasty and lumpectomy without reconstruction. *Ann Surg Oncol.* 2016;23(1):65–71. <https://doi.org/10.1245/s10434-015-4611-3>.
16. Crown A, Laskin R, Weed C, Rocha FG, Grumley J. Evaluating need for additional imaging and biopsy after oncoplastic breast-conserving surgery. *Ann Surg Oncol.* 2020;27:3650–6. <https://doi.org/10.1245/s10434-020-08500-y>.
17. Fisher B, Anderson S, Bryant J, Margolese RG, Deutsch M, Fisher ER, et al. Twenty-year follow-up of a randomized trial

- comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. *N Engl J Med.* 2002;347(16):1233–41. <https://doi.org/10.1056/NEJMoa022152> **20-year follow-up of the landmark NSABP B-06 trial demonstrating the survival equivalence of breast-conserving therapy and mastectomy.**
18. Silverstein MJ. Radical mastectomy to radical conservation (extreme oncoplasty): a revolutionary change. *J Am Coll Surg.* 2016;222(1):1–9. <https://doi.org/10.1016/j.jamcollsurg.2015.10.007> **Early report of extreme oncoplasty.**
 19. Crown A, Laskin R, Rocha FG, Grumley J. Extreme oncoplasty: expanding indications for breast conservation. *Am J Surg.* 2019;217(5):851–6. <https://doi.org/10.1016/j.amjsurg.2019.01.004>.
 20. Waljee JF, Hu ES, Ubel PA, Smith DM, Newman LA, Alderman AK. Effect of esthetic outcome after breast-conserving surgery on psychosocial functioning and quality of life. *J Clin Oncol.* 2008;26(20):3331–7. <https://doi.org/10.1200/JCO.2007.13.1375> **Study demonstrating the importance of aesthetic outcomes on psychosocial outcome in patients with breast cancer.**
 21. Kelemen P, Pukancsik D, Ujhelyi M, Savold A, Kovacs E, Ivady G, et al. Comparison of clinicopathologic, cosmetic, and quality of life outcomes in 700 oncoplastic and conventional breast-conserving surgery cases: a single-centre retrospective study. *Eur J Surg Oncol.* 2019;45:118–24.
 22. Santos G, Urban C, Edelweiss MI, Zucca-Matthes G, de Oliveira VM, Arana GH, et al. Long-term comparison of aesthetical outcomes after oncoplastic surgery and lumpectomy in breast cancer patients. *Ann Surg Oncol.* 2015;22(8):2500–8. <https://doi.org/10.1245/s10434-014-4301-6>.
 23. Cardoso MJ, Cardoso J, Amaral N, Azevedo I, Barreau L, Bernardo M, et al. Turning subjective into objective: the BCCT.core software for evaluation of cosmetic results in breast cancer conservative treatment. *Breast.* 2007;16(5):456–61. <https://doi.org/10.1016/j.breast.2007.05.002>.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.