Published in final edited form as:

Plast Reconstr Surg. 2012 October ; 130(4): 513e–523e. doi:10.1097/PRS.0b013e318262f059.

Current Status of Implant-based Breast Reconstruction in Patients Receiving Postmastectomy Radiation Therapy

Steven J. Kronowitz, MD, FACS

Department of Plastic and Reconstructive Surgery, The University of Texas MD Anderson Cancer Center, Houston, Texas

Abstract

Background—Increasing numbers of patients with breast cancer are being treated with postmastectomy radiation therapy (PMRT). The author reviewed the literature to determine the clinical impact of this increasing use of PMRT in patients with breast cancer who desire implant-based breast reconstruction.

Methods—The author searched the MEDLINE database for articles on breast reconstruction and radiation therapy published between January 2008 and June 2011, and reviewed the abstracts of those articles to identify articles with information about the impact of radiation on implant-based breast reconstruction. This subgroup of articles was reviewed in detail.

Results—Two-hundred eighty-five articles were identified. 19 papers were reviewed in detail. 8 papers provided level III evidence; one provided level I or II ($n = 8$) evidence from high-quality multicenter or single-center randomized controlled trials or prospective cohort studies. Two papers provided level IV evidence from case series and were included in the review because they offered a novel approach or perspective. The most recent studies find a significant need for unplanned or major corrective surgery in irradiated breasts reconstructed with implants. Although breast implant reconstruction in irradiated breasts is associated with high rates of complications; only a minority of patients require conversion to an autologous tissue flap.

Conclusions—Although the majority of patients who undergo implant-based reconstruction and receive radiation ultimately keep the implant reconstruction, patient surveys show that radiation has a significantly negative effect on patient satisfaction.

INTRODUCTION

Although most reconstructive surgeons agree that breasts reconstructed with autologous tissue tend to fare better than breasts reconstructed with implants in patients who have received or will receive postmastectomy radiation therapy (PMRT), reconstruction with autologous tissue is not always feasible or desired. The major approaches to implant-based reconstruction in use today are one-stage and two-stage reconstruction. The debate continues as to whether to perform the second stage (placement of the permanent implant) of two-stage implant-based reconstruction before or after PMRT; controversy focuses on the long-term fate of the permanent implant. The relevance of the question of when to place the permanent implant in relation to PMRT has become even more important in light of the

Address correspondence and reprint requests to: Steven J. Kronowitz, M.D., F.A.C.S. The University of Texas MD Anderson Cancer Center Department of Plastic Surgery, Unit 1488 PO Box 301402 Houston, TX 77230-1402 Telephone: (713) 794-1247; Fax: (713) 794-5492 skronowi@mdanderson.org.

Disclosure

The author serves on a Scientific Advisory Committee for Allergan Medical, Irving, CA.

increasing use of one-stage implant-based reconstruction with immediate implant placement at the time of mastectomy.

In 2009, the author published a review in *Plastic and Reconstructive Surgery* on radiation therapy and breast reconstruction.¹ Recently, the author reviewed articles on that topic published since the time of the original review. In a companion article that will appear in the journal in an upcoming issue, the author summarized the new findings on radiation therapy and autologous tissue-based reconstruction. Here, the author summarizes the new findings on radiation therapy and implant-based reconstruction.

To find articles for review, the author searched the MEDLINE database for studies of radiation therapy and breast reconstruction published between January 2008 and June 2011 (Figure 1). The search terms used were breast reconstruction and radiation therapy. Relevant studies were assigned a level of evidence using the American Society of Plastic Surgeons Evidence Rating Scale for Therapy (Table 1). Two-hundred eighty-five articles were identified, and the abstracts of those articles were reviewed to identify articles that addressed the most pressing radiation-related issues facing reconstructive breast surgeons. This subgroup of articles was reviewed in detail.

OVERVIEW OF ARTICLES INCLUDED IN THE REVIEW

Nineteen articles that addressed the most pressing radiation-related issues facing reconstructive breast surgeons were selected for detailed assessment and included in this review (Table 2). Eight papers provided level III evidence, mostly from retrospective comparative studies. One paper provided level I or II ($n = 8$) evidence from high-quality multicenter or single-center randomized controlled trials or prospective cohort studies. Two papers provided level IV evidence from case series and were included in the review because they offered a novel approach or perspective.

IMPACT OF RADIATION ON THE RECONSTRUCTED BREAST

In general, radiation increases the risk of complications and poor aesthetic outcomes of implant-based breast reconstruction.

A retrospective review of 1037 patients was performed to determine if radiation therapy increases the risk of major complications that necessitate reoperation.² A total of 559 patients had undergone reconstruction with a tissue expander plus an implant. Twenty-seven patients had received radiation therapy before and 70 had received radiation therapy after implant-based breast reconstruction. Among patients who had tissue expander-implant reconstructions, the major complication rate was 24.4 percent without radiation therapy and 45.4 percent with radiation therapy. The overall complication rates for radiation delivered *before* (63.6 percent) and *after* (58.3 percent) implant-based reconstruction. Ultimately, 70.1 percent of the patients with implant-based reconstruction who underwent radiation therapy retained the original implant-based reconstruction, however 10.3 percent of patients who lost the implant went on to have autologous reconstruction. The authors concluded that radiation was found to be the greatest risk factor for major complications in tissue expander/implant reconstruction (**level III evidence**).

