

Breast reconstruction de novo by water-jet assisted autologous fat grafting – a retrospective study

Totale Brustrekonstruktion durch Wasserstrahl-assistierten autologen Eigenfettgewebettransfer – eine retrospektive Studie

Abstract

Background: Autologous fat grafting has become a frequent, simple, reproducible and low-risk technique for revisional or partial breast reconstruction. The presented European multicenter study describes an optimized treatment and follow-up protocol for the de novo breast reconstruction after total mastectomy by lipotransfer alone.

Methods: A retrospective European multicenter trial included 135 procedures on 28 (35 breasts) postmastectomy patients (mean 52.4 years). All women were treated with the water-jet assisted fat grafting method (BEAULI™) combined with additional procedures (NAC reconstruction, contralateral mastopasty) and evaluated with at least 6 months follow-up (mean 2.6 years). Sonography or mammography, clinical examination, patient questionnaire (10-point Likert scale) and digital photographs were carried out.

Results: On average the patients received 4 to 6 procedures each with a single volume of 159 ml (± 61 ml) over 21 months (range 9 months to 2.5 years). In total 1,020 ml (± 515 ml) fat were grafted till a complete breast reconstruction was achieved. Irradiated patients needed a significantly higher volume than non-irradiated ($p < 0.041$). Main treatment complications were liponecrosis (2.59%), infection (0.74%) and granuloma (0.74%). Patient satisfaction was overall high to very high (96%) and confirmed the good aesthetic results (68%) and the natural softness, contour and shape of the reconstructed breast.

Conclusions: A complete breast reconstruction with large volume fat grafting is alternatively possible to standard techniques in selected cases. It takes at least 4 to 6 lipotransfers in the course of 2 years. Patients with prior radiotherapy may require even up to 8 sessions over nearly 3 years of treatment.

Keywords: autologous fat grafting, lipotransfer, breast reconstruction, mastectomy

Zusammenfassung

Hintergrund: Heutzutage wird der autologe Eigenfettgewebettransfer in der rekonstruktiven Brustchirurgie als eine risikoarme und einfach anwendbare Methode angesehen und derweilen routiniert für Zweiteingriffe oder Teilaufbauten verwendet. Bisher sind nur wenige Patientenfälle mit einem kompletten Brustaufbau nach totaler Mastektomie beschrieben worden.

Material und Methoden: Im Rahmen einer europaweiten Multicenterstudie erhielten insgesamt 28 Patientinnen einen kompletten Brustaufbau nach uni- oder bilateraler Ablatio mammae. Jener wurde ausschließlich mittels Wasserstrahl-assistierter BEAULI™-Methode vollzogen, wobei man diese individuell mit gängigen Verfahren wie einer MAK-Rekonstruktion oder einer kontralateralen Reduktionsplastik kombinierte. Zur Auswertung fand die klinische und radiologische Nachuntersuchung (Ultraschall oder Mammographie) nach abgeschlossener Behandlung

Delia Letizia Hoppe¹

Klaus Ueberreiter²

Yves Surlemont³

Hilkka Peltoniemi⁴

Marco Stabile⁵

Susanna Kauhanen⁶

1 BG Unfallklinik Tübingen, Klinik für Hand-, Plastische, Rekonstruktive und Verbrennungschirurgie, Tübingen, Germany

2 Parkklinik Birkenwerder, Birkenwerder, Germany

3 Clinique Saint Antoine, Rouen University Hospital, Paediatric and Dermatologic Plastic Surgery, Bois Guillaume, France

4 Plastic Surgery Hospital KL, Helsinki, Finland

5 Azienda Sanitaria di Piacenza, Cremona, Italy

6 Helsinki University Hospital, Department of Plastic and Reconstructive Surgery, Helsinki, Finland

und mindestens 6 Monaten (durchschnittlich 2,6 Jahren) Verlaufszeit statt. Zusätzlich wurde anhand digitaler Fotoaufnahmen und Fragebögen (10-Punkte-Likert-Skala) das ästhetische Endergebnis bewertet und die Patientenzufriedenheit ermittelt.

Ergebnis: Im Durchschnitt wurden 4 bis 6 Einzelsitzungen mit jeweils 159 ml (± 61 ml) über einen Zeitraum von 21 Monaten (9 Monate bis max. 2,5 Jahre) durchgeführt, um durch ein Endvolumen von 1.020 ml (± 515 ml) einen kompletten Brustaufbau zu erreichen. Hierbei wiesen Patientinnen nach adjuvanter Radiatio eine signifikant höhere Eingriffsrate und Volumenbedarf auf ($p < 0,041$). Als postoperative Komplikationen traten Infektionen (0,74%), Granulome (0,74%) oder Fettnekrose (2,59%) auf. Es konnte eine hohe Patientenzufriedenheit (95,42%) mit guten bis sehr gutem ästhetischem Ergebnis (67,68%) festgestellt werden.

Schlussfolgerungen: Der autologe Eigenfettgewebettransfer kann zu einem kompletten Brustaufbau nach Ablatio mammae in ausgewählten Fällen eingesetzt werden, wobei durchschnittlich 4 bis 6 Lipotransfers in einem Zeitraum von ca. 2 Jahren vorgesehen sind. Nach adjuvanter Radiotherapie können bis zu 8 Sitzungen im Verlauf von bis zu 3 Jahren notwendig sein. Die vorliegenden Ergebnisse führten in den entsprechenden Schwerpunktzentren zur Entwicklung optimierter Behandlungsstandards von Brustkrebspatientinnen.

Schlüsselwörter: autologer Eigenfettgewebettransfer, Lipofilling, rekonstruktive Brustchirurgie, Mastektomie

Introduction

According to the American Cancer Society the incidence of breast cancer constantly increased during the last decades. In 2011 an estimated 230,480 new cases of invasive breast cancer are diagnosed in the U.S. [1]. Similar results were found 1995 to 2006 on European women in their 20s and 30s [39]. Hence younger patients contribute to an upward trend in breast reconstruction [5], [9], [11], [13], [30], [68].

The first report about lipotransfer in female breasts was already published by Holländer in 1910 [24]. Gradually autologous fat grafting has become a frequent, simply reproducible and low-risk technique in revisional or partial reconstruction of the breast [8], [12], [17], [27]. In order to meet the increasing demand and to ensure patient safety different societies of Plastic Surgery formed special Fat Graft Task Forces [6], [20], [51], [58]. The potential risk of free fat tissue transfer to the breast in oncologic patients remains to be discussed [29], [37], [45], [62], [70], [71], but one must clearly distinguish between the situation where there is breast parenchyma left and the situation, such as in our patients, where the whole gland has been removed. Although lipotransfer has become very popular, only a limited number of case series about autologous fat grafting for complete breast reconstruction has been reported up to date [3], [28], [46]. The presented European multicenter study describes an optimized treatment and follow-up protocol for the de novo breast reconstruction after total mastectomy by lipotransfer alone.

