

Do Reexcisions Impair Aesthetic Outcome in Breast Conservation Surgery? Exploratory Analysis of a Prospective Cohort Study

Joerg Heil, MD¹, Kathrin Breitzkreuz¹, Michael Golatta, MD¹, Elena Czink¹, Julia Dahlkamp¹, Joachim Rom, MD¹, Florian Schuetz, MD¹, Maria Blumenstein, MD¹, Geraldine Rauch, PhD², and Christof Sohn, MD¹

¹University Breast Unit Heidelberg, Heidelberg, Germany; ²Institute of Medical Biometry and Informatics, University of Heidelberg, Heidelberg, Germany

ABSTRACT

Purpose. Reexcision is a clinically relevant aspect of oncological breast conservation surgery. The influence of reexcision on aesthetic outcome is described differently in the literature. Our aim was to analyze this question in a well-defined cohort with standardized study instruments.

Methods. A total of 439 patients from a prospectively followed cohort were included in this analysis. Aesthetic results were assessed by the Breast Cancer Treatment Outcome Scale (BCTOS) aesthetic status. Dates of assessments were shortly after surgical interventions and before surgery. Group comparison was performed between patients with reexcisions (80 cases; 18%) and patients without reexcision (359 cases; 82%). We considered variables of differing distribution between the two groups that could hypothetically influence BCTOS aesthetic status in a nonparametric analysis of covariance (ANCOVA).

Results. The aesthetic status of patients with reexcisions was found to be significantly worse than for patients with a single breast conservation surgery ($P < 0.0001$) when tested by a nonparametric ANCOVA model. Because patients with reexcisions had more noninvasive tumors (25% vs. 8%, $P = 0.0001$) and tumors were larger in patients with reexcision ($P = 0.01$), we included these variables as possible covariates in the multivariate model. The model was adjusted for the BCTOS aesthetic status before and shortly after the first surgery.

Conclusions. Our findings suggest that reexcision in breast conservation surgery impairs aesthetic outcome, at least when assessed shortly after surgery.

Today, breast conservation therapy (BCT) is accepted as standard treatment for early breast cancer.^{1–3} For patients undergoing lumpectomy, reexcision is often necessary to obtain tumor-free margins in order to decrease the incidence of local recurrence of the primary tumor.^{4,5} Review of literature has yielded various rates of reexcision ranging from 11% to 56%, mostly around 20%.^{6–11}

Many risk factors are reported to be associated with involved margins after lumpectomy indicating a higher a priori risk for reexcision: younger age, tumor-related factors (large tumor size, lobular differentiation, multifocal disease, negative estrogen receptor, presence of extensive intraductal component, T3 disease) and diagnosis-related aspects (absence of diagnosis before surgery, microcalcification on mammogram, patients referred from screening).^{6–11}

A favorable aesthetic outcome is the main argument to choose a BCT and is at least the surgery's second most important aim after oncological safety. The breast is a symbol of femininity and attractiveness, and the nipple is an important source of erotic stimulus for many women. Breast cancer patients therefore could prefer BCT if they have the choice between BCT and mastectomy to keep the integrity of their own body image.¹² Better aesthetic results correlate with a higher quality of life.^{13–19} Negative effects on aesthetic outcome are described for patients with younger age or higher body mass index (BMI). Furthermore, in the literature, tumor- and surgery-related factors are described: larger or palpable tumors, superior medial or inferior lateral tumor localization, specimen volume, absolute and relative resected breast volume, surgical complications as postoperative seroma or chest wall separation, radiotherapy, number of radiation fields, and radiation boost.^{20–23} There is some evidence that reexcision has a negative impact on aesthetic outcome, whereas other studies could not find this correlation.^{20–22}

Previous studies have shown that objective methods and expert opinions do not match very well with patients' subjective judgments of their breast appearance.^{24–26} Therefore, standardized subjective questionnaires, such as the Breast Cancer Treatment Outcome Scale (BCTOS), are necessary to measure satisfaction and fulfillment of patients' individual expectations. Our study instrument, the German version of the BCTOS, is a validated questionnaire used to measure aesthetic outcome.¹⁸

The aim of this study was to explore in a large prospectively assigned, well-defined cohort of patients whether reexcisions worsen aesthetic outcome. Besides the fact that a reexcision increases hospitalization and psychological distress, worse aesthetic outcome would be another important argument in our attempts to decrease reexcision rates.