In another study, the BREAST-Q reconstruction module questionnaire was applied to assess patient satisfaction with breast appearance in 482 patients who underwent implant-based breast reconstruction.³ A total of 176 patients had silicone implants, and 306 had saline implants. Although the multivariate model showed higher patient satisfaction with silicone implants ($p = 0.032$), receipt of prior radiation therapy ($p < 0.001$) or a history of PMRT ($p = 0.002$) were found to have a significant negative effect on satisfaction with reconstructed

breasts in both women who received silicone implants and those who received saline implants (**level I evidence**).

Studies of Radiation Therapy Delivered Before Reconstruction

A study using the prospective database of the Danish Registry for Plastic Surgery evaluated associations between radiation and capsular contracture or reoperation in 717 patients who underwent delayed 1- or 2-stage implant-based breast reconstruction.⁴ A history of radiation therapy was associated with an increased risk of severe capsular contracture after both 1-stage procedures (adjusted hazard ratio [HR], 3.3; 95 percent CI, 0.9-12.4) and 2-stage procedures (HR, 7.2; 95 percent CI, 2.4-21.4). Similarly, a history of radiation therapy was associated with a nonsignificantly increased risk of reoperation after both 1-stage procedures (HR, 1.4; 95 percent CI, 0.7-2.5) and 2-stage procedures (HR, 1.6; 95 percent CI, 0.9-3.1). The rate of reconstruction failure was highest (13.2 percent) for 2-stage procedures performed in patients with a history of radiation therapy. The authors concluded that breast reconstruction approaches other than implants should be seriously considered among women who have received radiation therapy (**level II evidence**).

A study from the United Kingdom evaluated a hypofractionation technique for radiation delivery (40 Gy in 15 fractions over 3 weeks) in 178 patients who underwent implant-based breast reconstruction.⁵ The goal of the study was to determine whether hypofractionation (versus standard fractionation) would reduce the risk of capsular contracture. Forty-one of the 178 patients received postoperative radiation therapy, and the remaining patients did not. In the radiation therapy group, 8 patients had severe capsular contracture necessitating revisional surgery, for a crude rate of 19.5 percent. The actuarial rates of severe capsular contracture at 1, 2, 3, 4, 5, and 6 years of follow-up were 0 percent, 5 percent, 5 percent, 21 percent, 30 percent, and 30 percent. In the nonirradiated group, there were no cases of severe capsular contracture. This difference was highly significant ($p < 0.001$) (**level III evidence**).

Khansa and colleagues evaluated whether prior breast conservation therapy (BCT) leads to higher rates of complications and dissatisfaction with subsequent mastectomy and breast reconstruction.⁶ This study evaluated 802 reconstructions, 137 in women who had prior BCT and 665 in women who did not have prior BCT. BCT did correlate with increased risk of skin flap necrosis (12.4 percent versus 6.8 percent, $p = 0.024$) but did not correlate with higher rate of *other* complications or lower rates of satisfaction with aesthetic outcomes. (**level III evidence**). Patients receiving an expander/implant reconstruction after BCT did not have increased rates of complication or dissatisfaction. It is difficult, however, to make evident conclusions about the use of implants after BCT from their results, given the small number of patients in that group (10 patients).

Studies of Radiation Therapy Delivered After Reconstruction

Roostanaeian and colleagues utilized the Danish Registry for Plastic Surgery to evaluate outcomes of immediate implant insertion at the time of mastectomy and found that compared to patients who did not receive PMRT, patients who received PMRT had a significantly increased rate of need for revision ($p = 0.047$) and significantly lower mean aesthetic scores (2.46 versus 3.39) (**level IV evidence**).⁷

A prospective, multi-institutional study evaluated the factors associated with reconstruction failure in 141 consecutive patients undergoing mastectomy and immediate 2-stage breast reconstruction with a tissue expander and implant and radiation therapy.⁸ The second stage (implant placement) was performed after PMRT. After a median follow-up time of 37 months, Baker I or II capsular contracture was observed in 67.5 percent of patients, and Baker III or IV capsular contracture in 32.5 percent. There were 32 reconstruction failures.

Multiple regression analysis revealed that 3 factors were associated with reconstruction failure: T3 or T4 tumor, smoking, and positive axillary nodes (**level II evidence**).

Jhaveri and colleagues determined long-term complication rates and cosmetic results in 92 patients who underwent modified radical mastectomy; immediate reconstruction with either a tissue expander plus an implant (69 patients) or autologous tissue (23 patients); and PMRT.⁹ The rate of grade 3 or 4 complications (grade 3, surgical intervention or intravenous antibiotics required; grade 4, removal or replacement of the reconstructed breast) was 33.3 percent for expander-implant reconstruction versus 0 percent for autologous tissue-based reconstruction ($p = 0.001$). The rate of grade 2-4 complications (functional score ≥ 2 , impact on ability to perform activities of daily living) was 55 percent for expander-implant reconstruction versus 8.7 percent for autologous tissue-based reconstruction ($p < 0.001$). Acceptable cosmesis was reported in 51 percent of patients in the expander-implant group versus 82.6 percent of patients in the autologous-tissue group ($p = 0.007$). The authors concluded that in patients undergoing PMRT after immediate reconstruction, implant-based reconstruction is associated with more long-term complications and worse cosmetic results than autologous tissue-based reconstruction (**level II evidence**).