Patients and methods

A retrospective study on complete breast reconstruction in post-mastectomy patients by autologous fat grafting was performed in four European centers in Germany, Finland and France between July 2008 and February 2012. Patient demographics, comorbidities, type of breast cancer with corresponding primary therapy, individual lipotransfer procedures and complications are listed in Table 1. We included 28 non-smoking women (mean age 52.4 years), after total mastectomy, failed implant reconstruction ($n=1$) or single stage expander application ($n=5$). Exclusion criteria were diabetes mellitus, obesity ($\text{BMI } 30 \text{ kg/m}^2$), prior flap-based reconstruction and implants in situ. Also excluded were patients who received subcutaneous mastectomy or breast conserving therapy. Weight changes exceeding 5 kg during our treatment also led to exclusion of the study. Mean follow-up time was 2.6 years (range 6 months to 3.7 years). Cancer follow-up was carried out in an unchanged manner. Preoperative clinical and radiological (mammography or sonography) assessments were done to exclude recurrent disease. During follow-up adverse palpation findings or pain in the reconstructed breast were addressed by magnetic resonance imaging (MRI) and/or ultra sound (US) examinations and core needle biopsy (CNB) when needed. Aesthetic evaluation was performed using digital pre- and postoperative photographs. They were reviewed and scored on a 5-point scale by two independent, blinded board-eligible plastic surgeons. Patient satisfaction was detected by a questionnaire with a 10-point Likert scale [35]. Continuous

Table 1: Demographics, comorbidities, treatment and impact (BMI, Body Mass Index; SD, standard deviation)

	No.	(%)	SD
Demographics			
Included patients	28	(100)	
Median age (years)	52.5		± 9.3
Median weight (kg)	69		± 10.2
Median BMI (cm ² /kg)	24.1		± 4.4
Included breasts	33		
unilateral	23	(82.1)	
bilateral	5	(17.9)	
Comorbidities			
Irradiation	16	(57.1)	
Chemotherapy	20	(71.4)	
Prosthesis	5	(17.8)	
Expander	3	(10.7)	
Combined (expander plus prosthesis)	2	(7.1)	
Treatment			
Reconstructive sessions per patient	4.15		± 1.56
Additional touch-ups	12	(42.8)	
Total netto volume (ml) in clinical trial	21,449		
Average volume per patient (ml)	1,020.3		± 515.2
Average volume per procedure (ml)	158.9		± 60.6
Impact of PMRT			
Number of PMRT patients	16	(57.1)	
Number of non-irradiated patients	12	(42.8)	
PMRT			
– total volume grafted (ml)	13,430		
– number of procedures	80		
– average volume per procedure (ml)	167.875		± 51.09
– average procedures per patient	5		
– average volume per patient (ml)	833.8		
Non-irradiated			
– total volume grafted (ml)	8,019		
– number of procedures	55		
– average volume per procedure (ml)	145.8		± 48.98
– average procedures per patient	4.5		
– average volume per patient (ml)	668.3		
Compared PMRT volumes per procedure in irradiated to non-irradiated patients	p>0.0409; α=0.05		

data were described with average median, minimum and maximum, and categorical data with absolute and relative frequencies. Statistical analyses were performed by the software package Office (Microsoft Corporation, Redmond, WA, USA).

Autologous fat grafting was performed by one senior surgeon in each center according to the standardized protocol of the BEAULI™ method [65] (see also [21], [22], [64]). The abdomen, waist, back, thighs and upper arms served as donor sites. The BEAULI™ method is characterized by harvesting of small vital fat cell clusters by water-jet assisted liposuction (body-jet®). Constant irrigation in combination with a standard gentle suction pressure of 0.5 bar ensures a lipoaspirate of high quality without physical input from the surgeon's side. Continuous, simultaneous filtering and washing takes place in a sterile closed system (LipoCollector™). The fat is thereafter extracted into 50 cm³ syringes, and *decanting* takes place for 5–10 min. For immediate reinjection, excess fluid is removed from the base of the 50 cm³ syringe and the fat

transferred into smaller syringes (10 cm³). No centrifugation is done. The BEAULI™ injection cannula is inserted through 1–3 tiny stab incisions (≤2 mm) to the breast area. The total fat volume grafted per procedure differed individually between 50 ml and 360 ml. In 12 patients (43%) operative reconstruction of the nipple areola complex (NAC) or contralateral mastoplasty were combined with the large volume fat transfer in order to regain symmetry. Two patients suffered from excessive disturbing skin and subcutaneous fat in the axillary region. This excess fold was turned into a lateral fasciocutaneous flap and used to redefine the submammary fold in these two patients. The trial was designed and performed according to the Declaration of Helsinki. All patients treated were offered a full range of breast reconstruction methods but all chose explicitly the lipofilling method. Written informed consent about the risks (i.e. tumor induction), potential complications and the experimental character of the method were signed by all parties.