METHODS

Aesthetic Outcome Measure

The BCTOS was designed to assess women's subjective evaluation of the aesthetic and functional outcome after breast cancer treatment.²⁷ In total, there are 22 items in three subscales: aesthetic status, functional status, and breast sensitivity status. The aesthetic status subscale consists of seven items: breast size, nipple appearance, breast shape, elevation, scar tissue, fit of bra, and clothing.¹⁸ Patients rate these items according to symmetry between treated and untreated breast on a 4-point Likert scale (1 = no difference between treated and untreated breast, 4 = large difference between treated and untreated breast). The mean of these seven single items is defined as aesthetic status.

Course of Study and Description of Study Population

This analysis was designed as part of an explorative, single-institution, prospective cohort study to evaluate aesthetic and functional outcome of BCT. All patients with primary histologically proven one-sided breast cancer with the intention to be treated conservatively were screened and included before their first breast conservation surgery. The study was approved by the ethics commission of the University of Heidelberg Medical School. All patients provided written informed consent. We only considered early breast cancer stages 0, 1, and 2, with 64% of the patients having stage 1 disease. Patients were included before their first breast conservation surgery. They received a strict timetable of assessments, including one BCTOS questionnaire before surgery and a BCTOS questionnaire shortly after each surgical intervention. The BCTOS questionnaire was also assessed before surgery to receive a baseline BCTOS aesthetic status for each woman.

Patients were only considered eligible for this analysis if a complete BCTOS aesthetic status score after their final surgical intervention existed. Additionally, patients converted to mastectomy were excluded because the BCTOS was not designed to capture aesthetic outcome in this population.

Between August 28, 2007, and November 17, 2010, a total of 746 women were screened for the study. A total of 661 patients were included into the study before surgery. In this cohort, reexcision or secondary/tertiary mastectomy was performed in 165 patients (25%). Fifty-one patients (7%) had a secondary/tertiary mastectomy. Of the remaining 610 patients, 439 (72%) contributed a complete BCTOS aesthetic status after the final breast conservation intervention. The BCTOS questionnaire after the final breast conservation surgical intervention was allocated and answered in the group with reexcision after a median time of 3 (mean 6.6, range 1–33) days, and in the group without reexcision after a median time of 4 (mean 6.9, range 1–49) days. Reasons for missing cases (171 patients) could be identified: 19 patients (11%) had incomplete questionnaires, 16 (9%) withdrew their informed consent, and the remaining patients were dismissed from the hospital without notifying the study staff and were not able to come back. Three hundred fifty-nine women (82%) had one surgical intervention to achieve tumor-free margins (group 1), and in 80 cases (18%), one or more reexcisions were performed (1 reexcision = 75; 2 reexcisions = 5). Twenty of these women had noninvasive tumors, and 60 women had invasive tumors (with or without in-situ disease). Reasons for reexcision in the group with invasive cancers were unclear margins (Rx) with respect to the in-situ component in 11 cases (18%), incomplete resection (R1) of the in-situ component in 22 cases (37%), and incomplete resection of the invasive tumor in 27 cases (45%). In summary, data from 439 patients were included in the analysis. Patient characteristics are presented in Table 1.