Studies Comparing Radiation Therapy Delivered Before and After Reconstruction

Several studies have compared the effects of radiation therapy delivered before and after reconstruction on outcomes of implant-based reconstruction.

One study examined the effect of radiation on implant-based breast reconstruction. The reconstructed breasts were separated into 3 groups: PMRT before breast reconstruction ($n = 57$), immediate reconstruction followed by PMRT ($n = 59$), and breast reconstruction without PMRT (control) ($n = 665$).¹⁰ The overall complication rate was higher for patients who received PMRT (before or after reconstruction) than for the control patients (39.66 percent versus 23.16 percent, $p < 0.001$). Compared with the control treatment, immediate reconstruction before PMRT was associated with a higher overall complication rate (47.46 percent versus 23.16 percent; $p < 0.001$) and a higher rate of late (>90 days) complications (33.90 percent versus 15.59 percent; $p < 0.001$). However, a validated questionnaire found that general and aesthetic satisfaction was similar between patients in the 2 groups. In contrast, delayed reconstruction after PMRT was associated with complication rates and general satisfaction similar to those in the control group but with decreased aesthetic satisfaction compared to the control (50 percent versus 66.88 percent, $p < 0.035$) (**level III evidence**).

A study from the United Kingdom examined how the sequencing of radiation therapy and reconstruction with LD flaps plus implants affected outcomes.¹¹ They compared long-term outcomes between 13 patients who underwent immediate reconstruction followed by radiation therapy and 11 patients who underwent radiation therapy followed by delayed reconstruction. Postoperative photographs of the natural and reconstructed breast were scored by a panel of 18 judges at 6 months and annually for as long as they were followed, and quality-of-life questionnaire were administered to the patients. Over the long term, both groups fell within an acceptable cosmetic outcome range. However, there was a trend towards better cosmetic outcome in patients undergoing delayed reconstruction, with volume and contour of the upper pole being most negatively affected in the irradiated reconstructions. Patient satisfaction was similar between the 2 groups, but 4 of the 11 patients who had delayed reconstruction patients in retrospect would have preferred immediate reconstruction (**level II evidence**).

A meta-analysis was performed to determine the optimal sequencing of breast reconstruction and PMRT.¹² The analysis, which included 1105 patients from 11 studies, showed that the rate of adverse events is 4.2 times as high in patients undergoing PMRT as it is in patients not undergoing PMRT. When PMRT was delivered after immediate breast reconstruction, patients who had autologous tissue-based reconstruction had one-fifth the risk of adverse events of patients who had implant-based reconstruction. A similar pattern was seen when PMRT was delivered before delayed breast reconstruction (**level III evidence**).

POSTRADIATION SKIN CHANGES TO PREDICT COMPLICATION RATES AND COSMETIC OUTCOMES

An interesting study by Parsa and colleagues was designed to determine if a classification system based on postradiation skin changes could be devised to select candidates for delayed expander-implant reconstruction after radiation therapy.¹³ The study included 27 patients who had undergone bilateral mastectomies followed by adjuvant radiation therapy delivered to only 1 side of the chest wall and then bilateral submuscular expander-implant reconstruction. Early postradiation skin changes were classified as moderate or severe, and aesthetic outcomes were classified as good, acceptable, or poor. In patients whose chest walls displayed moderate skin changes without induration after irradiation, aesthetic outcomes after reconstruction were similar on the irradiated and nonirradiated sides ($p>0.50$). In contrast, in patients who developed induration or severe postradiation skin changes, the rate of modified Baker IV capsular contracture was higher on the irradiated side, and the rate of poor aesthetic outcomes on the irradiated side was 75 percent in patients with severe skin changes and 100 percent in those with induration (**level II evidence**).

COMBINING A FLAP WITH AN IMPLANT TO DECREASE THE RATE OF COMPLICATIONS IN PREVIOUSLY IRRADIATED PATIENTS

Chang and colleagues evaluated whether the addition of a flap to implant-based breast reconstruction in previously irradiated breasts decreased the occurrence of complications.¹⁴ They found that in patients who had undergone preoperative irradiation, patients who had reconstruction with a free transverse rectus abdominis myocutaneous (TRAM) flap plus an implant had a significantly lower loss rate than patients who had reconstruction with an expander and implant only (5.0 percent versus 30.3 percent, $p < 0.04$). Also, the rate of reconstruction failure was significantly lower in patients who had reconstruction with an LD flap plus an implant (15.2 percent) or a TRAM flap plus an implant (10.0 percent) than in patients who had reconstruction with an expander and implant only (42.2 percent; $p < 0.03$) (**level III evidence**).

