Target volume definition after closed-cavity surgery: clinical considerations

V. Strnad, D. Kauer-Dorner

Introduction

Surgery still remains an important part in the treatment of breast cancer with the addition of adjuvant therapies such as radiotherapy, chemotherapy, and hormonal therapy. Especially breast-conserving surgery in combination with radiotherapy has become an attractive alternative to mastectomy over the last two decades for patients with ductal carcinoma in situ, stage I, and selected stage II breast cancer [1, 2, 3]. Using interstitial partial breast irradiation the understanding of breast-conserving surgery and its impact on the anatomy of the female breast is essential for the understanding and correct definition of the treatment target.

Individual variations of the anatomy of the female breast after breast-conserving surgery

Two different techniques are used for conventional breast-conserving surgery (BCS), i.e. quadrantectomy and lumpectomy.

Quadrantectomy is a segmental mastectomy in which a whole quadrant (approximately one fourth) of the breast is removed, including the tissue surrounding the tumour (skin and fascia pectoralis). Macroscopic resection margins should be 2 cm in healthy tissue [4].

Lumpectomy is the surgical excision of a tumour with very small safety margins (1–3 mm in healthy tissue). It is more or less an aggressive biopsy and only appropriate for highly differentiated "low-risk" tumours. The so-called *"wide excision"* is a lumpectomy with safety resection margins of 1 cm trying to follow the anatomy of the breast glands. Only small parts of the skin above the tumour and of the fascia pectoralis have to be removed [5]. In both techniques the remaining breast parenchyma is mobilized and the wound is closed to get a closed cavity. In most breast centres the cavity is marked with surgical clips.

Intra-operative insertion of implants for radiotherapy provides direct vision on the tumour area, and thus appropriate coverage of the treatment target by the implants is possible. When performing brachytherapy 6 to 8 weeks after surgery, radiotherapists have to deal with an anatomic topography of the breast that is different from the pre-operative situation. With quadrantectomy, up to a whole quadrant is removed. The cavity is closed with the adjacent lobules, ducts, fascia strands, and the mammary fat of the quadrants beside or below the cavity if possible (figure 1). With "wide excision", the tumour and the invaded adjacent ducts, lobules, and fascia strands are removed with a safety margin following the anatomic topography of the quadrant. The wound cavity is closed with the tissue next to the resection margins (figure 2). Being aware of the preoperative mammograms and the kind of conventional BCS, the target area can be localized by the help of the surgical clips. Even without marking clips the target area can be defined by "clinical" three-dimensional (3D) reconstruction using preoperative mammograms (see pp. 29–32 and pp. 39–42).

The aim of BCS is to remove the whole tumour with a clear margin of healthy tissue in order to reduce the risk of local recurrence. However,

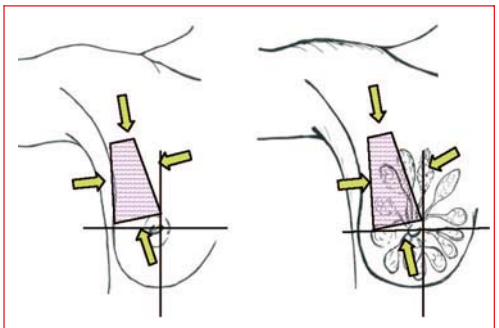

Figure 1. **Schematic picture of quadrantectomy.**

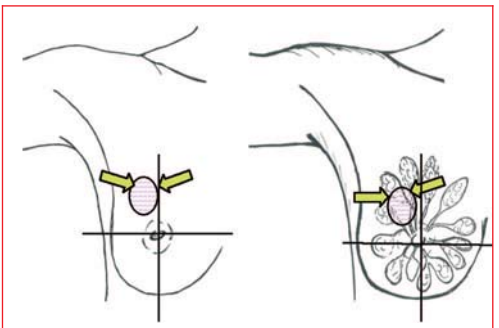

Figure 2. **Schematic picture of "wide excision".**

the wider the margin of normal tissue removed with the tumour, the higher the risk of visible breast deformity with poor cosmetic outcome. Especially, in tumours located in the centre of the breast or in close proximity to the nipple (retro-mamillar location) or in the lower quadrants, BCS often yields cosmetically unacceptable results. Thus, there is a conflict between an excision wide enough to get optimal oncological control and small enough to avoid major deformities and a large size difference between both breasts [6].

