

Does postoperative radiation therapy represent a contraindication to expander-implant based immediate breast reconstruction? An update 2012-2014

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Abstract. – OBJECTIVE: Post-mastectomy radiotherapy (PMRT) is well known in the plastic surgery community for having a negative impact on expander-implant based immediate breast reconstruction (IBBR), although recently some technical improvements allow better results. Very recent papers would suggest that there is no difference in postoperative complications in patients receiving post-mastectomy radiotherapy using modern techniques. However, study results are often biased by small groups of patients and by heterogeneity of radiotherapy timing, different surgical techniques and measured outcomes.

MATERIALS AND METHODS: We have conducted a MEDLINE search to summarize the latest data (2012-2014) on the topic. Search was conducted using the following parameters: breast reconstruction AND implant AND expander AND post-mastectomy radiotherapy.

RESULTS: The MEDLINE search showed 53 reports, demonstrating a great interest on this topic; among these 37 dealt specifically with post-mastectomy radiotherapy after breast reconstruction. In particular, 15 were amenable to plastic surgeons, 6 to breast surgeons, 9 to radiotherapists and 7 to oncologists. Papers amenable to plastic surgeons highlighted the highest rate of undesired results, although with recent advances such as delayed-immediate reconstruction or protective lipofilling.

CONCLUSIONS: PMRT remains an undesired event when pursuing an implant-based breast reconstruction, although it does not represent an absolute contraindication. The higher rate of complications reported by plastic surgeons and not by other specialists can be explained with the greater attention to aesthetic details, such as capsular contractures, that our community has. Technical strategies to prevent complications described in this community

now allow better results, should be well known and improved if possible in the future.

Key Words:

Immediate breast reconstruction, Mastectomy, Radiotherapy, Implant, Expander.

Introduction

Breast reconstruction is becoming more and more an integral part of breast cancer treatment, due to the younger age of detection and to the good results now possible^{1,2}. Expander/implant based breast reconstruction appears to be the most common type of breast reconstruction, reaching 80% of any reconstruction in most centers³. The trend is moving undoubtedly to immediate instead of delayed reconstruction⁴. On the other side, trend towards partial and conservative (Skin and Nipple Sparing Mastectomies, SSM & NSM) mastectomies is creating a rise in the number of patients undergoing radiotherapy.

PMRT is currently indicated for patients with T3 or stage III tumors and those with 4 or greater positive axillary nodes. The median dose used in patients with a tumor larger than 5 cm and with more than 4 positive lymph nodes is 50 Gy five days a week for 5 weeks⁵, although the indications are now broadening with lower doses (hypofractionated therapy). PMRT is well known in the medical community for having a negative impact on immediate IBBR⁶, although new technical strategies are now decreasing complications. However, in the last years several papers from other scientific communities seem to invalidate

these data, suggesting the feasibility of IBBR in the setting of PMRT.

The aim of our study was to review the most recent data on this topic in order to have realistic and updated results, elucidating modern strategies to minimize complications.

Materials and Methods

The Pubmed search was set for the following terms: breast reconstruction AND implant AND expander AND post-mastectomy radiotherapy, limiting the search to the period 2012-2014. All studies that reported outcomes of expander/implants reconstruction with the use of post-mastectomy radiotherapy were searched. Relevant publications were identified. Studies where data could not be extracted or where patients number was not relevant were excluded from the study. Then, papers were also divided according to the leading specialty analyzing data (e.g.: plastic surgery, radiotherapy, oncology, etc.).

Results

Among papers published on the topic, most were amenable to plastic surgeons, followed by, in descending order, radiotherapists and radiologists, oncologists and breast surgeons. A summarizing table follows (Table I).

Discussion

Breast cancer is the leading cause of death in women worldwide with an estimated incidence of 1 every 9 woman affected. Surgery, combined with radiotherapy and systemic oncological treatments, represents the mainstay for stages II-III. Breast conserving surgery and mastectomy are the available surgical options: the choice between them depends on tumor characteristics and patient preferences¹. Mastectomy followed by IBBR is, in most cases, a favorable option^{2,4}, however post-reconstruction radiation therapy increases many immediate and late complications (Figures 1 and 2) such as capsular contracture, tissue ulceration, implant exposure with final implant removal and reconstructive failure^{5,6}. Patients who had PMRT following immediate breast reconstruction with autologous tissues demonstrated suboptimal aesthetic results with other kind of complications

Table I. Papers published on the topic divided according to the leading specialty.