SAFETY OF A TISSUE EXPANDER OR IMPLANT ON THE CHEST WALL DURING RADIATION DELIVERY

There has been some confusion regarding the safety of delivering radiation with a tissue expander on the chest wall because of the metallic magnetic saline-filling port located within the expander. In addition, concerns have arisen regarding the geometric delivery of 3-beam radiation therapy with a breast implant on the chest wall and whether adequate coverage can be obtained, especially if the internal mammary nodes require treatment. An increasing number of studies are addressing these issues that should help clarify some of the confusion.

A recent study by Kronowitz and colleagues at The University of Texas MD Anderson Cancer Center indicated that the presence of a tissue expander on the chest wall during radiation therapy does not negatively impact recurrence-free survival.¹⁵ These authors

compared locoregional recurrence risk in 47 patients with advanced breast cancer (stages IIB and III) who were treated according to a protocol (skin-sparing mastectomy with tissue expander placement at mastectomy followed by definitive reconstruction after PMRT) and 47 disease-matched control patients who were treated with standard delayed reconstruction after PMRT (no skin preservation or tissue expander) during the same time period. They found no difference in 3-year recurrence-free survival rates between the 2 groups, and there were no locoregional recurrences in the protocol group after a median follow-up time of 40 months. Three-year recurrence-free survival rates were 92 percent for the protocol group and 86 percent for the control group ($p = 0.87$) (**level II evidence**).

Koutcher and colleagues at Memorial Sloan-Kettering Cancer Center evaluated the adequacy of intensity-modulated PMRT following immediate expander-implant reconstruction.¹⁶ Forty-one patients were identified and assessed for chest wall coverage and volume of heart and lungs irradiated. In 73 percent of the patients, all chest wall borders were adequately covered, and in 22 percent, all borders but 1 were adequately covered. At a median follow-up time of 29 months, the 30-month actuarial local control rate was 97 percent. They authors concluded that in women undergoing immediate expander-implant reconstruction, PMRT can achieve excellent local control with acceptable heart and lung doses, but when the internal mammary nodes are being treated, the doses to the heart and lungs will be higher than if the mammary nodes are not treated (**level III evidence**).

NEED FOR UNPLANNED OR MAJOR CORRECTIVE SURGERY IN IRRADIATED RECONSTRUCTED BREASTS

An interesting study assessed fibrosis of the reconstructed breast after radiation therapy in 109 patients who underwent breast reconstruction followed by PMRT.¹⁷ The median radiation therapy dose was 50.4 Gy; 44 patients received a boost dose of 10 Gy. Eighty-two patients had implant-based reconstructions, 20 had autologous tissue-based reconstructions, and 7 had combined reconstructions. In the implant group, fibrosis was assessed using the Baker classification; in all patients, fibrosis was assessed using the Common Terminology Criteria for Adverse Events. After a mean follow-up time of 34 months, the 3-year incidence of grade III fibrosis was 20 percent for the implant-based reconstructions and 43 percent overall. The 3-year rate of surgical correction of the contralateral breast was 30 percent, and 39 patients (35.8 percent) required unplanned surgery on the reconstructed breast. Boost treatment and reconstruction type (implant versus autologous tissue) were not significantly associated with the incidence of fibrosis (**level IV evidence**).

A study by Wong and colleagues evaluated the incidence of major corrective surgery in 62 patients who underwent modified radical mastectomy, immediate reconstruction, and radiation therapy.¹⁸ Nine patients had reconstruction with implants alone, 6 had reconstruction with an LD flap, 5 had reconstruction with an LD flap plus an implant, and 42 had reconstruction with autologous tissue alone. The median follow-up time was 10 months for implant patients and 13 months for nonimplant patients. The incidence of major corrective surgery was 40 percent (6/15 reconstructions) in the implant group and 9 percent (4/47) in the nonimplant group. Among the patients who were followed up for at least 6 months after PMRT, the rate of major corrective surgery within 6 months was 23 percent (3/13) in the implant group and 0 (0/38) in the nonimplant group ($p = 0.01$). Among the patients followed up for at least 12 months after PMRT, the rate of major corrective surgery within 12 months was 29 percent (2/7) in the implant group and 4 percent (1/24) in the nonimplant group. The authors concluded that patients who undergo mastectomy and immediate implant-based reconstruction followed by PMRT are at high risk for needing subsequent major corrective surgery. The difference in the rate of major corrective surgery

between the implant and nonimplant groups was significant in early follow-up (**level III evidence**).

AUTOLOGOUS FAT GRAFTING TO IMPROVE COSMETIC OUTCOMES AFTER IRRADIATION OF RECONSTRUCTED BREASTS

A study evaluated the impact of fat grafting after irradiation of breasts reconstructed using implants.¹⁹ The study included 61 patients with 62 reconstructed breasts; twenty patients underwent multiple sessions of lipofilling, and the others did not and were considered controls. Three months after the last session of fat grafting, functional outcome was assessed using the LENT-SOMA scoring system (patient-scored symptom questionnaire of late treatment effects), and aesthetic outcome was evaluated using a visual 5-point scale. The LENT-SOMA scores after fat grafting were significantly better than those before fat grafting and were also significantly better than those for the untreated breasts. Similarly, the cosmetic outcomes were significantly enhanced after lipofilling. No complications occurred in the treated patients (**level II evidence**).