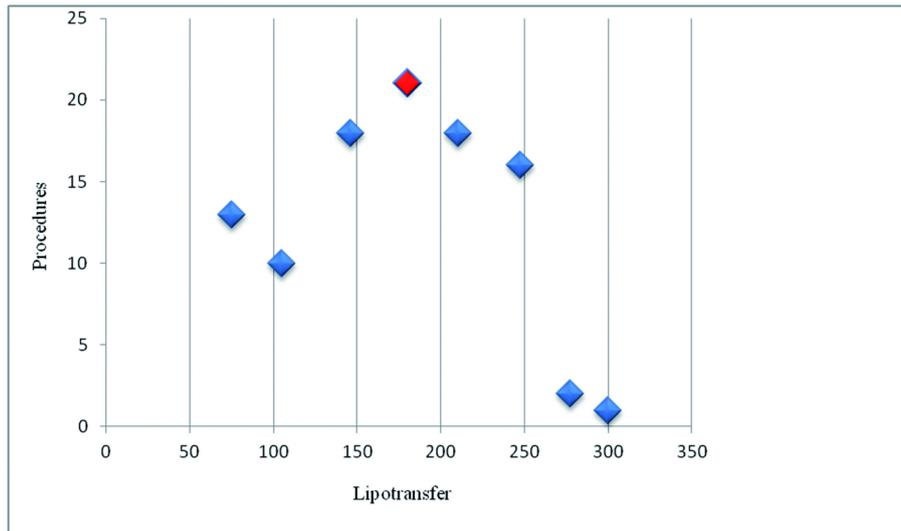


Figure 1: Numbers of procedures with median volumes (ml) grafted

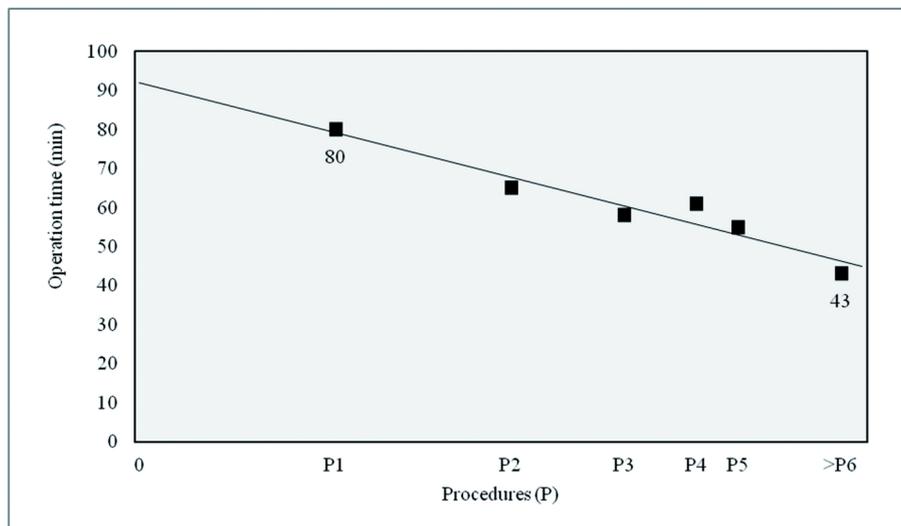


Figure 2: Median operation time (min) per procedure (P1–P10)

Results

Inclusion criteria of this study were fulfilled in 28 registered postmastectomy cases (WHO database ID: DRKS00004234 <http://apps.who.int/trialsearch/Trial.aspx?TrialID=DRKS00004234>). Five cases were bilateral, amounting to 33 reconstructed breasts by altogether 135 large volume fat grafting procedures. Sixteen patients (58%) had previously received post-mastectomy radiotherapy (PMRT) and 20 patients (71%) chemotherapy. Twenty-three patients had turned down traditional breast reconstruction methods such as autologous flap reconstruction or implants or the patients were not suitable for them (poor tissue, cardiac issues). Five patients with complications after immediate breast reconstruction with implants (capsular contraction, hardness, infection, rupture) received a complete reconstruction by lipotransfer. In five patients with extremely tight skin, temporary expanders were inserted at P1 and gradually deflated in the following procedures. The reconstructive treatment

started after a mean time period of 5.6 years (range 2 months to 13.8 years) after the end of primary therapy. Most frequently about 150 ml to 200 ml fat were transferred per procedure (peak shows 180 ml at $n=21$ in Figure 1). On average of 4.1 procedures (range 2 to 10) were performed to achieve a *complete breast reconstruction*. In our protocol the interval between the single procedures was at least 3 months, resulting in a mean total treatment period of 21 months (range 9 months to 2.5 years).

A median total volume of 1020 ml (± 515.2 ml) per patient was grafted to achieve complete reconstruction. Variations depended on individual breast size and BMI. The mean operation time was 50 min (± 9 min), but ranged to 60 min (± 29 min) in procedures P1 and P2 when further reconstructive steps were carried out (Figure 2). Half of the patients (53%) underwent their intervention under *analgesic sedation* (remifentanyl hydrochloride plus propofol) with *spontaneous breathing*. All

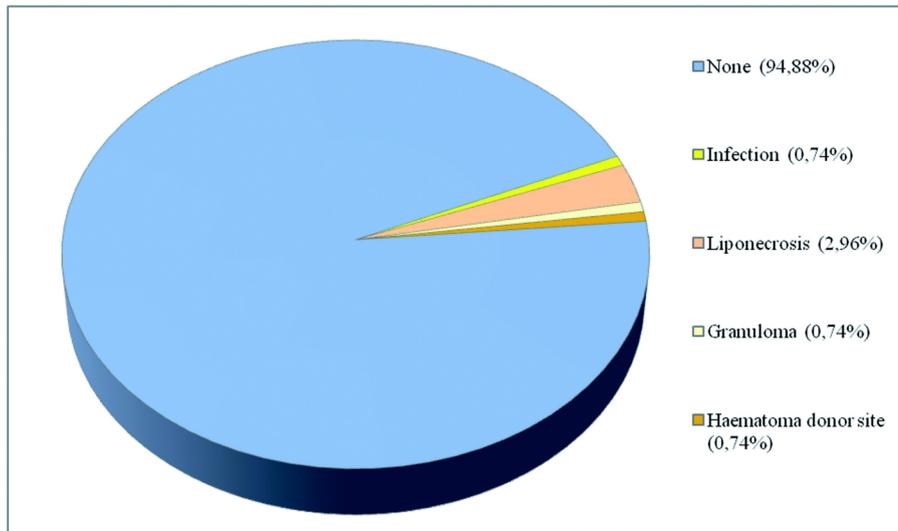


Figure 3: Recorded complications in all procedures

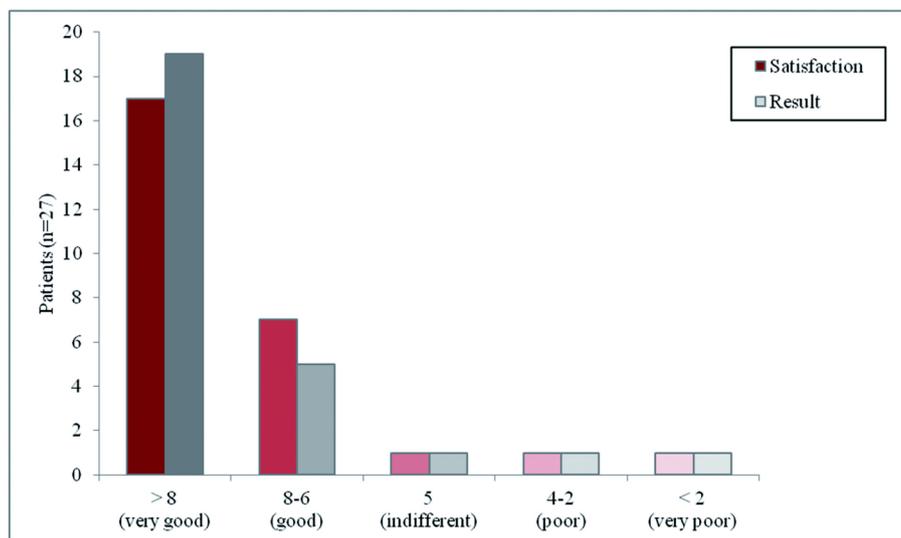


Figure 4: Evaluation of patient questionnaire (10-point Likert scale)

patients were either discharged from our institutions on the same day or stayed overnight for observation.

However, *irradiated* patients needed a *higher amount* of fat for the accomplishment of complete breast reconstruction compared to non-irradiated ($p > 0.041$). We observed different stages of reconstruction from P1 to P4 in patients with *PMRT*. Appearance and the texture of the skin improved, while the subcutaneous layer increased to final reformation of the cleavage.