Specialty	No of papers
Plastic Surgery	15
Radiotherapy	9
Oncology	7
Breast Surgery	6

(liponecrosis, flap atrophy), which analysis is beyond the aim of this paper⁷.

Recently, the scenario has changed, together with a great scientific interest on the topic. Although PMRT has been considered a relative contraindication to IBBR⁴, some studies are now invalidating this consideration. On the other side, new approaches such as the delayed-immediate reconstruction⁸, the MSKCC protocol⁹ and protective lipofilling¹⁰ on irradiated expanders are decreasing complications in this subset of patients.

Historically, the approach of radiologists and radiotherapists was negative towards the effect of irradiation to breast reconstruction, often suggesting to delay reconstructive procedures. Krueger compared the rates of complications and patient satisfaction among breast cancer patients treated with mastectomy and tissue expander/implant reconstruction with and without radiotherapy, showing how irradiated patients had a higher rate of expander/implant reconstruction failure and complications than non-irradiated patients⁵. A study conducted in 2006 quantified the impact of PMRT planning on immediate breast reconstruction; patients who had mastectomy and immediate reconstruction followed by radiation therapy were compared with patients who had undergone mastectomy without intervening reconstruction. The study showed that radiation treatment planning after immediate breast reconstruction was compromised in more than half of the patients, with the largest compromises observed in those with left-sided cancers⁶.

However, recently Anderson et al¹¹ underlines the feasibility of breast reconstruction in the setting of PMRT with no significant difference in the overall rate of major or minor complications found between patients who underwent breast reconstruction with a tissue expander/implant or permanent implant followed by PMRT.

Carnevale et al¹² evaluated treatment related complications, outcomes and patient satisfaction

in women with locally advanced breast cancer who received post-mastectomy radiation therapy after breast reconstruction. Their conclusion was that radiotherapy can be safely delivered after breast reconstruction, with a low complication rate and good patient satisfaction. Eriksson et al¹³ analyzed the effects of prior and postoperative radiotherapy on surgical outcomes and patient-reported outcome measures in implant based immediate breast reconstruction. The post-operative infection rate did not differ between postoperatively irradiated and non-irradiated patients but was higher in previously irradiated patients.

The plastic surgery community usually highlights the complications caused by radiotherapy in IBBR. Pestana et al¹⁴ tried to evaluate factors associated with increased rate of complications in women who underwent breast reconstruction as well as radiotherapy. They conducted a review of patients who underwent mastectomy, radiation and breast reconstruction, and collected patient demographics, operative procedure, breast irradiation timing and postoperative complications. Firstly, they found that the timing of the radiation can be a significant factor that can affect outcomes in irradiated breast reconstructions: patients who underwent irradiation before reconstruction were much better than patients who had radiotherapy after reconstruction to be completed. Secondly, patients with implant-based recon-



Figure 1. Chronic ulcerative radiodermatitis in a patient who underwent breast reconstruction with prosthesis.



Figure 2. Salvage with *Latissimus dorsi* flap.

struction were far more likely to have a failure of their reconstruction when compared to autologous reconstruction. Thirdly, the use of acellular dermal matrices during reconstruction showed an increased risk of major complications. Fourthly, implant-based reconstruction also correlates with higher rates of complications. Fifthly, factors like age, BMI, smoking and diabetes were not associated with increased complications or reconstruction failure rates. Kronowitz¹⁵ in 2012 also highlights the increased complications of implant based reconstruction in the setting of PMRT. He identified 285 articles, 19 were reviewed in detail. The most recent studies find a significant need for unplanned or major corrective surgery in irradiated breast reconstructed with implants. Patient surveys show that irradiation has a significantly negative effect on patient satisfaction.