Another study assessed the outcome of injecting autologous fat grafts at the time of delayed expander placement after prior mastectomy and radiation therapy.²⁰ In 65 patients, at the first operation, the authors inserted a tissue expander endoscopically under the pectoralis major muscle and performed total immediate expansion. The authors injected a mean of 150 ± 25 cc of fat in the upper quadrants between the skin and the pectoralis muscle. Three months later, they removed the expander, inserted a silicone implant, and injected a mean of 150 ± 30 cc of fat in the lower quadrants. After a mean follow-up time of 1 year, no complications were reported with fat injections; patients' mean satisfaction rating was 4 on a scale of 1 (low) to 5 (high); and there were no cases of capsular contracture greater than Baker I (**level II evidence**).

SUMMARY AND CLINICAL IMPACT OF THE EVIDENCE

Despite advances in reconstructive devices and materials, PMRT still appears to have an adverse impact on outcomes of implant-based breast reconstruction.^{2,3} Unfortunately, the most recent studies find a significant need for unplanned or major corrective surgery in irradiated breasts reconstructed with implants.^{17,18} However, the majority of patients who undergo implant-based reconstruction and PMRT ultimately keep the implant-based reconstruction; only a minority of patients require conversion to an autologous tissue flap.² Approximately one-third of patients continue to develop Baker III or IV capsular contracture.^{4,8} Despite higher patient satisfaction with silicone implants than with saline implants, receipt of prior radiation therapy or a history of PMRT has a significant negative effect on patient satisfaction.

Immediate one-stage reconstruction with placement of the implant at the time of mastectomy in patients who received PMRT had a significantly higher need for revision and lower aesthetic outcome scores than patients who had two-stage implant reconstruction with placement of the implant after PMRT.⁷ With two-stage implant reconstruction, exchange for the implant before PMRT had an higher overall complication rate than control patients (no PMRT); patients who have the implant placed after PMRT had no differences when compared with control patients.¹⁰

In the setting of PMRT, implant-based reconstruction continues to be associated with a higher incidence of major corrective surgery than autologous tissue-based reconstruction. Studies show that autologous tissue tolerates radiation better than implants.^{9,18} However, the addition of an autologous tissue flap to an implant-based breast reconstruction decreases

complications and reconstructive failures in previously irradiated patients.¹⁴ With LD flap and implant reconstruction, better aesthetic outcomes are found with delayed reconstruction after PMRT than with immediate reconstruction before PMRT because of improved volume and contour in the upper pole of the reconstructed breast.¹¹

Several studies reviewed found no significant evidence that a tissue expander or a breast implant on the chest wall during radiation delivery increases the risk of breast cancer recurrence.^{15,16} However, if the internal mammary nodes need to be treated in a patient with an implant on the chest wall, higher doses of radiation may have to be delivered to the heart and lungs, which may increase the risk of coronary artery disease and pulmonary fibrosis.¹⁶ Another approach to radiation delivery has included radiation therapy hypofractionation (40 Gy in 15 fractions over 3 weeks). Unfortunately, recent studies of radiation therapy hypofractionation has not shown promise in terms of reducing long-term rates of capsular contracture.⁵

Autologous fat grafting has become a popular technique to enhance the aesthetic outcomes after irradiation of reconstructed breasts. With this approach, improvements have been observed not only in aesthetic outcome but also in terms of fewer late effects of radiation therapy.¹⁹ It has even been suggested that autologous fat grafting in radiated implant-based reconstructions may even reduce the incidence of capsular contracture.²⁰ Classification of postradiation skin changes based on the degree of induration and on the severity of skin changes have been proposed to select the most suitable patients for delayed two-stage implant reconstruction.¹³

In conclusion, the increasing use of autologous fat grafting, acellular dermal matrix, and the potential for less tissue reactive techniques for radiation delivery hold promise for improving the outcomes of implant-based breast reconstruction in the setting of radiation. However, in the meantime, patients who will receive or have received radiation should be advised of the risks of implant-based breast reconstruction.

Acknowledgments

MD Anderson is supported in part by the National Institutes of Health through MD Anderson's Cancer Center Support Grant, CA016672.

REFERENCES

1. Kronowitz SJ, Robb GL. Radiation therapy and breast reconstruction: a critical review of the literature. *Plast Reconstr Surg*. 2009; 124(2):395–408. [PubMed: 19644254]
2. Berry T, Brooks S, Sydow N, Djohan R, Nutter B, Lyons J, Dietz J. Complication rates of radiation on tissue expander and autologous tissue breast reconstruction. *Ann Surg Oncol*. Oct; 2010 17(Suppl 3):202–10. [PubMed: 20853034]
3. McCarthy CM, Klassen AF, Cano SJ, Scott A, Vanlaeken N, Lennox PA, Alderman AK, Mehrara BJ, Disa JJ, Cordeiro PG, Pusic AL. Patient satisfaction with postmastectomy breast reconstruction: a comparison of saline and silicone implants. *Cancer*. Dec 15; 2010 116(24):5584–91. [PubMed: 21136577]
4. Hvilsum GB, Hölmich LR, Steding-Jessen M, Frederiksen K, Henriksen TF, Lipworth L, McLaughlin J, Elberg JJ, Damsgaard TE, Friis S. Delayed Breast Implant Reconstruction: Is Radiation Therapy Associated With Capsular Contracture or Reoperations? *Ann Plast Surg*. May 2.2011 E-pub.
5. Whitfield GA, Horan G, Irwin MS, Malata CM, Wishart GC, Wilson CB. Incidence of severe capsular contracture following implant-based immediate breast reconstruction with or without postoperative chest wall radiotherapy using 40 Gray in 15 fractions. *Radiother Oncol*. Jan; 2009 90(1):141–7. Epub 2008 Nov 1. [PubMed: 18977547]