During the minimum 6 months follow-up period no serious or unexpected adverse event occurred (Figure 3). As in all invasive breast reconstructive procedures, we observed *liponecrotic pseudocysts* (2.96%), *infection* (0.74%) and *granuloma* (0.74%) after the fat grafting procedures. One hematoma after liposuction was treated with puncture and antibiotics. All formations were frequently controlled by breast imaging and 87% *spontaneously resolved* after 6–12 months. Persisting or suspicious specimen were further investigated by biopsy and MRI. However two irradiated patients showed reduced or

missing engraftment due to heavy scarring or radiodamage of the recipient area (poor skin envelope and tissue perfusion). One dropout showed progressive distant metastasis of an invasive carcinoma after P3 and one regional recurrence occurred after the trial.

The specific questionnaire showed a response rate of 96.4% (Figure 4). Some comments about the reconstructed breast like feeling soft to touch, superior symmetry or regain of natural contour were added voluntarily. Three patients complained about superficial skin irregularities on donor sites. Evaluation of the aesthetic outcome was based on digital photographs and done on a 5-point scale (Figure 5). Overall an excellent to good result was achieved in 68% of the patients (Figure 6, Figure 7).

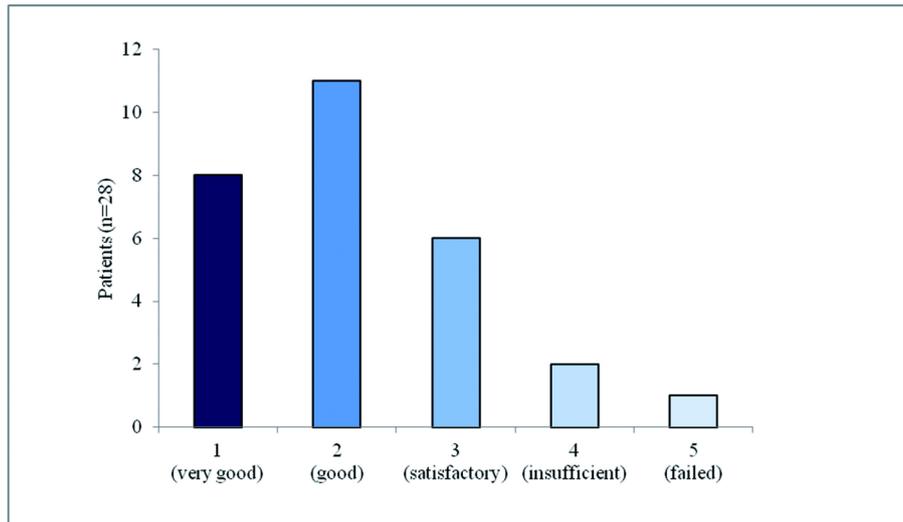


Figure 5: Results of the aesthetic outcome (5-point ranking scale)

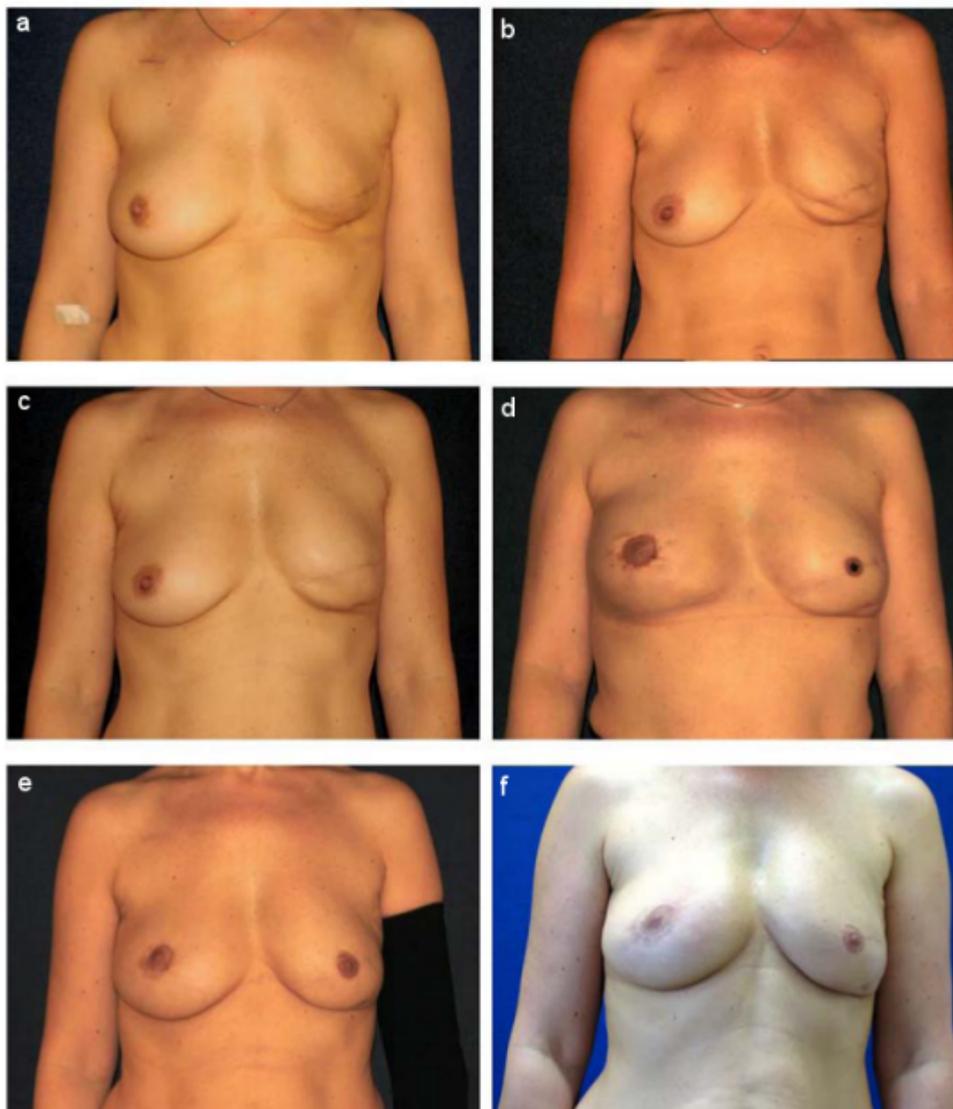


Figure 6: 56-year-old patient after total mastectomy left side in 2006. Outcome after 3 months (a) 300 ml grafted in P1, (b) 250 ml in P2. Below result (c) after P3 with 230ml transferred and (d) P4 with 210 ml combined with NAC reconstruction. Follow-up results after 12 months (e) and 18 months (f).