Influencing Factors on Reexcision and Aesthetic Outcome

Beside reexcision, we documented further variables that might hypothetically influence the aesthetic outcome: age, BMI, bra size, lymphadenectomy (sentinel lymph node excision or axillary dissection), incision method (periareolar, stellar, circular, others), scar length, specimen weight, surgical technique (lumpectomy or segmental resection, quadrantectomy), invasiveness (in-situ cancer vs. invasive cancer), tumor size, and localization of tumor. Lumpectomy or segmental resection refers to circumscribed breast conservation surgeries for tumor-free margins. Quadrantectomy was considered to be a more extensive breast-conserving

TABLE 1 Patient characteristics

Variable	No reexcision	Reexcision	<i>P</i>
Age (y)			0.35 ^a
No. of patients	359	80	
Mean	58.97	57.73	
Standard deviation	10.70	10.44	
BMI (kg/m ²)			0.31 ^a
No. of patients	358	80	
Mean	25.76	25.17	
Standard deviation	4.72	4.33	
Bra cup size			0.47 ^b
No. of patients	357	80	
A	49 (14%)	11 (14%)	
B	153 (43%)	41 (51%)	
C	95 (27%)	19 (24%)	
D–G	60 (17%)	9 (11%)	

^a Two-sided *t*-test^b Chi-square test

technique. All surgical procedures were performed by certified breast surgeons (more than 100 breast surgeries per year) with experience in oncoplastic techniques.

Statistical Analysis

Study patients were separated in two groups. The first group consisted of women who were operated only once to reach tumor-free margins. Their first surgery is equivalent to their final surgical intervention. The second group was formed by patients who had one or more reexcisions to achieve tumor-free margins.

We described our group and searched for structural differences in previously hypothesized influencing factors. Depending on the scale level, we compared the groups by a two-sample *t*-test, a Mann-Whitney test, or a chi-square test. All variables that showed statistically significant differences between the two groups can be interpreted as potentially influencing factors on the aesthetic outcome. Because we aim to quantify the influence of reexcisions only, we therefore had to adjust for other potentially influencing factors in our analysis; otherwise, our results could be biased. We analyzed the outcome variable (BCTOS after final surgical intervention) by a nonparametric analysis of covariance (ANCOVA) based on ranks for group comparison. Because score values generally correspond to an ordinal-scale level, standard ANCOVA models are not appropriate. A nonparametric alternative is to replace all observed values by their corresponding ranks

and to apply the statistical analysis on these rank values.²⁸ ANCOVA was adjusted for all potential influencing factors found in the baseline comparisons as well as for BCTOS aesthetic status before and shortly after the first surgical procedure. It is important to adjust for the BCTOS aesthetic status before and after the first surgery because otherwise the observed differences between groups regarding the aesthetic results might be fully explained by baseline differences in the aesthetic status. Additionally, we show the effect size and the direction of all influencing factors on BCTOS aesthetic. All statistical calculations were performed by SPSS software, version 17.0 (SPSS, Chicago, IL), or SAS software, version 9.0 (SAS Institute, Cary, NC). As an explorative analysis, all reported *P* values can be interpreted descriptively.

RESULTS

Analysis of Influencing Factors on Reexcision

Patient-related factors showed no statistically significant differences in group comparison between patients with and without reexcision. With respect to surgical and tumor-related factors, the differences occurred when comparing invasive (pT1–3) and noninvasive (pTis) tumors.

Patients with reexcisions had more noninvasive tumors (25% vs. 8% in the group without reexcisions, *P* = 0.0001). Of the patients with reexcisions, 40% had a tumors sized ≥ 20 mm, compared to 25% in the group of patients without reexcision (*P* = 0.001). On the other hand, there were fewer quadrantectomies in patients with reexcision (1% vs. 7%; *P* = 0.06). Taking into account similar distributions of cup sizes and larger tumors in the reexcision group, one could hypothesize that those without reexcision should have better aesthetic results, without considering reexcision as an influencing factor. Detailed results are provided in Tables 1, 2 and 3.

