# Adjuvant Radiotherapy in Autologous Breast Reconstruction

Subjects: Surgery

Contributor: Pablo Pfister , Seraina L. C. Müller , Anna-Lena Eberhardt , Medea Rodriguez , Nadia Menzi , Martin Haug , Dirk J. Schaefer , Elisabeth A. Kappos , Tarek Ismail

In autologous breast reconstruction, a sufficient flap volume is fundamental to restore breast shape and ensure an aesthetic outcome. After mastectomy, postoperative irradiation is regularly indicated in the oncological treatment algorithm. When administering radiation therapy after autologous reconstruction, the tissue transferred is inherently irradiated. Although there is evidence that points to a reduction in flap volume after adjuvant radiotherapy, the data have been contradicting and inconclusive.

breast reconstruction free flap flap volume adjuvant radiotherapy

## 1. Introduction

Current algorithms in breast cancer treatment include a personalized combination of drug therapy, surgical resection, and radiotherapy, depending on the age of the patient, cancer classification, and tumor characteristics [1]. With recent advancements in these therapeutic regimens, the population of long-term breast cancer survivors has substantially risen [2]. Consequently, there is now an increased research focus on the period following treatment. Pivotal to this phase is the patients' quality of life, making it imperative to provide them with a robust approach that yields lasting results, not only regarding oncological outcomes [3].

Even though breast-conserving therapy is a valid choice for many affected women, mastectomy still remains important when it comes to treating locally advanced disease or prophylactic surgeries [4][5]. Mastectomy is indicated in 30–40% of all breast cancer patients, a majority of whom choose a reconstruction of the amputated breast [6][7][8]. When choosing the reconstructive technique, there are several options available, including alloplastic methods using tissue expanders and implants, autologous reconstruction with free tissue transfer, and a combination of both [9]. While both approaches hold valid indications, recent studies have shown that autologous reconstructions lead to higher levels of breast satisfaction and psychosocial and sexual well-being [10][11][12][13]. For free flap autologous breast reconstruction, the deep inferior epigastric perforator (DIEP) flap is the current workhorse flap [14][15]. Other harvesting options include the profunda artery perforator flap (PAP), the transverse myocutaneous gracilis flap (TMG), and the superior gluteal artery perforator flap (SGAP) [16][17][18]. Although autologous reconstruction results in increased breast satisfaction, it is important to mention that the optimal personalized breast reconstruction approach is always based on joint and informed decision making between the patient and the surgeon [19]. Important in this decision making process is the potential influence of adjuvant treatment modalities on postoperative outcomes. This gains significant importance in the setting of adjuvant

radiotherapy since irradiation of the reconstructed breast has been shown to influence complication rates and aesthetic outcomes [20]. Postmastectomy radiotherapy is indicated for high-risk patients, especially for those with T3-4 disease or nodal involvement, to lower the risk of locoregional recurrence [21]. It increases local tumor control, reduces mortality, and has a relatively high benefit–risk ratio [22][23][24]. Potential downsides of radiotherapy are its late toxicities including fibrosis or the shrinking of the reconstructed tissue [25][26]. This effect could significantly impact breast symmetry and thus lead to a decrease in patient satisfaction [27]. To bypass this problem, breast reconstruction can be delayed until after radiotherapy. Evidence has shown a decrease in the number of surgical complications including volume loss, fat necrosis, and revision surgeries for delayed autologous reconstruction [28][29][30][31]. However, a delay of the reconstruction includes risks related to the alloplastic procedures, as well as the need for a multi-step procedure instead of immediate reconstruction [32]. There is still an ongoing debate about the ideal timing of reconstructive procedures, since other studies have shown that immediate autologous reconstruction is well tolerated regarding complications rates, even in the setting of planned adjuvant radiotherapy [31][33]. One argument against an immediate reconstruction is the suspected reduction in flap volume following irradiation. Despite some data indicating a decrease in flap volume following adjuvant radiotherapy, other authors have shown no significant influence [34][35][36][37][38][39][40].

## 2. Adjuvant Radiotherapy in Autologous Breast Reconstruction

Patients with autologous breast reconstruction after mastectomy experience a high satisfaction with their breasts and breast-related quality of life, which could potentially be influenced by adjuvant radiotherapy [41][42]. From an aesthetic standpoint, one of the primary surgical objectives of breast reconstruction is to achieve a balanced restoration of volume symmetrical to the contralateral side [43]. Since symmetrical breast volume represents a significant parameter for the outcome evaluation of breast reconstruction, a negative influence of adjuvant radiotherapy would be of clinical importance [40]. Assuming that postoperative radiotherapy considerably impacts free flap volume, delaying the reconstruction or opting for neoadjuvant radiotherapy would emerge as a valid alternative. In the scenario of preoperative radiotherapy, the complete avoidance of irradiating the reconstructed breast tissue could be achieved without compromising oncological safety [44]. Previous studies have shown that postmastectomy radiotherapy after breast reconstruction can lead to increased complication rates [26]. In this context, irradiation has been linked to a higher incidence of volume loss in the reconstructed breast [45][46][47].