Figure 7: 66-year-old patient after total mastectomy left side in 2002 with PMRT. Outcome in March 2009 after P1 (250 ml) and P2 (250 ml). Below results after three more sessions (P3 with 200 ml, P4 with 150 ml, P5 with 300 ml plus NAC reconstruction) and 3 months follow-up in June 2010. Final outcome after P6 with 100 ml, P7 with 250 ml and 6 months follow-up in December 2011.

Discussion

Fat tissue transplant has been approved as a safe and reliable method for breast reconstructive issues in oncologic patients [14], [50], [52]. Correction of soft tissue defects and deformities after breast cancer or insufficient reconstruction can be achieved [10], [19], [36], [54]. After five years of experience with over 276 primarily reconstructive procedures to the female breast, the authors support the BEAULI™ method. In selected cases it can supply an efficient and safe alternative to flap or implant based reconstruction. The treatment started on average 5.6 years (2 months to 13.1 years) after the end of primary therapy. We suggest waiting for at least 6 months after PMRT, because acute radiation injury can compromise the survival of the fat graft [4], [40], [69]. Autologous fat grafting offers a *stepwise breast reconstruction*. It generally consists in 4 to 6 procedures with a mean of 50 minutes operation time. They all can be applied over

a period of 21 months. Most of patients have been discharged on the same day. A surgical learning curve, reducing the risk of complications and the operation time has been demonstrated [15]. As a major advantage, additional reconstructions of the breast can be performed in conjunction with the fat grafting procedure (e.g. NAC, contralateral mastoplasty). Occasionally expanders were inserted as temporary space holders to maintain or increase the skin envelope [48]. Successive expander's deflation of 50 ml to 80 ml was combined with lipofilling. In five cases autologous fat grafting was used as a salvage method after failure of implant reconstruction. In contrast to other large volume fat grafting techniques, our complication rates per procedure for liponecrotic pseudocysts formation (2.96%), infection (0.74%) or granuloma (0.74%) are very low [7], [26], [32], [34], [66]. Fat necrosis within the breast mainly occurs as common phenomenon after trauma, biopsy, implant removal, flap reconstruction, lipotransfer or radiation [16], [18], [41],

[44], [60], [63]. Thus oncologic patients must be advised about side effects before the discovery of suspicious specimen postoperatively [47]. Serial fat injection to post-irradiated mastectomy scars improved fibrosis and skin elasticity [2], [55], [59], [61]. Our findings on the higher fat volume grafted after PMRT confirm recent studies [53], [57]. Future evaluations should include a scoring system like LENT-SOMA [23], [43]. Limited or total missing size increase in two cases was definitively contributed to severe post-irradiation skin atrophy and local tissue radio-damage [31], [38], [53]. Possible scar excision, facioto-mies or temporary space holders should be considered as a pretreatment of PMRT patients [33], [49]. Patient satisfaction was overall high to very high (96%) and confirmed the good aesthetic results (68%) and the natural softness, contour and shape of the reconstructed breast. No significant unfavorable results were detected in the determined follow-up, however our findings don't allow any conclusions about the long-term risk of breast cancer recurrence after lipotransfer [25], [42], [56], [67], [72]. The investigators emphasize the importance of regular clinical and radiological follow-up in post-mastectomy patients irrespective of the reconstruction procedure applied.

Conclusions

Our study demonstrates that autologous fat grafting is a suitable way not only to restore local defects after conservative breast reconstructive surgery or radiodamages, but also to achieve complete breast reconstruction. Based on the presented results and recent literature a new *treatment protocol* has been developed in our institutions. Now patients with PMRT receive a pretreatment with 4 *ambulant small volume graftings* of 50–80 ml fat to *resolve scar fibrosis* after a safety period of at least 6 months to the last irradiation session. In this way, chronic tissue injury decreases gradually and an adequate recipient area can be obtained. The grafting technique is easy combinable with other oncoplastic methods like NAC reconstruction or contra lateral mastoplasty. Our follow-up and patient satisfaction reveal encouraging results, but further investigations on lipotransfer in breast cancer patients are mandatory.

Notes

Authorship

Delia Letizia Hoppe and Klaus Ueberreiter have equally participated.

Competing interests

Klaus Ueberreiter has filed after the publication in Germany a U.S. patent application in 2009 for the water-jet assisted fat grafting technique called BEAULI™. As one

of the inventors of the LipoCollector™ System, he receives some royalties from Human Med Inc. (producer of the Body-jet® and the LipoCollector™ System). He has not received any financial support for the presented trial. Neither he has commercial interests based on the subject of the study nor on its publication.

The other authors declare that they have no competing interests.

Ethics

An institutional review board (IRB) review was not required as all reported devices were cleared for marketing by the FDA.

The study was carried out under European law and the Declaration of Helsinki.

Meeting presentations

Content of the original article has been presented on the IMCAS in July 2012 (Shanghai – China), the 44th DGPRÄC conference in September 2012 (Bremen – Germany) and the 8th BEAULI™-Workshop in June 2013 (Berlin – Germany)

References

1. American Cancer Society. Breast Cancer Facts & Figures 2011–2012. Atlanta: American Cancer Society Inc; 2012. Available from: <http://www.cancer.org/acs/groups/content/@epidemiologysurveillance/documents/document/acspc-030975.pdf>
2. Autio P, Saarto T, Tenhunen M, Elomaa I, Risteli J, Lahtinen T. Demonstration of increased collagen synthesis in irradiated human skin in vivo. *Br J Cancer*. 1998 Jun;77(12):2331-5. DOI: 10.1038/bjc.1998.387
3. Babovic S. Complete breast reconstruction with autologous fat graft – a case report. *J Plast Reconstr Aesthet Surg*. 2010 Jul;63(7):e561-3. DOI: 10.1016/j.bjps.2009.11.027
4. Bernstein EF, Sullivan FJ, Mitchell JB, Salomon GD, Glatstein E. Biology of chronic radiation effect on tissues and wound healing. *Clin Plast Surg*. 1993 Jul;20(3):435-53.
5. Bertolini F, Lohsiriwat V, Petit JY, Kolonin MG. Adipose tissue cells, lipotransfer and cancer: a challenge for scientists, oncologists and surgeons. *Biochim Biophys Acta*. 2012 Aug;1826(1):209-14. DOI: 10.1016/j.bbcan.2012.04.004
6. Carvajal J, Patiño JH. Mammographic findings after breast augmentation with autologous fat injection. *Aesthet Surg J*. 2008 Mar-Apr;28(2):153-62. DOI: 10.1016/j.asj.2007.12.008
7. Castelló JR, Barros J, Vázquez R. Giant liponecrotic pseudocyst after breast augmentation by fat injection. *Plast Reconstr Surg*. 1999 Jan;103(1):291-3. DOI: 10.1097/00006534-199901000-00046
8. Chajchir A. Fat injection: long-term follow-up. *Aesthetic Plast Surg*. 1996 Jul-Aug;20(4):291-6.
9. Chan CW, McCulley SJ, Macmillan RD. Autologous fat transfer – a review of the literature with a focus on breast cancer surgery. *J Plast Reconstr Aesthet Surg*. 2008 Dec;61(12):1438-48. DOI: 10.1016/j.bjps.2008.08.006