Due to this conflict a new innovative approach in BCS was developed over the last few years, i.e. *oncoplastic surgery* [7–10]. This concept combines techniques of plastic surgery, i.e. reshaping the remaining breast or reconstructing the affected breast, with the oncological goal of a sufficient excision to get rid of the tumour. With plastic surgery it is possible to reshape the breast, replace the nipple, and gain breast symmetry. The majority of tumours are still managed with conventional wide local excision. However, in case of unfavourable tumour-to-breast volume ratio or unfavourable tumour location (e.g., central, retro-mamillar, or inferior location), this new concept can improve the aesthetic outcome of breast-conserving management or avoid mastectomy. Oncoplastic techniques include *volume displacement* and *volume replacement* techniques.

Simple volume displacement, i.e. reshaping with displacement of nearby breast parenchyma into the defect, can yield best cosmetic results. Immediately after wide excision, volume displacement is performed by undermining the mammary, thus mobilizing it off the chest wall and the remaining breast tissue near the skin. If simple volume displacement is insufficient, remodelling mammaplasty is an alternative option in large breasts. Plastic-surgery reduction techniques for breast reshaping immediately after wide excision result in a smaller breast with normal shape. Surgery to the other, healthy breast is often required to balance both sides. If the amount of remaining healthy breast tissue is insufficient to reconstruct the affected breast, volume replacement techniques are used. The resection deformities are reduced by importing tissue from elsewhere into the defect, e.g. using local glandular flaps or musculocutaneous latissimus dorsi flaps.

For accurate localisation of the planning target volume (PTV) for radiotherapy, radiooncologists have to be aware of the displacement of the target area relative to the preoperative situation by these novel surgical interventions, even if marking clips are placed by the surgeon. Displacement techniques and, even more, replacement techniques use glandular tissue, fascia strands, and mammary fat tissue for remodelling the affected breast. After plastic-surgery intervention it can not be exactly defined from which segments of the breast the material for remodelling was taken. Figure 3 shows glandular displacement from the upper medial quadrant into a defect in the upper lateral quadrant. The oncoplastic surgery technique chosen by

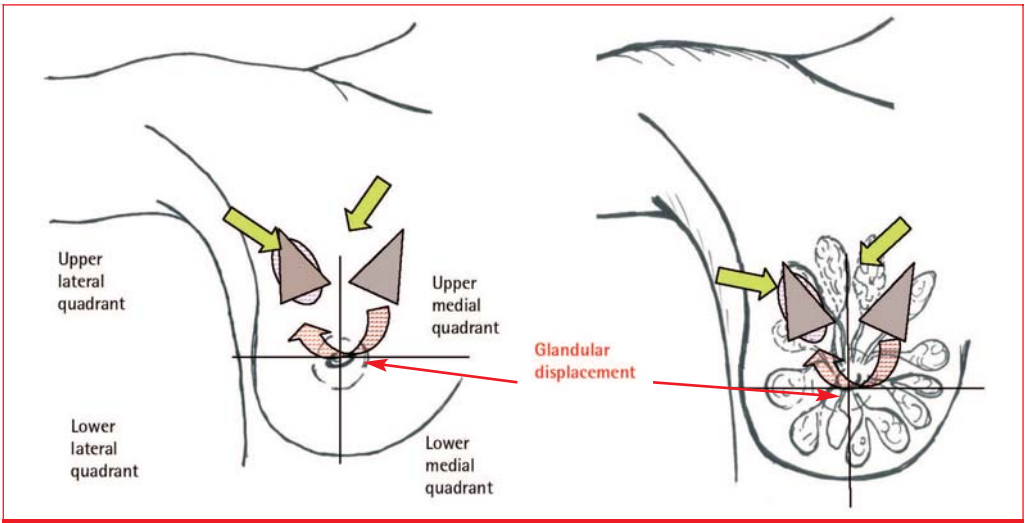

Figure 3. **Schematic picture of volume replacement technique.**

the surgeon for the individual patient depends on various factors including size and shape of the breast, glandular-tissue-to-fat-tissue volume ratio, localization of the tumour, and tumour-to-breast volume ratio.

Although clinical experience has taught radiotherapists that marking clips, clinical "3D" reconstruction with pre-operative mammograms, postoperative CT, and sometimes ultrasound are quite reliable methods for the localization of the CTV (clinical target volume = tumour bed) and of the PTV (planing target volume), we have to be careful with the new oncoplastic surgery techniques compared to conventional BCS. Intensive communication between the radiotherapists and the oncological breast surgeons and sufficient information about the anatomical changes after oncoplastic closed-cavity surgery are required in order to appropriately plan and perform accelerated partial breast irradiation (APBI).