Particular types of mastectomy were also studied. Reish et al¹⁶ evaluated the breast reconstruction outcomes after nipple-sparing mastectomy and radiation therapy. Outcomes of irradiated patients and non-irradiated patients were compared: patients with radiation had higher incidence of a secondary procedure for capsular contracture. The total nipple retention rate in patients with radiation and nipple-sparing mastectomy was high, and the reconstruction failure rate was 8%. So nipple-sparing mastectomy and immediate reconstruction in patients who had or will have radia-

tion is associated with higher incidence of complications and operative revisions compared to patients without radiation.

In the effort of limiting complications, a question was raised on the possible benefit of irradiating deflated expanders. A study conducted by Celet Ozden¹⁷ on rabbits answered to this question, showing that expander deflation immediately prior to radiotherapy may even increase the adverse effects such as chronic radiodermatitis (epidermal atrophy, dermal inflammation and fibrosis, neovascularisation and vascular changes as well as increased capsule thickness) especially around the lower expander pole. Newer techniques such as protective lipofilling or the delayed-immediate approach are helping. Protective lipofilling aims at giving at irradiated expanders a fat capsule, thus, avoiding skin ulceration, capsular contracture, and implant exposure.

The delayed-approach, described by Krownitz⁹, bypasses the problem but indeed proposes the use of autologous tissue, after radiotherapy on the expander. In summary, the point of view of plastic surgeons on the problem remains skeptical^{18,19}.

Recently, Cordeiro et al²⁰ published the largest prospective long-term study concerning the outcomes evaluation in women with immediate tissue expander/implant reconstruction and post-mastectomy radiation therapy. The study was conducted on a total of 2133 breast implant reconstructions with a mean follow-up of 56.8 months. Three hundred nineteen implants received radiation. Implant loss occurred in 9.1% of irradiated implants and 0.5 percent of nonirradiated implants. Capsular contracture grade IV was present in 6.9 percent of irradiated and 0.5 percent of nonirradiated implants. They found no difference between groups regarding implant replacement. Ninety-two percent of irradiated patients had good to excellent aesthetic result, and 94.2% would choose implants again. Predicted implant loss rates were 17.5% and 2.0% for irradiated and nonirradiated implants, respectively, at 12 years, and predicted implant replacement rates were 12.7 percent and 8.8 percent, respectively, at 8 years. Most patients had a good to excellent aesthetic result and preserve their reconstruction at 12 years²⁰.

The opinion of general surgeons (breast surgeons) is somewhat in the middle. Korwar et al²¹ illustrated the effects of radiotherapy on complications and patient reported outcomes after skin reducing mastectomy and immediate reconstruc-

tion. A prospective database of women undergoing skin reducing mastectomy, dermal sling and immediate implant reconstruction was analyzed. They found no statistically significant increased rate of major complications like implant loss and capsular contracture when skin reducing mastectomy and immediate reconstruction are combined with radiotherapy. In their opinion, the overall patient satisfaction was high even after radiotherapy.

Baschnagel et al²² reported the rate of breast reconstruction failure and cosmetic outcomes after post-mastectomy radiation therapy with temporary tissue expanders or implants in place. No risk factors, as smoking, diabetes mellitus, hypertension, menopausal status, were found to be associated with reconstruction failure. In many patients who did not experience reconstruction failure, good cosmesis was observed.

Shah et al²³ examined cosmesis, complications, and factors associated with aesthetic outcomes in patients undergoing reconstruction and receiving post-mastectomy radiotherapy: radiotherapy with breast reconstruction is potentially associated with increased rates of complications and reconstruction loss regardless of reconstruction techniques utilized.

Sharpe et al²⁴ studied the impact of bilateral mastectomy versus unilateral mastectomy on short term outcomes and adjuvant therapy: bilateral mastectomy patients have significantly greater delays in having surgery and receiving adjuvant therapy; however, these data may not be clinically significant.