BCTOS Aesthetic Status

The BCTOS aesthetic status for the different times of assessment for the patients with and without reexcision is displayed in Fig. 1. Patients without reexcisions had a median BCTOS aesthetic status of 1 before the surgical procedure and a score of 1.71 after surgery. Patients with reexcision started with similar BCTOS aesthetic status before surgery (median 1.07). The aesthetic result worsened to a median of 1.59 at assessment shortly after first surgery and decreased to a median BCTOS aesthetic status of 1.85 after the last surgery.

TABLE 2 Surgery-related factors of the study cohort

Variable	No reexcision	Reexcision	<i>P</i>
Axillary surgery			0.92 ^b
No. of patients	326	63	
Sentinel lymph node	264 (81%)	51 (81%)	
Axillary dissection	62 (19%)	12 (19%)	
Incision method			0.60 ^b
No. of patients	333	75	
Periareolar	132 (40%)	26 (35%)	
Stellar	128 (38%)	31 (41)	
Circular	54 (16%)	11 (15%)	
Other	19 (6%)	7 (9%)	
Scar length (cm)			0.45 ^a
No. of patients	285	65	
Mean	7.66	7.28	
Standard deviation	3.75	3.17	
Specimen weight (g)			0.99 ^a
No. of patients	346	77	
Mean	65.65	65.58	
Standard deviation	55.01	54.19	
Surgical technique			0.06 ^b
No. of patients	359	80	
Lumpectomy or segmental resection	335 (93%)	79 (99%)	
Quadrantectomy	24 (7%)	1 (1%)	

^a Two-sided *t*-test^b Chi-square test**TABLE 3** Tumor-related factors of the study cohort

Variable	No reexcision	Reexcision	<i>P</i>
Invasiveness			<0.0001 ^a
No. of patients	359	80	
No (in situ)	28 (8%)	20 (25%)	
Yes (invasive)	331 (92%)	60 (75%)	
Tumor size			0.001 ^a
No. of patients	352	78	
≤20 mm	263 (75%)	47 (60%)	
>20 mm	89 (25%)	31 (40%)	
Tumor localization			0.42 ^a
No. of patients	358	80	
Upper–outer quadrant	168 (47%)	35 (44%)	
Upper–inner quadrant	55 (15%)	17 (21%)	
Lower–outer quadrant	31 (9%)	10 (13%)	
Lower–inner quadrant	30 (8%)	5 (6%)	
Retromammilar	21 (6%)	6 (8%)	
Other	53 (15%)	7 (8%)	

^a Chi-square test*BCTOS Aesthetic Status*

Both groups were comparable with respect to nearly all hypothetically influencing variables of aesthetic outcome that we analyzed. We considered those variables with different frequencies in the two analyzed groups (invasiveness, tumor size) as well as BCTOS aesthetic status before and after the first surgery as covariates in the nonparametric ANCOVA to explain the BCTOS aesthetic status after the final surgery. Those patients who underwent one or more reexcisions reported worse aesthetic outcome ($P < 0.0001$). Thus, patients without reexcision corresponded to smaller score values indicated by the negative effect size of -35.17 reported in Table 4. This statistically significant difference seems to be independent of invasiveness and tumor size.

DISCUSSION*ANCOVA, Statistical Significance, and Clinical Relevance*

Patients who underwent one or more reexcisions reported worse aesthetic outcome ($P < 0.0001$). This result seems initially puzzling when looking at the median aesthetic scores for all times of assessment displayed in Fig. 1. Indeed, the median scores after final surgery are quite similar for both groups, and the reexcision group is only slightly worse (1.85 for patients with reexcision vs. 1.71 for patients without reexcision). However, the overall results have to be interpreted with respect to the baseline scores. A fair comparison between groups is only possible if the median aesthetic scores after the first surgery would be equal in both groups. However, as can be seen in Fig. 1, the aesthetic status after the first surgical intervention for patients receiving a second operation is considerably better than for patients receiving only one surgery (1.71 for patients without reexcision vs. 1.59 for patients with reexcision). The group of patients receiving reexcision clearly had a worse aesthetic outcome (1.59 to 1.85 BCTOS aesthetic status). By including the BCTOS aesthetic status before and after the first surgery as covariates in the nonparametric ANCOVA, we adjusted our analysis for these baseline differences with respect to the aesthetic score, and thus a fair comparison between these groups can be obtained. Therefore, the observed significant difference between groups resulting from the ANCOVA model should be used for interpretation rather than direct comparison of the median values after the last surgery.