Value of the surgical report and the pathological report

Detailed knowledge of the surgical and pathological findings plays a key role in the correct determination of the localization and the target volume. Both reports must have been completed in all details at the time of the implantation and have to be considered during the implantation.

During the analysis of the *surgical report* it must be taken into account which surgical technique was used. The surgical technique used essentially decides how the respective resection surfaces correlate to each other. Also important is the localization and the extent of any secondary resections as well as the statements of the surgeon regarding the placement of surgical clips. In order to become familiar with the "new" individual anatomy of the breast after breast-conserving surgery, the radiation oncologist (brachytherapy surgeon) should at this time ideally be joined by the surgeon at the operating table.

With all this information it is then possible to analyze the *pathological report*. The radiation oncologist should pay particular attention to the following aspects: Tumour size and shape, histological type, resection margins, the extension of ductal carcinoma in situ (DCIS) component, and further pathological risk factors. The report must describe tumour shape in general (e.g. spherical, elliptoid, longish) including the size and direction of any irregular tumour off-

shoots. Tumour size and tumour shape must also be described quantitatively in three dimensions such that the extension of the tumour along all three special axes ($a \times b \times c$) can be estimated from the pathological findings. Particular attention has to be paid to the distances of the tumour from the thorax wall and from the skin. The histological type of the tumour decides how large the resection margins should be. In case of lobular cancer the margin should be at least 5 mm, in case of other histological types a margin of ≥ 2 mm is sufficient.

The size of the resection margins also influences the decision about the size of the brachytherapy safety margins which have to be covered by the implant. Generally, the surgical resection margin and the brachytherapy safety margin together must comprise at least 2 cm. For correct evaluation, determination, and implementation of this requirement it is essential that the radiation oncologist (brachytherapist) knows the widths of the resection margins in all 6 directions, if necessary also including resection margins after secondary resection. In case of secondary resections information on the topographic orientation and on the width of the "new" resection margins is extremely important.

Because the skin and the thoracic wall are not part of the PTV it is also important to check whether skin and thoracic wall fascia remained intact or any part was resected. If the resection margins are wider than 2 cm, we recommend to cover the brachytherapy safety margins to a width of at least 1 cm with the implant.

Potential contraindications for APBI such as tumour size greater than 3 cm, lymph and blood vessel invasion, extensive DCIS, or extensive intraductal component (EIC) have to

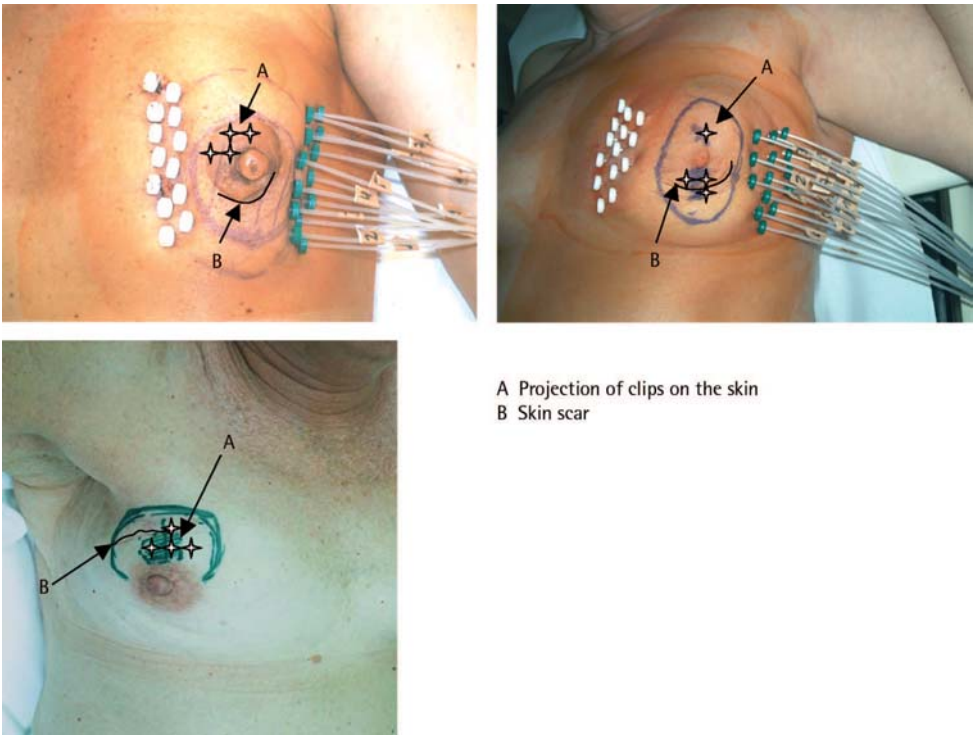

Figure 4. **Examples for discrepancies between the localization of the skin scar and the position of the surgical clips.**

be excluded on the basis of the pathological findings.