10. 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.* 2008 Aug;122(2):356-62. DOI: 10.1097/PRS.0b013e31817d6303
11. Claro F Jr, Figueiredo JC, Zampar AG, Pinto-Neto AM. Applicability and safety of autologous fat for reconstruction of the breast. *Br J Surg.* 2012 Jun;99(6):768-80. DOI: 10.1002/bjs.8722
12. Coleman SR. Structural fat grafting. *Aesthet Surg J.* 1998 Sep-Oct;18(5):386, 388. DOI: 10.1016/S1090-820X(98)70098-6
13. Coleman SR, Saboeiro AP. Fat grafting to the breast revisited: safety and efficacy. *Plast Reconstr Surg.* 2007 Mar;119(3):775-85; discussion 786-7. DOI: 10.1097/01.prs.0000252001.59162.c9
14. Cordeiro PG. Breast reconstruction after surgery for breast cancer. *N Engl J Med.* 2008 Oct;359(15):1590-601. DOI: 10.1056/NEJMc0802899
15. Delay E, Garson S, Tousson G, Sinna R. Fat injection to the breast: technique, results, and indications based on 880 procedures over 10 years. *Aesthet Surg J.* 2009 Sep-Oct;29(5):360-76. DOI: 10.1016/j.asj.2009.08.010
16. Erol OO, Agaoglu G, Uysal AO. Liponecrotic pseudocysts following fat injection into the breast. *Plast Reconstr Surg.* 2010 Apr;125(4):168e-170e. DOI: 10.1097/PRS.0b013e3181d47054
17. Ersek RA, Chang P, Salisbury MA. Lipo layering of autologous fat: an improved technique with promising results. *Plast Reconstr Surg.* 1998 Mar;101(3):820-6. DOI: 10.1097/00006534-199803000-00038
18. Fraser JK, Hedrick MH, Cohen SR. Oncologic risks of autologous fat grafting to the breast. *Aesthet Surg J.* 2011 Jan;31(1):68-75. DOI: 10.1177/1090820X10390922
19. Gurunluoglu R, Gurunluoglu A, Williams SA, Tebockhorst S. Current trends in breast reconstruction: survey of American Society of Plastic Surgeons 2010. *Ann Plast Surg.* 2013 Jan;70(1):103-10. DOI: 10.1097/SAP.0b013e31822ed5ce
20. Gutowski KA; ASPS Fat Graft Task Force. Current applications and safety of autologous fat grafts: a report of the ASPS fat graft task force. *Plast Reconstr Surg.* 2009 Jul;124(1):272-80. DOI: 10.1097/PRS.0b013e3181a09506
21. Herold C, Reichelt A, Stieglitz LH, Dettmer S, Knobloch K, Lotz J, Vogt PM. MRI-based breast volumetry-evaluation of three different software solutions. *J Digit Imaging.* 2010 Oct;23(5):603-10. DOI: 10.1007/s10278-009-9264-y
22. Herold C, Ueberreiter K, Cromme F, Grimme M, Vogt PM. Ist eine intramuskuläre Injektion bei autologer Fetttransplantation zur Mamma sinnvoll? – Eine MRT-volumetrische Studie. [Is there a need for intrapectoral injection in autologous fat transplantation to the breast? – An MRI volumetric study]. *Handchir Mikrochir Plast Chir.* 2011 Apr;43(2):119-24. DOI: 10.1055/s-0030-1269931
23. Hoeller U, Tribius S, Kuhlmeier A, Grader K, Fehlauer F, Alberti W. Increasing the rate of late toxicity by changing the score? A comparison of RTOG/EORTC and LENT/SOMA scores. *Int J Radiat Oncol Biol Phys.* 2003 Mar;55(4):1013-8. DOI: 10.1016/S0360-3016(02)04202-5
24. Holländer E. Über einen Fall von fortschreitendem Schwund des Fettgewebes und seinen kosmetischen Ersatz durch Menschenfett. *Münch Med Wochenschr.* 1910;66:47.
25. Hou WK, Xu YX, Yu T, Zhang L, Zhang WW, Fu CL, Sun Y, Wu Q, Chen L. Adipocytokines and breast cancer risk. *Chin Med J.* 2007 Sep;120(18):1592-6.
26. Hyakusoku H, Ogawa R, Ono S, Ishii N, Hirakawa K. Complications after autologous fat injection to the breast. *Plast Reconstr Surg.* 2009 Jan;123(1):360-70; discussion 371-2. DOI: 10.1097/PRS.0b013e31819347ba
27. Illouz YG, de Villiers YT. *Body sculpturing by lipoplasty.* London: Churchill Livingstone; 1989. p. 390-4.
28. Illouz YG, Sterodimas A. Autologous fat transplantation to the breast: a personal technique with 25 years of experience. *Aesthetic Plast Surg.* 2009 Sep;33(5):706-15. DOI: 10.1007/s00266-009-9377-1
29. Iyengar P, Combs TP, Shah SJ, Gouon-Evans V, Pollard JW, Albanese C, Flanagan L, Tenniswood MP, Guha C, Lisanti MP, Pestell RG, Scherer PE. Adipocyte-secreted factors synergistically promote mammary tumorigenesis through induction of anti-apoptotic transcriptional programs and proto-oncogene stabilization. *Oncogene.* 2003 Sep;22(41):6408-23. DOI: 10.1038/sj.onc.1206737
30. Khouri RK, Eisenmann-Klein M, Cardoso E, Cooley BC, Kacher D, Gombos E, Baker TJ. Brava and autologous fat transfer is a safe and effective breast augmentation alternative: results of a 6-year, 81-patient, prospective multicenter study. *Plast Reconstr Surg.* 2012 May;129(5):1173-87. DOI: 10.1097/PRS.0b013e31824a2db6
31. Khouri RK, Smit JM, Cardoso E, Pallua N, Lantieri L, Mathijssen IM, Khouri RK Jr, Rigotti G. Percutaneous aponeurotomy and lipofilling: a regenerative alternative to flap reconstruction? *Plast Reconstr Surg.* 2013 Nov;132(5):1280-90. DOI: 10.1097/PRS.0b013e3182a4c3a9
32. Kim H, Yang EJ, Bang SI. Bilateral liponecrotic pseudocysts after breast augmentation by fat injection: a case report. *Aesthetic Plast Surg.* 2012 Apr;36(2):359-62. DOI: 10.1007/s00266-011-9790-0
33. Krumboeck A, Giovanoli P, Plock JA. Fat grafting and stem cell enhanced fat grafting to the breast under oncological aspects – recommendations for patient selection. *Breast.* 2013 Oct;22(5):579-84. DOI: 10.1016/j.breast.2013.05.006
34. Lee KS, Seo SJ, Park MC, Park DH, Kim CS, Yoo YM, Lee IJ. Sepsis with multiple abscesses after massive autologous fat grafting for augmentation mammoplasty: a case report. *Aesthetic Plast Surg.* 2011 Aug;35(4):641-5. DOI: 10.1007/s00266-010-9605-8
35. Likert R. A technique for the measurement of attitudes. *Arch Psychol.* 1932;22(140):55.
36. Losken A, Pinell XA, Sikoro K, Yezhelyev MV, Anderson E, Carlson GW. Autologous fat grafting in secondary breast reconstruction. *Ann Plast Surg.* 2011 May;66(5):518-22. DOI: 10.1097/SAP.0b013e3181fe9334
37. Manabe Y, Toda S, Miyazaki K, Sugihara H. Mature adipocytes, but not preadipocytes, promote the growth of breast carcinoma cells in collagen gel matrix culture through cancer-stromal cell interactions. *J Pathol.* 2003 Oct;201(2):221-8. DOI: 10.1002/path.1430
38. 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.* 2009 Apr;62(4):488-93. DOI: 10.1016/j.bjps.2007.11.046
39. Merlo DF, Ceppi M, Filiberti R, Bocchini V, Znaor A, Gamulin M, Primic-Zakelj M, Bruzzi P, Bouchardy C, Fucic A; AIRTUM Working Group. Breast cancer incidence trends in European women aged 20-39 years at diagnosis. *Breast Cancer Res Treat.* 2012 Jul;134(1):363-70. DOI: 10.1007/s10549-012-2031-7