Besides the statistical significance of the results, it is necessary to quantify the effect size to judge its clinical relevance. The effect measures displayed in Table 4 are

FIG. 1 Box plots showing aesthetic scores at different times of assessment. The higher the score, the worse the aesthetic outcome. *Med* median

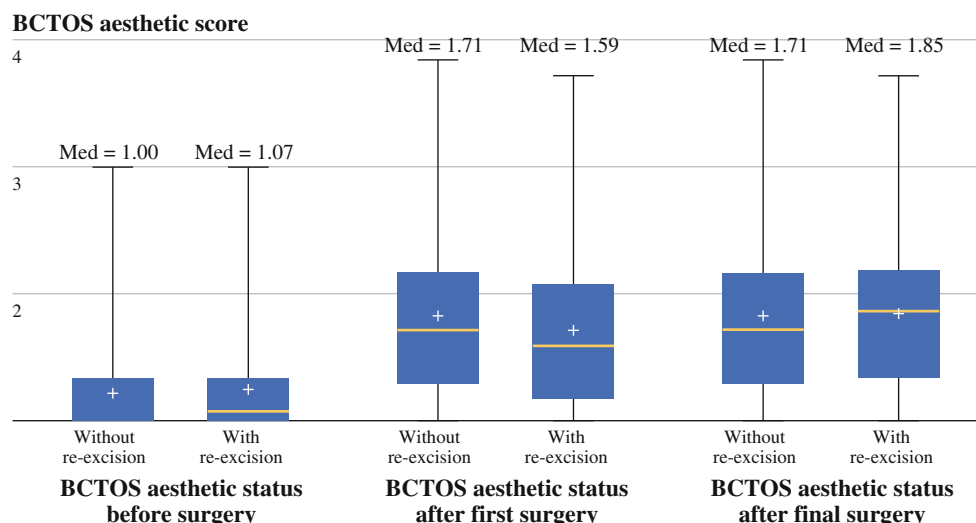


TABLE 4 ANCOVA model to explain BCTOS aesthetic status after final surgery^a

Variable	Parameter estimate ^b	Standard error of parameter estimate	<i>P</i> ^c
BCTOS aesthetic status			
Before surgery	0.04	0.02	0.0402
After first surgery	0.98	0.02	<0.0001
Invasiveness			
No (in situ)	-13.95	7.04	0.0484
Yes (invasive)	0	-	-
Tumor size			
≤20 mm	3.84	4.43	0.3869
>20 mm	0	-	-
Reexcision			
No	-35.17	5.7	<0.0001
Yes	0	-	-

^a For continuous variables (BCTOS aesthetic status before and after first surgery) a positive parameter estimate indicates that the BCTOS aesthetic status after final surgery increases for increasing values of the corresponding variable

^b For class variables (invasiveness, tumor size, reexcision) a negative parameter estimate indicates that the BCTOS aesthetic status after final surgery is smaller in the first class than in the second which corresponds to a better aesthetic outcome within the first class

^c Descriptive *P* values for the *F*-test to test the null hypothesis that the corresponding parameter $\beta_i = 0$

useful to show the direction of influence; however, their absolute values are difficult to interpret because these effect measures are related to the ranks of the original scores. Nevertheless, the effect size can be estimated by considering the change within the median score from first to final surgery. For patients with reexcision, the BCTOS aesthetic status changed from 1.59 to 1.85, yielding a difference of 0.26. Thus, patients with one or more reexcisions are about 0.26 points worse than patients without reexcision. If we consider that the difference between the assessment before and after final surgery is 0.71 and 0.78 points, respectively, this difference in the reexcised women seems to be big enough to judge it clinically relevant.