6. Khansa I, Colakoglu S, Curtis MS, Yueh JH, Ogunleye A, Tobias AM, Lee BT. Postmastectomy breast reconstruction after previous lumpectomy and radiation therapy: analysis of complications and satisfaction. *Ann Plast Surg.* May; 2011 66(5):444–51. [PubMed: 21451371]
7. Roostaeian J, Pavone L, Da Lio A, Lipa J, Festekjian J, Crisera C. Immediate placement of implants in breast reconstruction: patient selection and outcomes. *Plast Reconstr Surg.* Apr; 2011 127(4): 1407–16. [PubMed: 21460648]
8. Gross E, Hannoun-Levi JM, Rouanet P, Houvenaeghel G, Teissier E, Ellis S, Resbeut M, Tallet A, Vaini Cowen V, Azria D, Cowen D. [Evaluation of immediate breast reconstruction and radiotherapy: factors associated with complications]. *Cancer Radiother.* Dec; 2010 14(8):704–10. Epub 2010 Aug 2. French. [PubMed: 20674442]
9. Jhaveri JD, Rush SC, Kostroff K, Derisi D, Farber LA, Maurer VE, Bosworth JL. Clinical outcomes of postmastectomy radiation therapy after immediate breast reconstruction. *Int J Radiat Oncol Biol Phys.* Nov 1; 2008 72(3):859–65. Epub 2008 May 28. [PubMed: 18472362]
10. Lee BT, A Adesiyun T, Colakoglu S, Curtis MS, Yueh JH, E Anderson K, Tobias AM, Recht A. Postmastectomy radiation therapy and breast reconstruction: an analysis of complications and patient satisfaction. *Ann Plast Surg.* May; 2010 64(5):679–83. [PubMed: 20395800]
11. McKeown DJ, Hogg FJ, Brown IM, Walker MJ, Scott JR, Weiler-Mithoff EM. The timing of autologous latissimus dorsi breast reconstruction and effect of radiotherapy on outcome. *J Plast Reconstr Aesthet Surg.* Apr; 2009 62(4):488–93. [PubMed: 18262481]
12. Barry M, Kell MR. Radiotherapy and breast reconstruction: a meta-analysis. *Breast Cancer Res Treat.* May; 2011 127(1):15–22. Epub 2011 Feb 20. [PubMed: 21336948]
13. Parsa AA, Jackowe DJ, Johnson EW, Lye KD, Iwahira Y, Huynh TV, Pedro P, Pang J, Parsa FD. Selection criteria for expander/implant breast reconstruction following radiation therapy. *Hawaii Med J.* Apr; 2009 68(3):66–8. [PubMed: 19441617]
14. Chang DW, Barnea Y, Robb GL. Effects of an autologous flap combined with an implant for breast reconstruction: an evaluation of 1000 consecutive reconstructions of previously irradiated breasts. *Plast Reconstr Surg.* Aug; 2008 122(2):356–62. [PubMed: 18626350]
15. Kronowitz SJ, Lam C, Terefe W, Hunt KK, Kuerer HM, Valero V, Lance S, Robb GL, Feng L, Buchholz TA. A multidisciplinary protocol for planned skin-preserving delayed breast reconstruction for patients with locally advanced breast cancer requiring postmastectomy radiation therapy: 3-year follow-up. *Plast Reconstr Surg.* Jun; 2011 127(6):2154–66. [PubMed: 21311392]
16. Koutcher L, Ballangrud A, Cordeiro PG, McCormick B, Hunt M, Van Zee KJ, Hudis C, Beal K. Postmastectomy intensity modulated radiation therapy following immediate expander-implant reconstruction. *Radiother Oncol.* Mar; 2010 94(3):319–23. [PubMed: 20096946]
17. Classen J, Nitzsche S, Wallwiener D, Kristen P, Souchon R, Bamberg M, Brucker S. Fibrotic changes after postmastectomy radiotherapy and reconstructive surgery in breast cancer. A retrospective analysis in 109 patients. *Strahlenther Onkol.* Nov; 2010 186(11):630–6. [PubMed: 21072625]
18. Wong JS, Ho AY, Kaelin CM, Bishop KL, Silver B, Gelman R, Harris JR, Hergrueter CA. Incidence of major corrective surgery after post-mastectomy breast reconstruction and radiation therapy. *Breast J.* Jan-Feb; 2008 14(1):49–54. [PubMed: 18186865]
19. Panettiére P, Marchetti L, Accorsi D. The serial free fat transfer in irradiated prosthetic breast reconstructions. *Aesthetic Plast Surg.* Sep; 2009 33(5):695–700. Epub 2009 May 30. [PubMed: 19484176]
20. Serra-Renom JM, Muñoz-Olmo JL, Serra-Mestre JM. Fat grafting in postmastectomy breast reconstruction with expanders and prostheses in patients who have received radiotherapy: formation of new subcutaneous tissue. *Plast Reconstr Surg.* Jan; 2010 125(1):12–8. [PubMed: 20048576]