40. Momoh AO, Colakoglu S, de Blacam C, Gautam S, Tobias AM, Lee BT. Delayed autologous breast reconstruction after postmastectomy radiation therapy: is there an optimal time? *Ann Plast Surg.* 2012 Jul;69(1):14-8. DOI: 10.1097/SAP.0b013e31821ee4b6
41. Momoh AO, Colakoglu S, Westvik TS, Curtis MS, Yueh JH, de Blacam C, Tobias AM, Lee BT. Analysis of complications and patient satisfaction in pedicled transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flap breast reconstruction. *Ann Plast Surg.* 2012 Jul;69(1):19-23. DOI: 10.1097/SAP.0b013e318221b578
42. Muehlberg FL, Song YH, Krohn A, Pinilla SP, Droll LH, Leng X, Seidensticker M, Rieke J, Altman AM, Devarajan E, Liu W, Arlinghaus RB, Alt EU. Tissue-resident stem cells promote breast cancer growth and metastasis. *Carcinogenesis.* 2009 Apr;30(4):589-97. DOI: 10.1093/carcin/bgp036
43. Panetti P, Marchetti L, Accorsi D. The serial free fat transfer in irradiated prosthetic breast reconstructions. *Aesthetic Plast Surg.* 2009 Sep;33(5):695-700. DOI: 10.1007/s00266-009-9366-4
44. Pearl RA, Leedham SJ, Pacifico MD. The safety of autologous fat transfer in breast cancer: lessons from stem cell biology. *J Plast Reconstr Aesthet Surg.* 2012 Mar;65(3):283-8. DOI: 10.1016/j.bjps.2011.07.017
45. Pérez-Cano R, Vranckx JJ, Lasso JM, Calabrese C, Merck B, Milstein AM, Sassoon E, Delay E, Weiler-Mithoff EM. Prospective trial of adipose-derived regenerative cell (ADRC)-enriched fat grafting for partial mastectomy defects: the RESTORE-2 trial. *Eur J Surg Oncol.* 2012 May;38(5):382-9. DOI: 10.1016/j.ejso.2012.02.178
46. Petit JY, Lohsiriwat V, Clough KB, Sarfati I, Ikhrai T, Rietjens M, Veronesi P, Rossetto F, Scevola A, Delay E. The oncologic outcome and immediate surgical complications of lipofilling in breast cancer patients: a multicenter study – Milan-Paris-Lyon experience of 646 lipofilling procedures. *Plast Reconstr Surg.* 2011 Aug;128(2):341-6. DOI: 10.1097/PRS.0b013e31821e713c
47. Pettus BJ, Brandt KE, Middleton WD, Reichert VC. Sonographic findings in a palpable abnormality after mastectomy and autologous fat grafting. *J Ultrasound Med.* 2011 Apr;30(4):576-8.
48. Piroth MD, Piroth DM, Pinkawa M, Woodruff SG, Holy R, Eble MJ. Immediate reconstruction with an expander/implant following ablatio mammae because of breast cancer: side effects and cosmetic results after adjuvant chest wall radiotherapy. *Strahlenther Onkol.* 2009 Oct;185(10):669-74. DOI: 10.1007/s00066-009-2013-9
49. Quoc CH, Meruta A, La Marca S, Fabiano L, Toussoun G, Delay E. Breast amputation correction of a horse bite using the lipomodelling technique. *Aesthet Surg J.* 2013 Jan;33(1):93-6. DOI: 10.1177/1090820X12469808
50. Reavey P, McCarthy CM. Update on breast reconstruction in breast cancer. *Curr Opin Obstet Gynecol.* 2008 Feb;20(1):61-7. DOI: 10.1097/GCO.0b013e318282f2329b
51. Rennekampff HO, Reimers K, Gabka CJ, Germann G, Giunta RE, Knobloch K, Machens HG, Pallua N, Ueberreiter K, Heimbürg Dv, Vogt PM. Möglichkeiten und Grenzen der autologen Fetttransplantation – "Consensus Meeting" der DGPRAC in Hannover, September 2009 [Current perspective and limitations of autologous fat transplantation – "consensus meeting" of the German Society of Plastic, Reconstructive and Aesthetic Surgeons at Hannover; September 2009]. *Handchir Mikrochir Plast Chir.* 2010 Apr;42(2):137-42. DOI: 10.1055/s-0030-1249672
52. Rietjens M, De Lorenzi F, Rossetto F, Brenelli F, Manconi A, Martella S, Intra M, Venturino M, Lohsiriwat V, Ahmed Y, Petit JY. Safety of fat grafting in secondary breast reconstruction after cancer. *J Plast Reconstr Aesthet Surg.* 2011 Apr;64(4):477-83. DOI: 10.1016/j.bjps.2010.06.024
53. Rigotti G, Marchi A, Galiè M, Baroni G, Benati D, Krampera M, Pasini A, Sbarbati A. Clinical treatment of radiotherapy tissue damage by lipoaspirate transplant: a healing process mediated by adipose-derived adult stem cells. *Plast Reconstr Surg.* 2007 Apr;119(5):1409-22; discussion 1423-4. DOI: 10.1097/01.prs.0000256047.47909.71
54. Rigotti G, Marchi A, Stringhini P, Baroni G, Galiè M, Molino AM, Mercanti A, Micciolo R, Sbarbati A. Determining the oncological risk of autologous lipoaspirate grafting for post-mastectomy breast reconstruction. *Aesthetic Plast Surg.* 2010 Aug;34(4):475-80. DOI: 10.1007/s00266-010-9481-2
55. Sarfati I, Ikhrai T, Kaufman G, Nos C, Clough KB. Adipose-tissue grafting to the post-mastectomy irradiated chest wall: preparing the ground for implant reconstruction. *J Plast Reconstr Aesthet Surg.* 2011 Sep;64(9):1161-6. DOI: 10.1016/j.bjps.2011.03.031
56. Schäffler A, Schölmerich J, Buechler C. Mechanisms of disease: adipokines and breast cancer – endocrine and paracrine mechanisms that connect adiposity and breast cancer. *Nat Clin Pract Endocrinol Metab.* 2007 Apr;3(4):345-54. DOI: 10.1038/ncpendmet0456
57. 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.* 2010 Jan;125(1):12-8. DOI: 10.1097/PRS.0b013e3181c49458
58. Snyderman RK. Breast cancer and fat transplants. *Plast Reconstr Surg.* 1988 Jun;81(6):991. DOI: 10.1097/00006534-198806000-00052
59. Spear SL, Wilson HB, Lockwood MD. Fat injection to correct contour deformities in the reconstructed breast. *Plast Reconstr Surg.* 2005 Oct;116(5):1300-5. DOI: 10.1097/01.prs.0000181509.67319.cf
60. Sullivan SR, Fletcher DR, Isom CD, Isik FF. True incidence of all complications following immediate and delayed breast reconstruction. *Plast Reconstr Surg.* 2008 Jul;122(1):19-28. DOI: 10.1097/PRS.0b013e3181774267
61. Sultan SM, Barr JS, Butala P, Davidson EH, Weinstein AL, Knobel D, Saadeh PB, Warren SM, Coleman SR, Hazen A. Fat grafting accelerates revascularisation and decreases fibrosis following thermal injury. *J Plast Reconstr Aesthet Surg.* 2012 Feb;65(2):219-27. DOI: 10.1016/j.bjps.2011.08.046
62. Sun B, Roh KH, Park JR, Lee SR, Park SB, Jung JW, Kang SK, Lee YS, Kang KS. Therapeutic potential of mesenchymal stromal cells in a mouse breast cancer metastasis model. *Cytotherapy.* 2009;11(3):289-98, 1 p following 298. DOI: 10.1080/14653240902807026
63. Tan PH, Lai LM, Carrington EV, Opaluwa AS, Ravikumar KH, Chetty N, Kaplan V, Kelley CJ, Babu ED. Fat necrosis of the breast – a review. *Breast.* 2006 Jun;15(3):313-8. DOI: 10.1016/j.breast.2005.07.003
64. Ueberreiter K, Tanzella U, Cromme F. Autologe Fetttransplantation als Salvage-Verfahren nach Kapselkontraktur von Brustimplantaten. *Ästh Chirurgie.* 2011;26:1-8.
65. Ueberreiter K, von Finckenstein JG, Cromme F, Herold C, Tanzella U, Vogt PM. BEAULI™ – eine neue Methode zur einfachen und zuverlässigen Fettzell-Transplantation [BEAULI™ – a new and easy method for large-volume fat grafts]. *Handchir Mikrochir Plast Chir.* 2010 Dec;42(6):379-85. DOI: 10.1055/s-0030-1267913