Effect of Reexcision on Aesthetic Outcome

After the first surgical intervention, patients judged aesthetic outcome differently. Women without reexcisions tended to have a worse aesthetic outcome than those undergoing reexcision. We consider two possible explanations, as follows.

Taking into account similar distributions of cup sizes and larger tumors in the reexcision group, one could hypothesize that those without reexcision should have had better aesthetic results. On the other hand, there were more quadrantectomies in patients without reexcisions. Therefore, surgical intervention in the group without reexcisions

could have been relatively more radical. Radical treatment may have led to tumor-free margins, but also worsened aesthetic outcome. In the reexcision group, patients might have undergone a less radical intervention. Here, the surgeon's strategy could have been less radical to achieve the best aesthetic outcome by removing as little tissue as possible. This hypothesis is underlined by an analysis of specimen weight. Data of specimen weight after first surgery were not separated from that of the second surgery, but cumulative weights were comparable in both groups. We assume that an existing weight difference after the first surgical intervention was caught up by reexcision.

Second, 26% of the group with reexcisions did not attend the assessment after their first breast conservation surgery. This could have led to a change in group characteristics. Forms were completed on the day of discharge. Most patients did not know their personal pathologic results at this time, which could have influenced their answers. Missing patients could have been already informed about the necessity of a reexcision or the likelihood of experiencing psychosocial distress, and therefore they did not visit our study nurses. Those who completed the BCTOS were not so informed or did not expect a reexcision. We cannot entirely exclude the notion that patients who had not completed the BCTOS were those who already had worse aesthetic status after their first surgical procedure.

Reexcised patients showed a higher incidence of in-situ cancers. Furthermore, the mean size of these tumors was larger in the group with reexcision. According to our hypothesis of more and less radical surgical procedures, it could be assumed that in-situ cancers were treated less radically than invasive tumors, resulting in higher reexcision rates. Their volume could have been underestimated. Surgeons should keep this information in mind while operating on noninvasive tumors.

Independent Influencing Variable on Aesthetic Outcome

On the one hand, previous studies have suggested that the negative effect of reexcision on aesthetic outcome might be related to the increasing volume of removed breast tissue.^{21,29} On the other hand, reexcision and the volume of resected tissue are described as independent parameters for aesthetic outcome.^{20,30–32}

Assuming specimen weight is proportional to removed tissue volume—which might be criticized because there is no absolute correlation between resected tissue volume and specimen weight—our results suggest that that reexcision is an independent predictor for reduced aesthetic outcome. In our analysis, mean cumulative specimen weight was similar in the group with reexcision (group with worse

aesthetic outcome) compared to the group without reexcision.

Unfortunately, there is no absolute correlation between tissue volume and specimen weight. Density of breast tissue changes in each woman during her lifetime, and different women have differences in proportions of fat and of connective and glandular tissue; for example, women with a higher BMI have a higher percentage of fat. Documentation of absolute excised breast tissue volume should not satisfy the clinical scientist. One aim would be to describe the relative excised breast tissue volume. Therefore, volume of removed breast tissue and volume of breast would be necessary. However, there is no easy, reliable, and valid method to quantify relative excised breast tissue volume. We aimed to address this question by documenting bra size and weight of tissue removed. Moreover, one might argue that the fact that age and BMI showed the same distribution across both groups could support the use of specimen weight as a proxy for volume.