Fig. 1.
Citation Attribution Diagram

Table 1

American Society of Plastic Surgeons Evidence Rating Scale for Therapy

Level of Evidence	Qualifying Studies
I	High-quality, multicenter or single-center randomized controlled trial with adequate power; or systematic review of these studies.
II	Lesser quality, randomized controlled trial; prospective cohort study; or systematic review of these studies.
III	Retrospective comparative study; case-control study; or systematic review of these studies
IV	Case series
V	Expert opinion; case report or clinical example; or evidence based on physiology, bench research, or “first principles”

Reproduced with permission from Haase SC, Chung KC. An Evidence-Based Approach to Treating Thumb Carpometacarpal Joint Arthritis. *Plast Reconstr Surg* 127(2):918-25 2011.

Table 2

Evidence of Impact of Radiation on Breast Reconstructive Technique

Reference	Level of Evidence	Reconstructions	Timing of Reconstruction	Reconstructive Techniques	Results	Conclusion
Berry T, et al ²	III	1037 patients	Immediate	2-stage implant, Autologous (latissimus dorsi; pedicled and free TRAM; DIEP flaps)	Radiation increased the major complication rate of 2-stage implant reconstruction from 21.2 to 45.4%. There was no significant difference between the radiated and non-radiated autologous tissue reconstructions.	Increased major complication with radiated TE, but still successful majority of cases and radiation has no influence on autologous tissue reconstruction.
McCarthy CM, et al ³	I	482 patients	Delayed	Implant	Silicone implants preferred (P=.016) however receipt of PMRT had a significant negative effect on patient satisfaction (P < .000)	Information can be used to optimize patient decision-making.
Hvilsom GB, et al ⁴	II	717 reconstructions	Delayed	1- and 2-stage implant	History of PMRT associated with increased risk of severe capsular contracture for 1- and 2-stage procedures.	Breast Reconstruction approaches other than implants should be seriously considered among women who have received radiation therapy.
Whitfield GA, et al ⁵	III	178 patients	Immediate	1-and 2-stage implant (TE/I); autologous tissue (latissimus dorsi, pedicled and free TRAM, and DIEP flaps)	110 patients had implant-based reconstruction with a median follow up of 51 months. In the RT group (41 patients), there were 8 patients with severe capsular contracture, a crude rate of 19.5%, and in the unirradiated group, there were no cases of severe capsular contracture (p < 0.001).	This series showed a higher rate of capsular contracture with radiation therapy hypofractionation (40 Gy in 15 fractions over 3 weeks)
Khansa I, et al ⁶	III	802 reconstructions	Immediate postmastectomy reconstruction after prior BCT (lumpectomy plus radiation therapy)	2-stage implant (TE/I); autologous tissue (latissimus dorsi, pedicled and free TRAM, and DIEP flaps)	Prior BCT did not correlate with higher complication rates (p = 0.690) or lower satisfaction (p = 0.559); however, there was a higher rate of mastectomy skin flap necrosis with prior BCT compared to no prior BCT (12.4% versus 6.8%, p = 0.024).	Prior BCT does not increase overall complication rates or reduce satisfaction with breast reconstruction after completion mastectomy.
Roostaean J, et al ⁷	IV	35 patients	Immediate	Direct to Implant (1 stage implant)	Patients who receive PMRT had a significant (P=0.047) need for revision and lower mean in aesthetic scores than patients who did not receive PMRT (2.46 versus 3.19, respectively).	Immediate implant breast reconstruction safe and viable option. Recommend caution and patient counseling with history of PMRT.
Gross E, et al ⁸	II	141 patients	Immediate	2-stage implant	Baker 1 and 2 capsular contracture in 67.5%, Baker 3	Highest risk with immediate 2-stage implant in patients with large tumors T3/T4,