66. Valdatta L, Thione A, Buoro M, Tuinder S. A case of life-threatening sepsis after breast augmentation by fat injection. *Aesthetic Plast Surg.* 2001 Sep-Oct;25(5):347-9. DOI: 10.1007/s002660010147
67. Vona-Davis L, Rose DP. Angiogenesis, adipokines and breast cancer. *Cytokine Growth Factor Rev.* 2009 Jun;20(3):193-201. DOI: 10.1016/j.cytogfr.2009.05.007
68. Warren AG, Morris DJ, Houlihan MJ, Slavin SA. Breast reconstruction in a changing breast cancer treatment paradigm. *Plast Reconstr Surg.* 2008 Apr;121(4):1116-26. DOI: 10.1097/01.prs.0000305516.93441.fd
69. Yoshimura K, Sato K, Aoi N, Kurita M, Hirohi T, Harii K. Cell-assisted lipotransfer for cosmetic breast augmentation: supportive use of adipose-derived stem/stromal cells. *Aesthetic Plast Surg.* 2008 Jan;32(1):48-55; discussion 56-7. DOI: 10.1007/s00266-007-9019-4
70. Yu JM, Jun ES, Bae YC, Jung JS. Mesenchymal stem cells derived from human adipose tissues favor tumor cell growth in vivo. *Stem Cells Dev.* 2008 Jun;17(3):463-73. DOI: 10.1089/scd.2007.0181
71. Zhang Y, Bellows CF, Kolonin MG. Adipose tissue-derived progenitor cells and cancer. *World J Stem Cells.* 2010 Oct;2(5):103-13. DOI: 10.4252/wjsc.v2.i5.103
72. Zhang Y, Daquinag A, Traktuev DO, Amaya-Manzanares F, Simmons PJ, March KL, Pasqualini R, Arap W, Kolonin MG. White adipose tissue cells are recruited by experimental tumors and promote cancer progression in mouse models. *Cancer Res.* 2009 Jun;69(12):5259-66. DOI: 10.1158/0008-5472.CAN-08-3444

Corresponding author:

Delia Letizia Hoppe, M.D.
 BG Unfallklinik Tübingen, Klinik für Hand-, Plastische, Rekonstruktive und Verbrennungschirurgie,
 Schnarrenbergstrasse 95, 72076 Tübingen, Germany,
 Phone: +49 711-64897212
 dhoppe@bgu-tuebingen.de

Please cite as

Hoppe DL, Ueberreiter K, Surlmont Y, Peltoniemi H, Stabile M, Kauhanen S. Breast reconstruction de novo by water-jet assisted autologous fat grafting – a retrospective study. *GMS Ger Med Sci.* 2013;11:Doc17.
 DOI: 10.3205/000185, URN: urn:nbn:de:0183-0001854

This article is freely available from

<http://www.egms.de/en/journals/gms/2013-11/000185.shtml>

Received: 2013-05-06

Revised: 2013-11-15

Published: 2013-12-12

Copyright

©2013 Hoppe et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en>). You are free: to Share – to copy, distribute and transmit the work, provided the original author and source are credited.