Collier et al²⁵ studied the problem minimizing the deleterious effect of radiotherapy following 54 patients who underwent implant based breast reconstruction and received postmastectomy radiation and comparing complications such as infection, implant loss and capsular contracture between two groups. What they observed was that the timing of radiation did not affect individual complication rates for patient who underwent implant-based breast reconstruction after immediate tissue expander placement. The same conclusion was reached by Aristei et al²⁶, they in particular followed 101 patients, from 1997 to 2009, who received RT after breast reconstruction. 92 of these, because of risk factors for relapse and 9 because the relapse had occurred. At RT, 90 patients had temporary tissue expanders and 11 had permanent implants. 12 patients underwent neoadjuvant chemotherapy; all patients received adjuvant chemo-and/or hormone therapy. What he

observed was that at a median follow-up of 50 months, late toxicities occurred in 28 patients such as pain, lymphedema, cutaneous and subcutaneous toxicity, rupture, displacement or loss of shape of the prosthesis was observed in 8 patients. Capsular contracture of various stage was classified in 89 patients. A total of 12 prostheses were removed. Judgments of cosmetic results were available from 81 physicians and 84 patients. Outcomes were excellent/good in 58/81 physician judgments and in 57/84 patient evaluations. Overall inter-rater agreement on outcome was good.

In conclusion, he asserts that RT to reconstructed breast was associated with low rates of late toxicity and prosthesis removal as well as cosmetic outcomes that were, on the whole, good to excellent.

Conclusions

The use of PMRT is increasing, together with the trend towards breast conserving surgery, and this can increase the rate of complications in patients undergoing breast reconstruction, especially for IBBR. The positive results reported in some studies are amenable to different specialties other than Plastic Surgery, and can be confusing. PMRT remains an undesired event in the setting of immediate breast reconstruction, particularly when performed with expander and implants²⁷⁻³². However, PMRT should NOT be considered anymore a contraindication to expander-implant based breast reconstruction³³⁻³⁵, because of new techniques and protocols such as 1) the *delayed immediate* approach 2) the *MSKCC protocol* and 3) *protective lipofilling on irradiated expanders*^{36,37}.

Conflict of Interest

The Authors declare that they have no conflict of interests.

References

- 1) SIGURDSON L, LALONDE DH. MOC-PS CME article: Breast reconstruction. *Plast Reconstr Surg* 2008; 121(1 Suppl): 1-12.
- 2) ROJE Z, ROJE Z, JANKOVIC S, NINKOVIC M. Breast reconstruction after mastectomy. *Coll Antropol* 2010; 34(Suppl 1): 113-123.
- 3) ALBORNOZ CR, BACH PB, MEHRARA BJ, DISA JJ, PUSIC AL, MCCARTHY CM, CORDEIRO PG, MATROS E. A paradigm

shift in US breast reconstruction: increasing implant rates. *Plast Reconstr Surg* 2013; 131: 15-23.