Other Factors Associated with Poor Aesthetic Outcomes

Negative effects on aesthetic outcome are described for patients with younger age and higher BMI. Furthermore, in the literature, tumor- and surgery-related influencing factors are described: larger or palpable tumors, superior medial or inferior lateral tumor localization, specimen volume, absolute and relative resected breast volume, surgical complications as postoperative seroma or chest wall separation, radiotherapy, number of radiation fields, and radiation boost. Because we assessed aesthetic outcome shortly after surgery, we cannot report on the radiation-associated variables. With respect to the other patient-, tumor-, and surgery-specific influencing factors, we described the cohort in detail. The statistical concept of our study was based on the idea that we would only include variables in the multivariate analysis that differed in distribution between the two groups of reexcised and nonreexcised patients. We therefore only included invasiveness and tumor size and did not analyze the impact of the other possible variables that might negatively affect aesthetic outcome.

CONCLUSION

Our findings suggest that reexcision in BCT negatively affects aesthetic outcome—at least shortly assessed after surgery. We interpret our results with caution because we only compared short-term outcomes without the influence of radiotherapy. Nevertheless, these findings could provide another argument to focus on reducing reexcision rates.

CONFLICT OF INTEREST None.

REFERENCES

1. Clarke M, Collins R, Darby S, et al. Effects of radiotherapy and of differences in the extent of surgery for early breast cancer on local recurrence and 15-year survival: an overview of the randomised trials. *Lancet*. 2005;366(9503):2087–106.
2. Fisher B, Anderson S, Bryant J, et al. Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. *N Engl J Med*. 2002;347:1233–41.
3. van Dongen JA, Voogd AC, Fentiman IS, et al. Long-term results of a randomized trial comparing breast-conserving therapy with mastectomy: European Organization for Research and Treatment of Cancer 10801 trial. *J Natl Cancer Inst*. 2000;92:1143–50.
4. Kreike B, Hart AA, van de Velde T, et al. Continuing risk of ipsilateral breast relapse after breast-conserving therapy at long-term follow-up. *Int J Radiat Oncol Biol Phys*. 2008;71:1014–21.
5. Mannell A. Breast-conserving therapy in breast cancer patients—a 12-year experience. *S Afr J Surg*. 2005;43:28–30.
6. Aziz D, Rawlinson E, Narod SA, et al. The role of reexcision for positive margins in optimizing local disease control after breast-conserving surgery for cancer. *Breast J*. 2006;12:331–7.
7. Cabioglu N, Hunt KK, Sahin AA, et al. Role for intraoperative margin assessment in patients undergoing breast-conserving surgery. *Ann Surg Oncol*. 2007;14:1458–71.
8. Chagpar AB, Martin RC 2nd, Hagendoorn LJ, Chao C, McMasters KM. Lumpectomy margins are affected by tumor size and histologic subtype but not by biopsy technique. *Am J Surg*. 2004;188:399–402.
9. Dillon MF, Hill AD, Quinn CM, McDermott EW, O'Higgins N. A pathologic assessment of adequate margin status in breast-conserving therapy. *Ann Surg Oncol*. 2006;13:333–9.
10. Kurniawan ED, Wong MH, Windle I, et al. Predictors of surgical margin status in breast-conserving surgery within a breast screening program. *Ann Surg Oncol*. 2008;15:2542–9.
11. Smitt MC, Horst K. Association of clinical and pathologic variables with lumpectomy surgical margin status after preoperative diagnosis or excisional biopsy of invasive breast cancer. *Ann Surg Oncol*. 2007;14:1040–4.
12. Margolis GJ, Goodman RL. Psychological factors in women choosing radiation therapy for breast cancer. *Psychosomatics*. 1984;25:464–6, 469.