Value of the skin scar

The scar in the skin indicates the site of the access taken by the surgeon for breast-conserving surgery. Common sense would suggest that the surgeon took the shortest way, and, thus, that the skin scar is located directly above the tumour bed. Unfortunately, this is only rarely the case. In fact, the skin scar is not informative at all concerning the localization of the tumour bed after breast-conserving surgery. Some examples are shown in figure 4. Our clinical experience in this regard was also confirmed by other groups [11–15]. For example, Harrington et al [16] found in 34 patients that the distance between the centre of the scar and the most distant clips was about 4 cm (up to 8 cm), and in one third of the patients the distance was even greater than 5 cm (figure 5). Therefore, using only the skin scar for target volume localization would result in a topographical miss in 70%, or even more, of patients.

In the largest study addressing the accuracy of using only the lumpectomy scar to define the clinical boost field, the authors performed a retrospective analysis of 316 patients and derived a number of hypothetical target fields using various scar-based planning techniques [14]. Despite using wide margins around the scar, inadequate coverage of the tumour bed as marked by surgical clips occurred in up to 88% of the cases. It was concluded that the lumpectomy scar was a poor indicator of the location of the underlying tumour bed as defined by surgical clips. The findings of different groups regarding the adequate coverage of the tumour bed when using only clinical localisation based on the skin scar in comparison to using surgical clips are summarized in table I, showing that

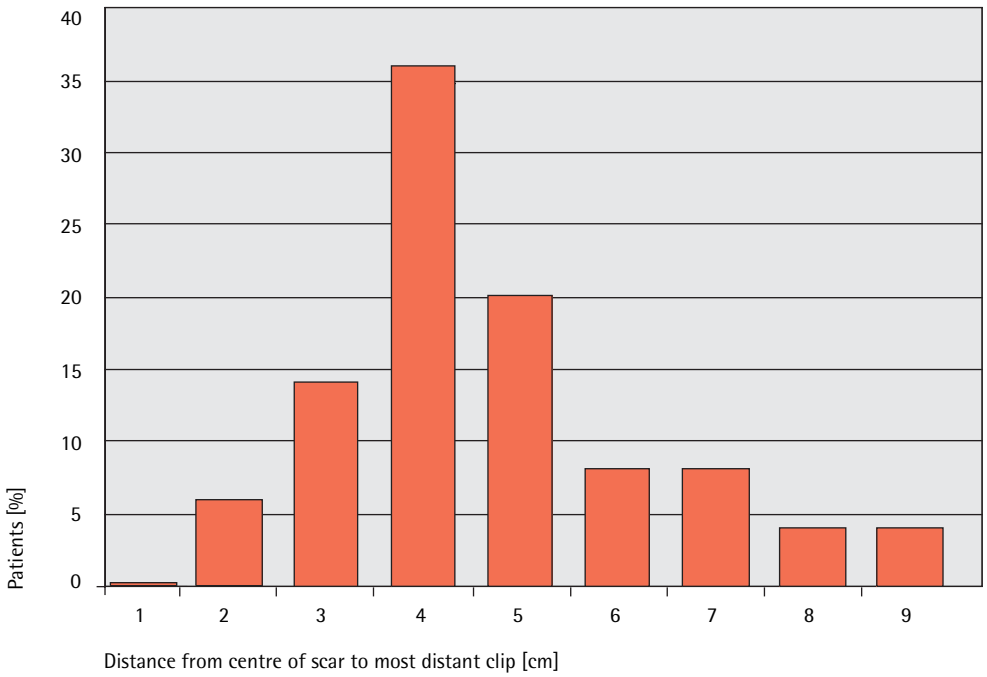

Figure 5. **Clips dispersal relative to the centre of the scar analyzed in 50 patients (modified from Harrington et al [16]).**