- 4) ANANTHAKRISHNAN P, LUCAS A. Options and considerations in the timing of breast reconstruction after mastectomy. *Cleve Clin J Med* 2008; 75(Suppl 1): S30-33.
- 5) KRUEGER EA, WILKINS EG, STRAWDERMAN M, CEDERNA P, GOLDFARB S, VICINI FA, PIERCE LJ. Complications and patient satisfaction following expander/implant breast reconstruction with or without radiotherapy. *Int J Radiat Oncol Biol Phys* 2001; 49: 713-721.
- 6) MOTWANI SB, STROM EA, SCHECHTER NR, BUTLER CE, LEE GK, LANGSYEIN HN, KRONOWITZ SJ, MERIC-BERNSTAM F, IBRAHIM NK, BUCHHOLZ TA. The impact of immediate breast reconstruction on the technical delivery of postmastectomy radiotherapy. *Int J Radiat Oncol Biol Phys* 2006; 66: 76-82.
- 7) TRAN NV, CHANG DW, GUPTA A, KROLL SS, ROBB GL. Comparison of immediate and delayed free TRAM flap breast reconstruction in patients receiving postmastectomy radiation therapy. *Plast Reconstr Surg* 2001; 108: 78-82.
- 8) KRONOWITZ SJ, HUNT KK, KUERER HM, BABIERA G, MCNEESE MD, BUCHHOLZ TA, STROM EA, ROBB GL. Delayed-immediate breast reconstruction. *Plast Reconstr Surg* 2004; 113: 1617-1628.
- 9) HO A, CORDEIRO P, DISA J, MEHRARA B, WRIGHT J, VAN ZEE KJ, HUDIS C, MC LANE A, CHOU J, ZHANG Z, POWELL S, MCCORMICK B. Long-term outcomes in breast cancer patients undergoing immediate 2-stage expander/implant reconstruction and postmastectomy radiation. *Cancer* 2012; 118: 2552-2559.
- 10) RIBUFFO D, ATZENI M, GUERRA M, BUCHER S, POLITI C, DEIDDA M, ATZORI F, DESSI M, MAREDDU C, LAY G. Treatment of irradiated expanders: protective lipofilling allows immediate prosthetic breast reconstruction in the setting of postoperative radiotherapy. *Aesth Plast Surg* 2013; 37: 1146-1152.
- 11) ANDERSON PR, HANLON AL, FOWBLE BL, MCNEELEY SW, FREEDMAN GM. Low complication rates are achievable after postmastectomy breast reconstruction and radiation therapy. *Int J Radiat Oncol Biol Phys* 2004; 59: 1080-1087.
- 12) CARNEVALE A, SCARINGI C, SCALABRINO G, CAMPANELLA B, OSTI MF, DE SANCTIS V, VALERIANI M, MINNITI G, AMANTI C, SANTANELLI F, ENRICI RM. Radiation therapy after breast reconstruction: outcomes, complications, and patient satisfaction. *Radiol Med* 2013; 118: 1240-1250.
- 13) ERIKSSON M, ANVEDEN L, CELEBIOGLU F, DAHLBERG K, MELDAHL I, LAGERGREN J, ERIKSEN C, DE BONIFACE J. Radiotherapy in implant-based immediate breast reconstruction: risk factors, surgical outcomes, and patient-reported outcome measures in a large Swedish multicenter cohort. *Breast Cancer Res Treat* 2013; 142: 591-601.
- 14) PESTANA IA, CAMPBELL DC, BHARTI G, THOMPSON JT. Factors Affecting Complications in Radiated Breast Reconstruction. *Ann Plast Surg* 2013; 70: 542-545.