13. Curran D, van Dongen JP, Aaronson NK, et al. Quality of life of early-stage breast cancer patients treated with radical mastectomy or breast-conserving procedures: results of EORTC Trial 10801. The European Organization for Research and Treatment of Cancer (EORTC), Breast Cancer Co-operative Group (BCCG). *Eur J Cancer*. 1998;34:307–14.
14. Kiebert GM, de Haes JC, van de Velde CJ. The impact of breast-conserving treatment and mastectomy on the quality of life of early-stage breast cancer patients: a review. *J Clin Oncol*. 1991; 9:1059–70.
15. Nano MT, Gill PG, Kollias J, Bochner MA, Malycha P, Winefield HR. Psychological impact and cosmetic outcome of surgical breast cancer strategies. *ANZ J Surg*. 2005;75:940–7.
16. Noguchi M, Saito Y, Nishijima H, et al. The psychological and cosmetic aspects of breast conserving therapy compared with radical mastectomy. *Surg Today*. 1993;23:598–602.
17. Wang HT, Barone CM, Steigelman MB, et al. Aesthetic outcomes in breast conservation therapy. *Aesthet Surg J*. 2008;28: 165–70.
18. Heil J, Holl S, Golatta M, et al. Aesthetic and functional results after breast conserving surgery as correlates of quality of life measured by a German version of the Breast Cancer Treatment Outcome Scale (BCTOS). *Breast*. 2010;19:470–4.
19. Heil J, Czink E, Golatta M, et al. Change of aesthetic and functional outcome over time and their relationship to quality of life after breast conserving therapy. *Eur J Surg Oncol*. 2011;37: 116–21.
20. Wazer DE, DiPetrillo T, Schmidt-Ullrich R, et al. Factors influencing cosmetic outcome and complication risk after conservative surgery and radiotherapy for early-stage breast carcinoma. *J Clin Oncol*. 1992;10:356–63.
21. Fedorcik GG, Sachs R, Goldfarb MA. Oncologic and aesthetic results following breast-conserving therapy with 0.5 cm margins in 100 consecutive patients. *Breast J*. 2006;12:208–11.
22. Waljee JF, Hu ES, Newman LA, Alderman AK. Predictors of breast asymmetry after breast-conserving operation for breast cancer. *J Am Coll Surg*. 2008;206:274–80.
23. Cochrane RA, Valasiadou P, Wilson AR, Al-Ghazal SK, Macmillan RD. Cosmesis and satisfaction after breast-conserving surgery correlates with the percentage of breast volume excised. *Br J Surg*. 2003;90:1505–9.
24. Heil J, Dahlkamp J, Golatta M, et al. Aesthetics in breast conserving therapy: do objectively measured results match patients' evaluations? *Ann Surg Oncol*. 2011;18:134–8.
25. Al-Ghazal SK, Fallowfield L, Blamey RW. Patient evaluation of cosmetic outcome after conserving surgery for treatment of primary breast cancer. *Eur J Surg Oncol*. 1999;25:344–6.
26. Al-Ghazal SK, Blamey RW. Cosmetic assessment of breast-conserving surgery for primary breast cancer. *Breast*. 1999;8:162–8.
27. Stanton AL, Krishnan L, Collins CA. Form or function? Part 1. Subjective cosmetic and functional correlates of quality of life in women treated with breast-conserving surgical procedures and radiotherapy. *Cancer*. 2001;91:2273–81.
28. Knoke JD. Nonparametric analysis of covariance for comparing change in randomized studies with baseline values subject to error. *Biometrics*. 1991;47:523–33.
29. Cardoso MJ, Cardoso J, Santos AC, et al. Factors determining esthetic outcome after breast cancer conservative treatment. *Breast J*. 2007;13:140–6.
30. Al-Ghazal SK, Blamey RW, Stewart J, Morgan AA. The cosmetic outcome in early breast cancer treated with breast conservation. *Eur J Surg Oncol*. 1999;25:566–70.
31. Lindsey I, Serpell JW, Johnson WR, Rodger A. Cosmesis following complete local excision of breast cancer. *Aust N Z J Surg*. 1997;67:428–32.
32. Taylor ME, Perez CA, Halverson KJ, et al. Factors influencing cosmetic results after conservation therapy for breast cancer. *Int J Radiat Oncol Biol Phys*. 1995;31:753–64.