### 2.1. The Importance of a Predictable Flap Volume

To preoperatively plan the required flap volume, understanding the extent to which this volume will ultimately be retained is crucial [40]. The objective of preoperative volume planning is to overcompensate the initial flap volume concerning its anticipated final volume. Although there have been some studies evaluating the residual postoperative flap volume, specific factors and their impacts have seldom been thoroughly examined [48]. Most volumetric assessment studies have focused on head and neck flap reconstruction. Particularly in cases of tongue reconstruction, flap volume remains an essential predictor of long-term functional outcomes, encompassing speech

production and swallowing function [49][50]. These studies have reported a postoperative volume reduction in a wide range from 10 to 55% [51][52].

Unfortunately, even when considering all those factors, predicting the final volumetric outcome remains somewhat inaccurate and cannot be generalized across different patient populations. This is due to substantial differences in the primary flap used, recipient site location, radiation doses, and varying radiobiological characteristics.

## 2.2. Methods of Measuring Flap Volume

Various options exist for objectively measuring flap volume, each with distinct technical profiles. Magnetic resonance imaging is recognized to be the most accurate method for assessing flap volume, but its high cost may limit its application in research [53]. Nevertheless, due to its exceptional image quality, MRI scans are preferred, particularly when evaluating soft tissues like the breast [53]. It has been successfully used in the assessment of flap volume in head and neck reconstruction, alongside with CT scans [54][55][56][57][58]. In contrast to MRI, CT scans are generally more accessible, cost-effective, and proficient in accurately measuring tissue volume [59][60]. However, the main drawback is the exposure to ionizing radiation [53]. In addition to postoperative evaluation, CT scans facilitate preoperative flap planning and the mapping of perforators, effectively reducing morbidity and duration in perforator flap reconstruction [53][61]. A relatively new diagnostic tool for volume measurement is 3D surface imaging, which has gained increasing attention in breast volumetry research [62]. This technique offers the advantage of swiftly capturing breast geometry while being non-invasive, preserving the natural shape of the breast in an upright posture [63]. Moreover, surface measurements allow for a direct correlation with MRI results, establishing them as reliable and reproducible methods suitable for clinical applications [64]. It is important to note that 3D imaging tends to provide smaller breast volume measurements compared to MRI [62][64].

## 2.3. Flap Volume after Breast Reconstruction and the Impact of Adjuvant Radiotherapy

Few studies have reported on volumetric outcomes following immediate autologous breast reconstruction in general. Park et al. observed an average volume reduction of around 10% two years postoperatively in patients receiving TRAM flap reconstruction without adjuvant radiotherapy [65]. When looking at the muscle:fat ratio, similar results to head and neck reconstruction were seen in TRAM flap breast reconstruction. Muscle tissue in TRAM flaps underwent a significant reduction of 70% after 15 months following the initial breast reconstruction in patients without adjuvant radiotherapy [66].

The second study, which also identified a significant negative impact, did not provide exact numerical values. Kim et al. utilized uni- and multivariable linear regression analysis to demonstrate statistical impact but did not present the absolute flap volume changes [36]. Among the remaining four studies, none found a significant difference. Among these, only one study provided precise numerical values measured using mammometry in 68 patients. At twelve months postoperatively, irradiated flaps exhibited an 8.9% volume reduction while non-irradiated flaps showed no volume reduction, although this difference did not reach statistical significance. Despite the specific

investigation into the impact of radiotherapy in the selected studies, there was relatively limited reporting on radiation doses and fractionation schedules.

None of the included studies examined the potential impact of various radiation doses or alternative fractionation schedules as variables. Surprisingly, only two studies detailed their employed radiation strategies. Historically, adjuvant radiotherapy for the breast and chest wall followed a normofractionation approach with single doses ranging from 1.8 to 2.0 Gray (Gy) up to a total dose of 50 Gy [67]. This conventional fractionation schedule was based on the premise that healthy tissue is more susceptible to changes in fraction dose compared to cancer cells. Administering 50 Gy in 25 fractions aimed to spare the surrounding organs, thereby minimizing acute and long-term side effects while ensuring optimal tumor control. Recent data have revealed that breast cancer might respond differently to changes in dose per fraction compared to other cancers. Consequently, protracting the treatment over five weeks may not offer advantages. Studies have established moderately hypofractionated radiotherapy as the standard of care after breast-conserving surgery, replacing conventionally fractionated treatment over five weeks, with 40 Gy delivered in 15 fractions. This shift has not shown differences in tumor control but has presented similar or even better cosmetic outcomes such as reduced breast induration, skin toxicity, and breast edema [68].

It demonstrated a 27% complication rate among irradiated patients with autologous reconstruction, with a low incidence of major complications at 3%. Notably, the total radiation dose emerged as one of the independent risk factors for these major complications [69]. However, none of these referenced studies evaluated the impact of different radiation doses or fractionation regimens on changes in free flap volume. While there is substantial evidence suggesting potential benefits of hypofractionated radiotherapy in terms of complication rates, its influence on free flap volume needs further confirmation.

# 3. Conclusions

Predictable flap and breast volumes remain crucial outcomes in immediate autologous breast reconstruction. Scholars cannot confirm or contradict adjuvant radiotherapy's impact on breast flap volume, and the limited body of evidence does not allow for a valid meta-analysis. One possible reason for the limited number of studies may be that a regular breast cancer follow-up typically does not necessitate volumetric evaluation. The primary imaging modality used, mammography, lacks validation for flap volume assessment [70]

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