- 15) KRONOWITZ SJ. Current status of implant-based breast reconstruction in patients receiving post-mastectomy radiation therapy. *Plast Reconstr Surg* 2012; 130: 513e-523e.
- 16) REISH RG, LIN A, PHILIPS NA, WINOGRAD J, LIAO EC, CETRULO CL JR, SMITH BL, AUSTEN WG JR, COLWELL AS. Breast reconstruction outcomes after nipple-sparing mastectomy and radiation therapy. *Plast Reconstr Surg* 2015; 135: 959-966.
- 17) CELET OZDEN B, GUVEN E, ASLAY I, KEMIKLER G, OLGAC V, SOLUK TEKESIN M, SERARSLAN B, TUMERDEM ULUG B, BILIGIN KARABULUT A, ARINCI A, EMEKLI U. Does partial expander deflation exacerbate the adverse effects of radiotherapy in two-stage breast reconstruction? *World J Surg Oncol* 2012; 10: 44.
- 18) AFOLABI OO, LALONDE DH, WILLIAMS JG. Breast reconstruction and radiation therapy: A Canadian perspective. *Can J Plast Surg* 2012; 20: 43-46.
- 19) 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* 2011; 127: 2154-2166.
- 20) CORDEIRO PG, ALBORNOZ CR, McCORMICK B, HU Q, VAN ZEE K. The impact of postmastectomy radiotherapy on two-stage implant breast reconstruction: an analysis of long-term surgical outcomes, aesthetic results, and satisfaction over 13 years. *Breast J* 2014; 134: 588-595.
- 21) KORVAR V, SKILLMAN J, MATEY P. Skin reducing mastectomy and immediate reconstruction: The effect of radiotherapy on complications and patient reported outcomes. *Eur J Surg Oncol* 2014; 40: 442-448.
- 22) BASCHNAGEL AM, SHAH C, WILKINSON JB, DEKHNE N, ARTHR DW, VICINI FA. Failure rate and cosmesis of immediate tissue expander/implant breast reconstruction after postmastectomy irradiation. *Clin Breast Cancer* 2012; 12: 428-432.
- 23) SHAH C, KUNDU N, ARTHUR D, VICINI F. Radiation therapy following postmastectomy reconstruction: a systematic review. *Ann Surg Oncol* 2013; 20: 1313-1322.
- 24) SHARPE SM, LIEDERBACH E, CZECHURA T, PESCE C, WINCHESTER DJ, YAO K. Impact of bilateral versus unilateral mastectomy on short term outcomes and adjuvant therapy, 2003-2010: a report from the national cancer data base. *Ann Surg Oncol* 2014; 21: 2920-2927.
- 25) COLLIER P, WILLIAMS J, EDHAYAN G, KANNEGANTI K, EDHAYAN E. The effect of timing of postmastectomy radiation on implant-based breast reconstruction: a retrospective comparison of complication outcomes. *Am J Surg* 2014; 207: 408-411.
- 26) ARISTEI C, FALCINELLI L, BINI V, PALUMBO I, FARNETI A, PETITTO RP, GORI S, PERRUCCI E. Expander/implant breast reconstruction before radiotherapy: outcomes in a single-institute cohort. *Strahlenther Onkol* 2012; 188: 1074-1079.
- 27) LAMBERT K, MOKBEL K. Does post-mastectomy radiotherapy represent a contraindication to skin-sparing mastectomy and immediate reconstruction? An update. *Surg Oncol* 2012; 21: e67-74.
- 28) REISH RG, DAMJANOVIC B, AUSTEN WG JR, WINOGRAD J, LIAO EC, CETRULO CL, BALKIN DM, COLWELL AS. Infection following implant based reconstruction in 1952 consecutive breast reconstructions: salvage rates and predictors of success. *Plast Reconstr Surg* 2013; 131: 1223-1230.
- 29) CORDEIRO PG, PUSIC AL, DISA JJ, McCORMICK B, VANZEE K. Irradiation after immediate tissue expander/implant breast reconstruction: outcomes, complications, aesthetic results and satisfaction among 156 patients. *Plast Reconstr Surg* 2004; 113: 877-881.
- 30) HO AL, BOVILL ES, MACADAM SA, TYLDESLEY S, GIANG J, LENNOX PA. Postmastectomy radiation therapy after immediate two-stage tissue expander/implant breast reconstruction: a University of British Columbia perspective. *Plast Reconstr Surg* 2014; 134: 1e-10e.
- 31) HIRSCH EM, SETH AK, DUMANIAN GA, KIM JY, MUSTOE TA, GALIANO RD, FINE NA. Outcomes of immediate tissue expander breast reconstruction followed by reconstruction of choice in the setting of postmastectomy radiation therapy. *Ann Plast Surg* 2014; 72: 274-278.
- 32) PELED AW, FOSTER RD, ESSERMAN LJ, PARK CC, HWANG ES, FOWBLE B. Increasing the time to expander-implant exchange after postmastectomy radiation therapy reduces expander-implant failure. *Plast Reconstr Surg* 2012; 130: 503-509.
- 33) LIN KY, BLECHMAN AB, BRENNIN DR. Implant-based, two-stage breast reconstruction in the setting of radiation injury: an outcome study. *Plast Reconstr Surg* 2012; 129: 817-823.
- 34) MIOTON LM, GAIDO J, SMALL W JR, FINE NA, KIM JY. Differences in breast aesthetic outcomes due to radiation: a validated, quantitative analysis of expander-implant reconstruction. *Can J Plast Surg* 2013; 21: 73-77.
- 35) LENTZ R, NG R, HIGGINS SA, FUSI S, MATTHEW M, KWEI SL. Radiation therapy and expander-implant breast reconstruction: an analysis of timing and a comparison of complications. *Ann Plast Surg* 2013; 71: 269-273.
- 36) LAM TC, HSIEH F, BOYAGES J. The effects of postmastectomy adjuvant radiotherapy on immediate two-stage prosthetic breast reconstruction: a systematic review. *Plast Reconstr Surg* 2013; 132: 511-518.
- 37) BROOKS S, DJOHAN R, TENDULKAR R, NUTTER B, LYONS J, DIETZ J. Risk factors for complications of radiation therapy on tissue expander breast reconstructions. *Breast J* 2012; 18: 28-34.