Reference	Level of Evidence	Reconstructions	Timing of Reconstruction	Reconstructive Techniques	Results	Conclusion
Jhaveri JD, et al ⁹	II	92 patients	Immediate	2-stage implant (TE/D); autologous tissue (latissimus dorsi, pedicled and free TRAM, and DIEP flaps)	The rate of grade 3 or 4 complications (necessitating surgical intervention or removal or replacement of reconstructed breast) was 33.3% for TE/I versus 0% for autologous tissue (p = 0.001). Acceptable cosmesis was reported in 51% of TE/I versus 82.6% of autologous tissue reconstruction (p = 0.007).	In patients undergoing PMRT after immediate reconstruction, autologous tissue-based reconstruction is associated with fewer long-term complications and better cosmetic results than reconstruction with a tissue expander plus an implant.
Lee BT, et al ¹⁰	III	919 reconstructed breasts	Immediate; Delayed	2-stage; Autologous with implant; Autologous only	Overall complication rates of patients who received PMRT before or after were higher than control group (no PMRT) (39.66% versus 23.16%; P<0.001).	Proper counseling of patients who may need PMRT, including her timing of reconstruction and PMRT may affect type of reconstruction.
McKeown DJ, et al ¹¹	III	24 patients	Immediate; Delayed	Autologous Latissimus Dorsi	Trend toward better outcomes in patients undergoing delayed reconstruction after PMRT than immediate reconstruction before PMRT, with volume and contour (upper pole) being most affected.	Similar patient satisfaction between 2 groups but most patients would have preferred immediate reconstruction before PMRT, so continue to offer immediate autologous latissimus reconstruction, yields satisfactory outcome.
Barry M, Kell MR ¹²	III	1105 (meta-analysis)	Immediate; delayed	2-stage implant (TE/D); autologous tissue (latissimus dorsi, pedicled and free TRAM, and DIEP flaps)	Patients undergoing PMRT were more likely to suffer morbidity compared to patients not undergoing PMRT. When PMRT was delivered after breast reconstruction, autologous reconstruction was associated with less morbidity than implant-based reconstruction.	PMRT has a detrimental effect on breast reconstruction outcome. When PMRT is delivered after immediate reconstruction, use of an autologous tissue flap results in less morbidity than implant-based reconstruction.
Parsa AA, et al ¹³	II	170 patients	Delayed	2-stage bilateral implant (PMRT to only 1 side of chest wall)	Patients who develop induration or severe post-radiation skin changes, have a greater rate of Baker class IV capsular contracture and poor results that range from 75% to 100% of reconstructed breasts.	A history of chest wall radiation should not exclude a patient from receiving tissue expander/implant reconstruction, especially patients who do not have severe skin changes or induration.
Chang D, et al ¹⁴	III	1000 patients	Delayed	2-stage implant; latissimus plus implant; TRAM plus implant	Fewer reconstruction failures when TRAM or latissimus combined with implant than with implant alone.	The addition of flap to implant in a previously irradiated breast has lower rates of implant loss.

Reference	Level of Evidence	Reconstructions	Timing of Reconstruction	Reconstructive Techniques	Results	Conclusion
Kronowitz S1, et al ¹⁵	II	47 patients	Delayed-delayed	Tissue expander placement at mastectomy to preserve breast skin followed by a delayed autologous tissue-based reconstruction after PMRT using preserved breast skin	The protocol group had a lower rate of complications of definitive breast reconstruction than the standard delayed-reconstruction group (24% versus 38%). There was no difference in 3-year recurrence-free survival rates between the groups.	Patients with advanced breast cancer may be able to undergo skin-preserving breast reconstruction after PMRT.
Koucher L, et al ¹⁶	III	41 patients	Immediate	2-stage implant (TE/I)	In 73% of patients, all chest wall borders were adequately covered, and in 22%, all borders but 1 were adequately covered; 30-month actuarial local control was 97%.	Women undergoing immediate expander-implant reconstruction, PMRT can achieve excellent local control with acceptable heart and lung doses
Classen J, et al ¹⁷	IV	109 patients	Immediate	2-stage implant (TE/I); autologous tissue (latissimus dorsi, pedicled and free TRAM, and DIEP flaps)	After a mean follow-up of 34 months, the 3-year incidence of grade III fibrosis was 20% as assessed using the Baker score (implant-based reconstructions) and 43% as assessed using the CTC/AE.	Severe fibrosis is a frequent complication after breast reconstruction and PMRT.
Wong JS, et al ¹⁸	III	62 patients	Immediate	Pedicled TRAM flap; latissimus dorsi flap; latissimus dorsi flap plus implant; implant alone	Of the patients followed 6 months after PMRT, none of the 38 nonimplant patients underwent major corrective surgery within 6 months, compared to 3 of the 13 (23%) implant patients (p = 0.01).	Patients who undergo immediate implant-based reconstruction followed by PMRT have a high rate of major corrective surgery.
Panettiere P, et al ¹⁹	II	61 patients	Immediate	Implants	Improvement in LENT-SOMA scores after fat grafting; the scores after fat grafting were lower than those before fat grafting and lower than irradiated reconstruction that were not fat grafted.	Fat grafting improves outcomes of irradiated reconstructed breasts with implants.
Serra-Renom JM, et al ²⁰	II	65 patients	Delayed	2-stage implant (TE/I)	Delayed 2-stage implant reconstruction after PMRT with fat grafting at time of expander placement and implant exchange was associated with no complications, good patient satisfaction, and no cases of capsular contracture (>than Baker classification 1).	With delayed reconstruction after PMRT, fat grafting in addition to traditional tissue expander and implant breast reconstruction achieves better outcomes with creation of new subcutaneous tissue.

PMRT: postmastectomy radiation therapy; TE: tissue expander; DIEP: deep inferior epigastric perforator; TRAM: transverse rectus abdominis myocutaneous; TFL: tensor fasciata, SIEA: superficial inferior epigastric artery; SGAP: superior gluteal artery perforator